Farm Income Risk Management (FIRM): A Decision Support System Approach

by

Rich Alderfer, Stephen Harsh, Jim Hilker, and J. Roy Black

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Commercial grain producers face income risks due to price and production uncertainty. Patrick et. al. surveyed 149 farmers in 12 states and found that acquiring market information was their most important management response for reducing farm income risk. They also found that the farmers surveyed felt commodity prices were the most important source of farm income risk. Branch and Olson found similar results in a survey of Wyoming ranchers. Product price risk is a substantial and controllable portion of farm income risk. This paper focuses on a method to evaluate commodity marketing alternatives as a means to manage income risk.

Choosing the appropriate mix of pricing alternatives and the number of bushels to commit to each alternative, is an ill-structured task, especially during the preharvest time period. The producer must consider the uncertainties of yield, futures and basis, as well as factors related to his or her ability (or desire) to bear risk. To date, producers have relied on judgement, experience and trial-and-error. Producers have lacked prescriptive tools for managing farm income risks through grain marketing. Marketing simulation efforts like the Whole Farm Risk Rating Model (Anderson and Ikerd) offer some assistance, but the decision of how and how many bushels to price is a nearly infinite search space.

Risk analysis research efforts using target MOTAD, E-V analysis and other methods have looked at marketing tactics to reduce farm income risk; however, these tools are rarely intended for use by individual producers. Some of these models require large historical databases that most producers could not afford or maintain. Some research models have employed econometric price forecasts that would also be difficult for farmers to manage. Many research-oriented models make restrictive assumptions about producer risk preferences and are therefore limited in their ability to represent individual producers. Finally, these previous efforts have been generally designed for powerful computers that producers can neither afford nor access.

The purpose of this project is to develop Decision Support System (DSS) components called Farm Income Risk Management (FIRM), to assist the decision-maker in risk management via commodity marketing. FIRM is designed for adaptive management of income risk for a single commodity. That is, the producer is able to run FIRM several times throughout the year, in order to update pricing strategies. FIRM does not explicitly consider other farm enterprises, opportunities to manage risk through crop selection and diversification, nor forecast intertemporal prices for dynamic pricing strategies. The single crop focus is an important initial step, before more complex models are constructed. These issues will be addressed again in concluding comments.

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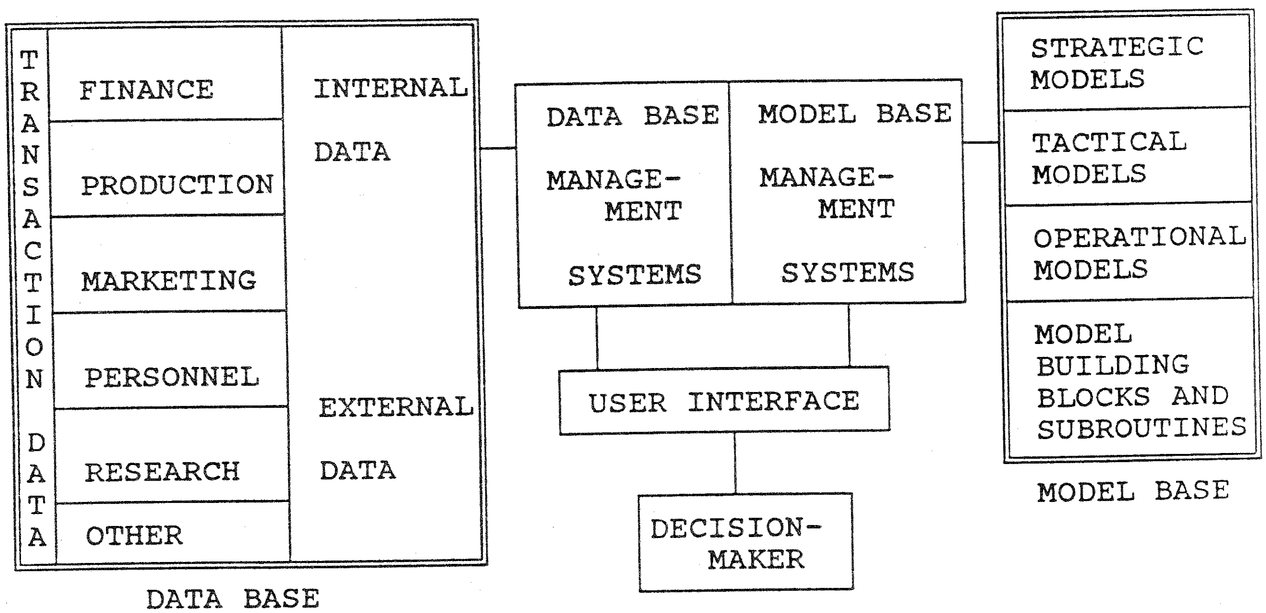
WHAT IS A DECISION SUPPORT SYSTEM (DSS)?

Sprague and Carlson described DSS as computer-based systems that help decision-makers confront ill-structured problems through direct interaction with data and analysis models. More specifically, Watson and Sprague outlined the conceptual design of a DSS and its components as shown in Figure 1. The three principle components of a DSS are the data base, model base and decision-maker. The integration of data and models into a DSS reduces data entry, since production and financial records are available to the model base. House is a good source for further DSS concepts and examples. Harsh detailed DSS in the context of agriculture, including a description of the Integrated Decision Support System project at Michigan State University. FIRM is part of this larger DSS project which is being designed to operate on powerful micro-computers (Intel 80286 and 80386 based machines).



Sprague & Watson (in House, 1983, p. 22)

Figure 1. Components of a Modern DSS

OVERVIEW OF FIRM

FIRM is a collection of DSS components designed to assist in marketing grain commodities. The FIRM prototype is designed for pricing soybeans. When testing for the prototype has been completed, its modular design will allow modification for the analysis of other commodities as well. FIRM is particularly suited to preharvest marketing for a delivery time chosen by the producer. FIRM can be run numerous times throughout the year, from the time that planted acres (or intended planted acres) are known until the cash commodity has been liquidated.

FIRM requires input on market prices and distributions of prices and yields expected in the future. FIRM measures farmer risk preferences and finds a portfolio of pricing alternatives that matches them. Below is an outline diagram showing the input and output of FIRM.

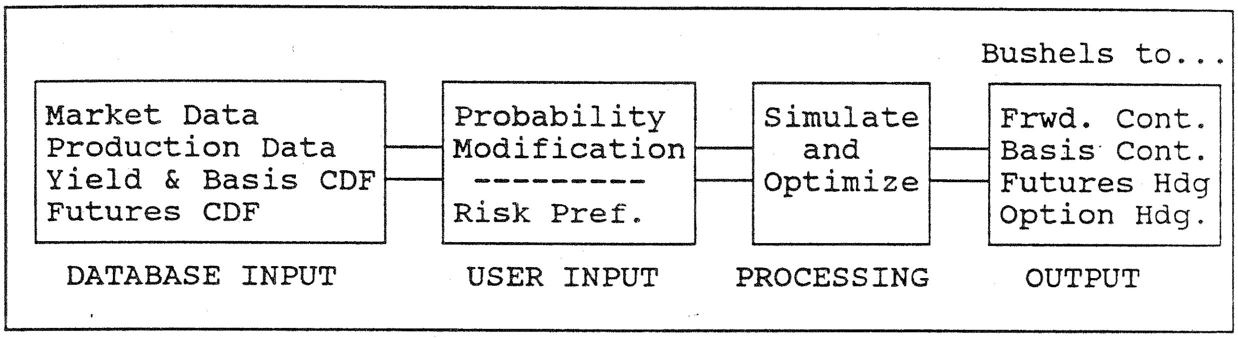


Figure 2. Overview of FIRM

FIRM contains multi-period simulation components to handle previous pricing commitments. However, in the optimization portion of FIRM, new pricing alternatives are examined for a single delivery period of the producer's choice. While FIRM can be run several times throughout the year, the optimization module considers two time periods: the day the model is run, and the ending (delivery) period.

FIRM is designed around the assumption that futures and options markets are reasonably efficient, especially for producer participants who lack economies of size and scale in information and transaction costs. FIRM uses option premiums to generate an ending period cumulative distribution function (CDF) for futures prices. Similar CDF's are formed for basis and yield using historical database values followed by subjective modification. A correlation matrix is entered and Monte Carlo observations on the multivariate distributions are generated. FIRM first simulates the status quo marketing plan to determine the expected income and standard deviation. These values are then used to seed an expert system which measures producer risk preferences. Next, non-linear optimization searches for mixture of pricing alternatives that maximize expected utility. In the final section, the decision-maker can simulate other marketing plans of his or her own choosing and compare them to the optimal. The next few sections are a closer look at each of the major components of FIRM.

THE MARKETING DATABASE

Quality records are the foundation for sound decision analysis. FIRM needs to know what previous commitments have been made for the crop in question and the amount of deterministic gains or losses to date (if any). Ferris designed a marketing record system to be kept on paper. This system will become the outline for a computerized grain marketing database. The database will record marketing transactions and contain information about brokerage commissions, storage costs on grain and other needed price data. The database will employ a DBase IV file format, but entry forms will be supplied to the producer, eliminating the need to purchase and learn DBase. To date, the marketing database has been outlined, and database tools are under development.

The most important portion of the marketing database for FIRM is the open position report. The open position report is a summary of marketing commitments yet to be delivered (contracts in the cash market) or offset (futures and options markets). The format for the open position report is shown in figure 3.

OPEN POSITION REPORT

Date	Crop	Contract Month	Mktg Method	# of Bu.	Prem or Price $/Bu.	Strike $/Bu.	Tran ¢/Bu.	Margin ¢/Bu.
2-16	Soy	11-89	For.Con.	1000	6.83	0.00	0.0	0.0
3-19	Soy	1-90	Buy Put	5000	.49	6.75	3.0	15.0

Figure 3. Report From the Marketing Database

When FIRM is executed, the first action is to read the open position report and retrieve entries related to the selected crop. FIRM will also need data from the production portion of the database. Important data are historical yields for the selected crop, acreage, and leasing arrangements for crop land.

ELICITING PROBABILITIES AND CORRELATIONS

The production portion of the database contains data on yield expectations, and historical yields for the selected crop. These values are used to suggest a discrete probability function for yield. Subjective modification of the discrete probabilities will take place before they are smoothed. Pease and Black have examined and refined yield elicitation methods. They offered triangulation and historical yields as "anchors" for subjective modification. A framework similar to theirs will provide the basis for elicitation of stochastic variables needed in FIRM.

To forecast the CDF for ending period futures prices, the Black option pricing model (BOPM) is used to measure implied market volatility, and the current futures price is the expected ending period futures price. The BOPM requires very little data compared to non-parametric methods (e.g. King and Fackler), or historical measures of volatility. The BOPM is not without criticism. Due to biases discussed in Hauser and Neff (1985a) it is necessary to use premiums on strike prices that are close to the market price of the underlying futures contract. The BOPM assumes a log-normal distribution for futures prices and a European style option contract. General equilibrium models like BOPM also fail to incorporate the effects of government commodity programs. Regardless of the criticisms and assumptions, the BOPM remains widely used in research and practice. It has performed reasonably well, especially given the model's simplicity (see Wilson or Hauser and Neff, 1985b).

Hilker and Black have developed a microcomputer-based version of the BOPM that computes implied futures volatility. This model was used in developing FIRM. The current call premium and futures price for soybeans are used to compute the BOPM standard deviation on futures returns (a log ratio of prices). This figure is then annualized and converted from a ratio into cents per bushel. The mean and standard deviation for ending period futures prices form a truncated normal distribution. The degree of truncation is minimal as the coefficient of variation (CV) is usually less than .2 for futures prices.

It is not necessary to price grain for the same delivery period each time FIRM is run. It is possible that previous commitments are for one month (e.g. November) while the next analysis considers contracts for a different month (e.g. January). Thus, elicitation of basis and futures CDF's will take place for the ending period being considered, as well as any other delivery periods for which there are previous commitments.

FIRM needs a correlation matrix to relate each of the marginal distributions being considered (e.g. cor[yield, basis]). The user must supply the correlations. Historical correlations will be helpful in assisting the decision-maker to form subjective correlations. Further empirical research in this area will be needed in order to supply the user with reasonable values for his or her modification. FIRM will check the determinant of the correlation matrix elicited to ensure that it is symmetric and positive definite. If the matrix is singular or negative definite errors will occur in later computations. Lehman demonstrated a pivotal condensation algorithm in FORTRAN that has been adapted for use in FIRM in order to validate the correlation matrix.

GENERATING OBSERVATIONS ON MULTIVARIATE DISTRIBUTIONS

With discrete CDF's for each marginal distribution (yield, basis and futures) and a reasonable correlation matrix, it is possible to compute random observations for each stochastic variable with properties that closely approximate the correlations and distributions. King outlined this process for non-parametric distributions. The method first produces uniform variates with desired correlations, and then transforms them to the desired distribution.

Fackler and King noted that using Spearman's rho increased data measurement difficulties, but improved the representativeness of the Monte Carlo data. For symmetric marginal distributions King's original methods are simpler to implement and perform well. For skewed distributions, the alternative correlation measures will be less intuitive for producers, but may be necessary to reduce bias in the sample observations. As correlations approaches zero, one or negative one, the difference in methods becomes less important. Further research on generation of multivariate distributions is needed, but for the moment, the methods originally outlined by King should be sufficient for the types of distributions and correlations expected in farm-level situations.

SIMULATION I (SIM1)

The multivariate distribution generator produces observations on yield, basis and futures for each contract month needed. It is a relatively simple matter to compute stochastic production, and using the status quo marketing plan, sell the crop. This produces observations on harvest-time income after all marketing costs. Pricing alternatives in the FIRM prototype include forward contracting, basis contracting, futures hedge (short only), buy a put, buy a call, or sell at the ending period cash price.

SIM1 buys grain, if needed, to meet forward and basis contract obligations at a user-supplied spread above the ending period cash price. Futures contracts are assumed to be offset in the middle of the month preceding the futures contract expiration, at which time delivery of cash grain takes place. Futures are offset at this time to avoid the often choppy markets nearer their expiration. Option contracts are also sold in the month prior to futures expiration since they are near expiration, and the time value is approaching zero.

SIM1 uses the stochastic variables (production, futures and basis), the pre-determined ones (i.e. acres, contract prices, etc.) and previous marketing commitments, to compute several important factors. An important output for subsequent calculations is the vector of total production not committed to forward or basis contracts. These bushels are available for additional marketing commitments, or left unpriced (until the ending period). SIM1 also computes the expected total production and expected cash bushels yet to be marketed. Other SIM1 output includes expected income, standard deviations for income, a vector of incomes from previous cash marketing commitments, plus income from previous futures and options contracts that have been offset.

ELICITATION OF RISK PREFERENCE (ELRISK)

Information on expected income and the standard deviation of income (from SIM1) is used to seed the elicitation of risk preference (ELRISK). ELRISK is an expert system based on the modified Ramsey approach. Halter and Mason used the Ramsey method for establishing five points on a von Neumann - Morganstern (vN-M) utility function. FIRM uses a modification of their method to elicit 10 to 14 points in the neighborhood of the problem setting. As suggested by Musser and Musser, the elicited preferences are described in the context of the problem the producer actually faces.

ELRISK sequentially presents the user with lotteries (described to the producer as marketing alternatives). Each lottery has two possible outcomes, each with equal probability. Three of the four possible payoffs in the first two lotteries are a function of the mean and standard deviation of income. A value for the fourth payoff giving equal expected outcomes is suggested to the user for his or her revision. The modified Ramsey method seeks a fourth payoff, which makes the user indifferent to the two lotteries. Expert system rules ensure that one lottery is not first order stochastic dominant over the other. Elicitation concludes when utilities have been elicited for incomes that are two (or more) standard deviations above and below the expected income. ELRISK includes two consistency checks for preferences. Throughout the elicitation, input values are validated and messages ask for clarification of the values if unfair games arise.

An electronic spreadsheet was used to develop and test ELRISK, but the logic and expert system rules of ELRISK will be rewritten in a standard programming language. When completed, ELRISK should include graphical user output of the elicited utility values. This will allow experienced users to evaluate their utility functions. No functional form of the utility function is assumed. Instead, corresponding utility and income values will be used in a table look-up function for linear extrapolation between and beyond the elicited points. This reduces computation time and makes no restriction on user preferences (except that more must be preferred to less).

LIMITING THE SEARCH AND SIM2

SIM2 is a second marketing simulation upon which the non-linear optimization is based. SIM2 is structured like SIM1 except the only random variables are ending period futures, basis levels and the number of bushels remaining to be priced in the cash market (from SIM1). Reducing the number of random variables (contract months) limits the search space for optimization and speeds execution. To further speed optimization, each time SIM1 is executed, the same vectors of stochastic variables will be used. This subjects each marketing portfolio to an identical set of stochastic values, reducing the length of the vectors needed. For a producer to consider new marketings (as opposed to previous commitments) for two different contract months, two separate runs with FIRM would be needed, and the results compared.

Some producers might not want to consider one or more of the available marketing alternatives offered by FIRM. This may be due to external factors, imposed constraints, or a lack of understanding of futures or options. If a producer wants to eliminate a particular marketing alternative, the explicit constraints for the maximum number of bushels marketed in that manner are reduced to zero.

Producers can consider a second constraint involving total bushels to be priced in the time period analyzed. A producer might wish to limit total marketings in any single optimization to some level that is a function of expected production. This user-supplied constraint is already incorporated in the prototype of FIRM.

SIM2 has one other characteristic that distinguishes it from SIM1. When SIM2 is run, the approximated utility function is known for the producer. SIM2 computes expected utility rather than the mean and standard deviation of income. SIM2 is only used in optimization. A third simulation will be used to compute additional performance measures for output to the screen or printer, once the optimum is located.

OPTIMIZATION

Manetsch and Park developed a variable alpha version of the Complex Algorithm for non-linear optimization (see Kuester and Mize for a previous version in FORTRAN). This Modified Complex Algorithm (MCA) allows explicit and implicit constraints on control variables, and is very robust at finding global optima. MCA is a stochastically seeded, sequential search method that seeks a maximum objective function value. In FIRM, the objective function is expected utility, and the control variables are the bushels to be marketed in each of the five marketing alternatives.

In the first iteration of MCA, K vertices of the N control variables are randomly generated (K > N). In each subsequent iteration, MCA finds the vertex with the lowest objective function value, and adjusts its control variables to move the vertex closer to the other superior vertices. This is done until all K vertices have objective function values that are within some value beta of each other. Beta is a system parameter measured in the same units as the objective function.

In commodity marketing, certain portfolios give nearly identical income distributions, due to the high degree of substitutability of pricing methods. This implies that the optimal marketing portfolio is likely to lie on a ridge with other portfolios that give near optimal performance. MCA has been adapted to the FIRM problem set, so that the optimization is repeated from 1 to M times, where M is determined by the user. On the first MCA run the explicit constraints are wide and the beta convergence parameter relatively large. In each subsequent MCA run, the constraints are reduced as a function of results of the previous run, and the beta is reduced. On each successive optimization, the user views the results. At that time, the user can halt optimization and proceed to SIM3, or ask MCA to iterate again with smaller beta and narrower constraints.

Narrowing the constraints and reducing beta allow the program to converge on the optima without substantially increasing run time. This iterative process is done at the user's command, but the constraints and beta are managed by MCA. This reduces the program complexity for the end-user and the number of total function calls to SIM2. MCA is complete, except for the enhancements of automating the constraint beta parameter changes. At the present, those adjustments are entered manually.

SIM3 AND FOLLOW-UP SIMULATIONS

Following optimization, a third simulation computes additional performance measures. SIM3 begins with the same static values for today's prices, and vectors of stochastic values for remaining bushels, futures price and basis, that were used in SIM2. SIM3 uses the optimal levels of control variables found in the solution of MCA. Expected utility, expected income, the standard deviation of income, expected cash bushels sold, and the 5th, 10th, 20th, and 80th percentiles of income are computed in SIM3. Marketing alternatives for each of the K vertices in the neighborhood of the optimum are listed in order, from highest to lowest utility. SIM3 also computes the risk premium the producer would desire to be indifferent between the highest utility plan, and each of the other marketing plans. SIM3 allows users to append new pricing portfolios of their own choosing, to those chosen by the MCA. This allows the producer to include factors like contract lumpiness in follow-up simulations. On the following page is a schematic showing details of the FIRM model.

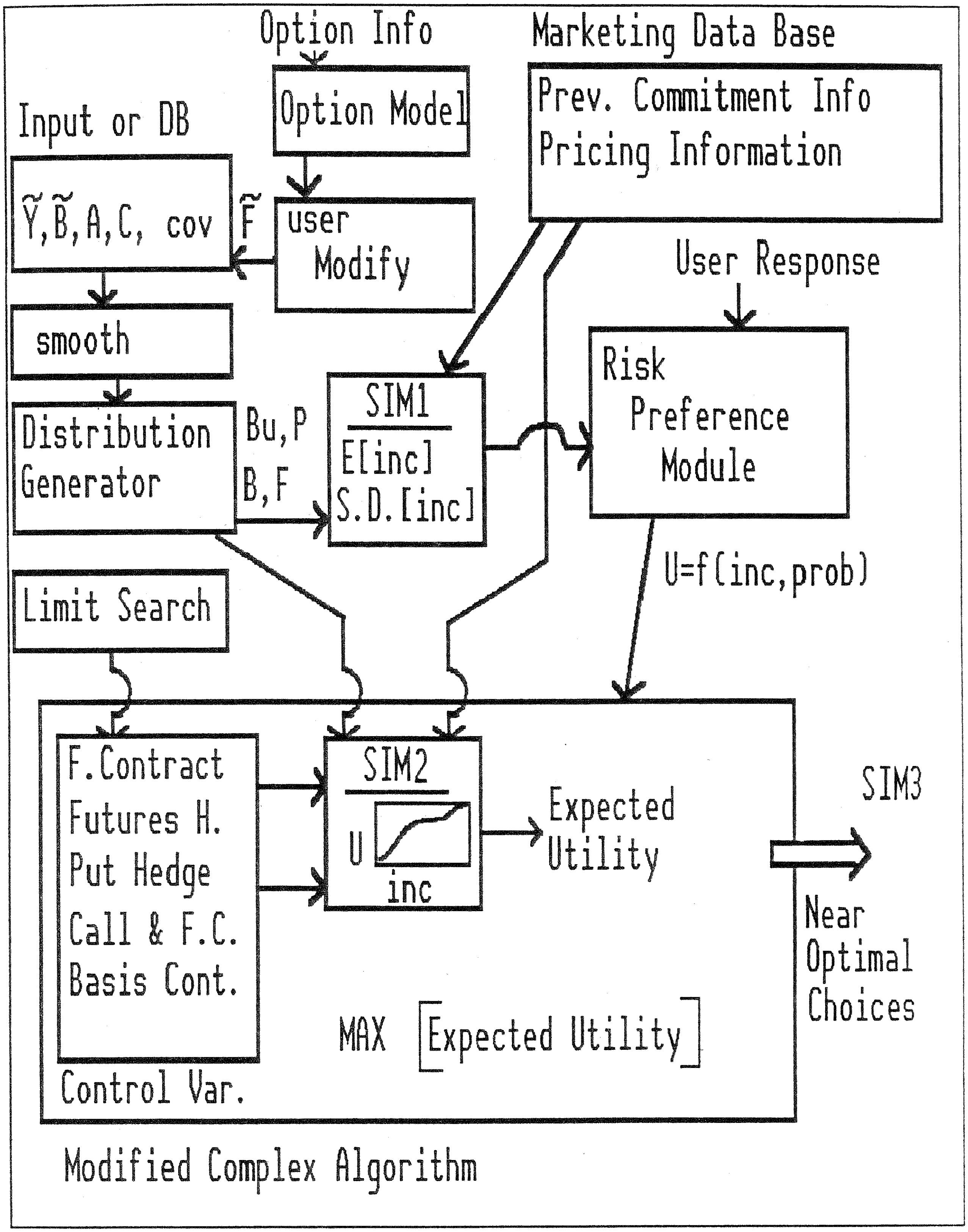


Figure 4. The FIRM Model

PRICING PORTFOLIOS FOR A PRODUCER

FIRM is still being developed and refined, but the simulation and optimization algorithms described have been written and preliminarily tested. Much of the remaining efforts involve input-output programming and further testing (both research and in the field). This section looks at output from FIRM for a mid-western producer with 250 acres of soybean production. Table 1 shows input values for critical variables.

TABLE 1 Program Input

Today's Date 4/4/89	Harvest Month 10/89
Acres = 250	Variable Costs / Ac. = $80
Bushels previously marketed = 0	U = f(Gross Margin)
Nov. CBOT Soybean Futures = $7.03	Nov. Forward Contract = $6.66
Basis Contract $ -.36 (cash - futures)	Options Strike Price = $7.00
Premium on Call Option = $.52	Premium on Put Option = $.46
R.T. Brokerage - futures = $.02	O.W. Brokerage - Options = 3%
Ave. Margin/Bu. - futures = $.30	Ave. Margin/Bu. - Options = $ 0.0
Interest Rate Per Month = 1.0%	Ask - Bid cash spread = $.05

Sample Statistics from 200 Monte Carlo Observations

Description	Random Variable	Mean	S.D.	Correlations X1	X2	X3
Yield	X1	28.74	5.7	1.0	-0.055	-0.153
Futures	X2	7.05	0.84	-0.055	1.0	0.039
Basis	X3	-0.36	0.09	-0.153	0.039	1.0
Gross Margin		27978	10897	(status quo plan)		

Subjectively Modified CDF for yield

P(y ≤ Y)	Yield	P(y ≤ Y)	Yield	P(y ≤ Y)	Yield
.0035	14	.3007	25	.9241	36
.0103	15	.3628	26	.9283	37
.0190	16	.4317	27	.9337	38
.0283	17	.5110	28	.9479	39
.0386	18	.5972	29	.9655	40
.0697	19	.6800	30	.9862	41
.0938	20	.7489	31	.9910	42
.1214	21	.8007	32	.9970	43
.1559	22	.8455	33		
.1972	23	.8800	34		
.2425	24	.9041	35		

Consider a hypothetical producer with a negative exponential vN-M utility function where Utility = K - a * EXP(-b * X). ELRISK could have been run for a real producer, but the utility function chosen has nice properties for the discussion to follow. For this utility function the Pratt-Arrow measure of absolute risk aversion is a constant and equal to b. This particular producer has values of 680, 1900, .00006 for K, a, and b respectively, and X is measured as gross margin. The constant absolute risk aversion (CARA) is commonly employed in risk theory and empirical studies of risk behavior.

Expected futures and basis distributions are assumed to be normally distributed (futures were truncated to guarantee positive prices). The non-parametric yield distribution was subjectively modified from 13 years of historical yields. Below are output screens for a single run of MCA with wide constraints on control variables and moderate convergence parameter. With 200 Monte Carlo observations, the solution was reached in 27 seconds on a 20 mhz. 80386 based microcomputer with math coprocessor.

Plan	Forw. Cont.	Futures Hedge	Put Hedge	Basis Cont.	Call Hedge	Expect CashBu	Total Bu.	Exp. Util	Risk Prem
1	3592	0	0	0	0	4745	9653	237.6	0.0
2	3974	1607	51	166	126	4438	8747	237.6	1.6
3	2432	1286	32	0	0	4610	8968	237.5	7.0
4	1612	2095	13	208	0	4794	8909	237.3	13.1
5	1632	2242	54	0	0	3594	7185	237.3	14.2
6	2703	1237	29	127	36	4117	7796	237.3	14.6
7	3067	608	4	0	0	3051	8976	237.2	18.5
8	2383	1660	64	7	0	4354	8486	237.2	19.1
9	2509	1723	32	65	30	4752	8502	237.1	23.0
10	972	3029	0	0	22	6212	10235	237.0	24.1
11	2368	1430	30	47	27	4368	10300	237.0	24.9
12	2644	2966	45	172	104	5552	9480	237.0	26.1
13	2746	1500	63	0	0	4769	8670	237.0	26.3
14	2332	2407	9	107	53	5219	8886	236.9	28.2
15	1923	1702	0	42	0	5364	9292	236.9	29.5
16	0	0	0	0	0	7184	7184	224.0	532.8

Vert.	Expected Util.	$Rev.	SDev. $Rev.	------- PERCENTILES --------- 5th	10th	20th	80th
1	237.6	27785	9642	12917	15835	19778	33498
2	237.6	27814	9702	12884	15720	19870	33895
3	237.5	27811	9707	12887	15739	19929	33953
4	237.3	27817	9729	12887	15795	20089	34044
5	237.3	27869	9827	12902	15244	20311	34540
6	237.3	27857	9806	12877	15282	20321	34406
7	237.2	27743	9588	13001	15770	19703	33616
8	237.2	27825	9756	12856	15603	20132	34165
9	237.1	27840	9789	12882	15297	20367	34352
10	237.0	27808	9733	12964	15653	20375	34118
11	237.0	27730	9572	13018	15753	19708	33700
12	237.0	27816	9752	12916	15671	20347	34199
13	237.0	27829	9776	12873	15350	20310	34289
14	236.9	27844	9806	12955	15236	20428	34406
15	236.9	27833	9788	12914	15277	20428	34355
16	224.0	27978	10897	8635	14042	19096	36212

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Figure 5. FIRM Output for an Individual Producer.

A downward bias in the forward contract price (3 cents), and a small upward bias in expected futures prices (2 cents) were used. These biases are minor and represent the small premium an elevator merchandiser might need to cover transactions costs of writing a forward contract. There was no bias between expected basis levels and the basis contract price.

The output in figure 5 lists the 15 pricing portfolios in solution when MCA converges (plans 1 - 15). With the small biases mentioned, forward contracts and futures hedging become near perfect substitutes, when used at moderate levels. Plans 1 - 15 are sorted with plan 1 giving the highest expected utility. The convergence parameter for the output in figure 5 was 1.0, so that all plans have an expected utility within 1.0 of each other. Plan 16 was a custom plan inserted by the decision maker after viewing the first 15 alternatives. The far right column labeled "Risk Premium" is the certainty equivalent difference between the best of the 15 plans and each of the plans below. The certainty equivalence is not displayed, but is simply the conversion of the expected utility of the risky alternative, back into dollars. This indicates that the difference in expected utility for this producer is $29.50 between plans 1 and 15. The producer should prefer the optimal plan over Plan 16 by $532.80. Figure 5 demonstrates a strength of MCA and its ability to meaningfully represent other pricing portfolios in the neighborhood of the optima.

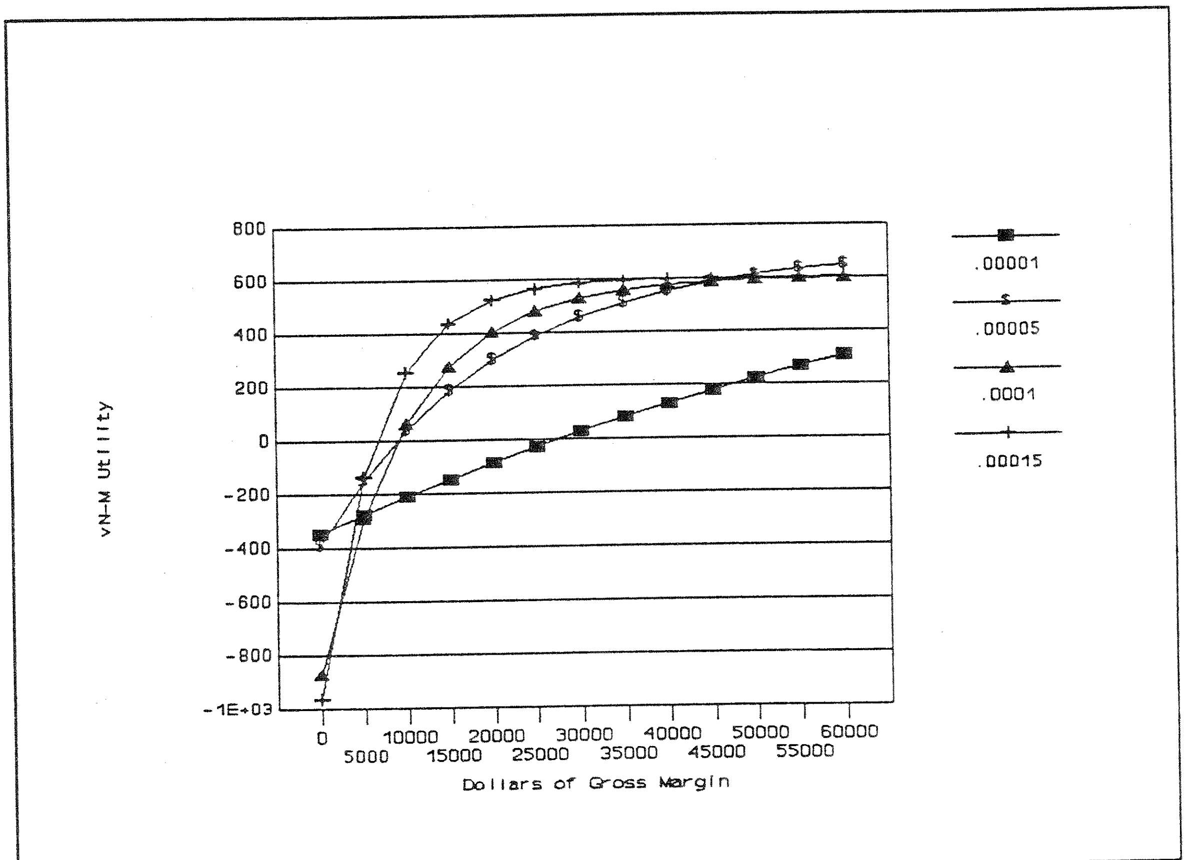

Figure 6. Four Negative Exponential Utility Functions

PRICING PORTFOLIOS FOR A SERIES OF PRODUCERS

The process used for the individual producer above can be repeated for 16 producers with CARA utility functions and varying degrees of risk aversion (the beta parameter of the utility function). In performing this analysis, smaller convergence parameters were used to reduce the solution set to 15 nearly identical pricing portfolios for each producer. In individual situations, such tight convergence is not recommended, since it reduces the solution information to the producer. Figure 6 shows 4 of the 16 utility functions that were used in constructing figure 7.

Figure 7 shows that producers who are more risk neutral will use little or no forward pricing in order to capture the more favorable expected cash price. As risk aversion increases forward contracting increases. With enough risk aversion, more grain should be priced, but over-committing in forward contracts is avoided by using the futures market.

Option hedging and basis contracting did not enter into solution. Basis risk was expected to be small (S.D. = 9 cents), so the unbiased basis contract offered little risk reduction. "At-the-money" put options were analyzed, and failed to enter into solution. One possible reason is that the price insurance that options provide may be less desireable for CARA utility functions, than some other functions (e.g. safety first type behavior).

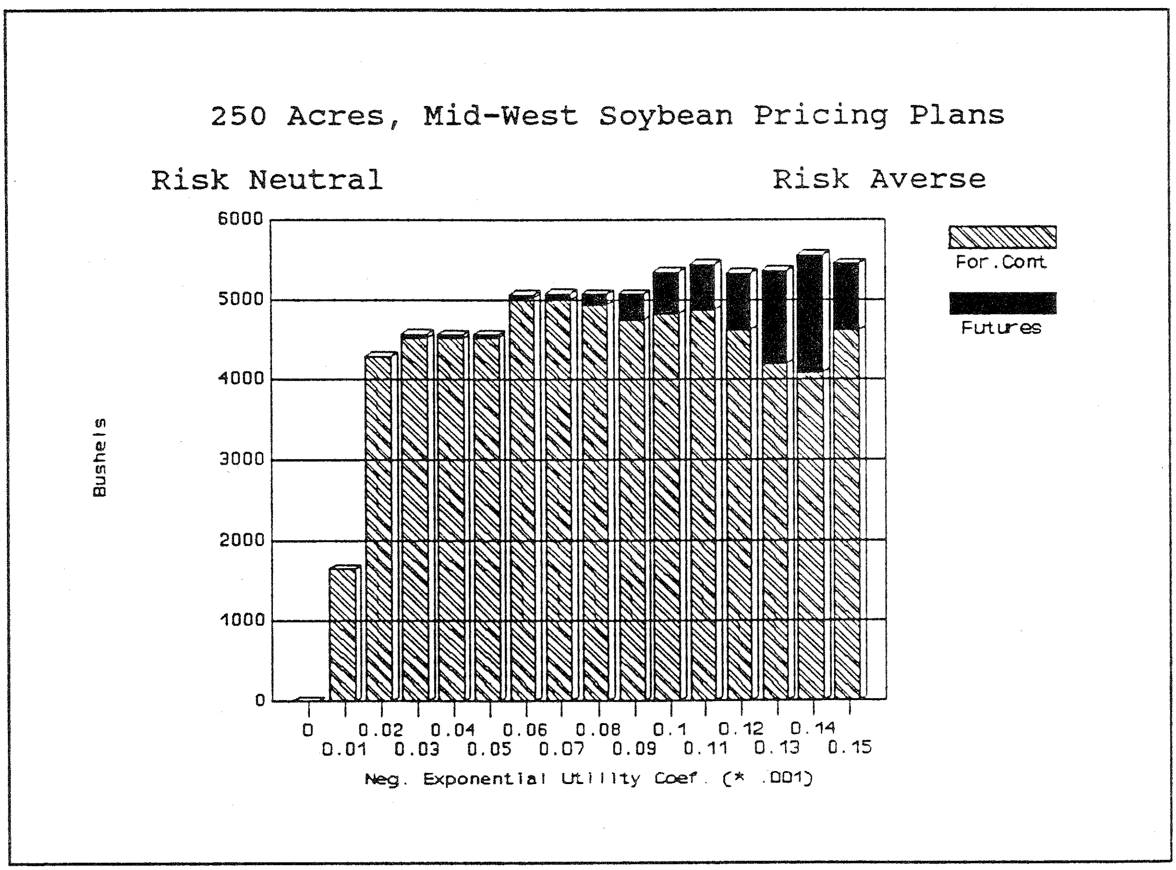

Figure 7. Optimal Marketing Portfolios Across Risk

CONCLUDING COMMENTS

FIRM is an adaptive management model that optomizes over the current and ending time periods. It can be run several times by the producer throughout the year. Karp, Lambert and McCarl, and Berg have looked at the dynamic stochastic problem of preharvest hedging. Based on their findings, there is a need for additional work in this area in order to examine the dynamic aspects of the problem. The individual producer solution shown in figure 5 demonstrates that optimal solutions are in a relatively flat neighborhood for some producers. In a dynamic stochastic framework, the solution space includes numerous intertemporal states and alternatives. This expansion of the problem will both increase computational demands and likely magnify the problem of the relatively flat optimal area.

The FIRM prototype currently examines only one crop, and relies on subjective risk elicitation to position that crop within the whole farm risk framework. This simplifies data entry (or database space) by eliminating income correlations between enterprises, and allows the producer to take different risk attitudes on different crops. It is possible to modify FIRM to include government commodity programs, multiple crops, other farm enterprise information, and perhaps crop insurance. Each additional feature will increase input and output complexity as well as computational time. Increased output complexity may make it more difficult for the decision-maker to interpret the solutions. Regardless, if they can improve information and decision making, increasingly complex models can and should be developed.

FIRM is a new concept in applied risk management through commodity marketing, that is based upon well accepted theory. FIRM will require substantial testing before it can be released to producers; however, the authors believe the approach presented will provide a new tool for producers that can increase the quality and quantity of market-related risk information they need and want. With the incorporation of electronic market data capture and the DSS structure, this added information will require small additional costs in management. Firm will also be a valuable tool for teaching risk management and commodity marketing to upper division undergraduate students and producers.

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