FINANCIAL PERFORMANCE AND 'NEW' RISK MANAGEMENT: AN APPLICATION TO PENNSYLVANIA DAIRY FARMS

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Introduction

Government support of agriculture has been a tradition since the Great Depression era. Many rationales for government support of agriculture exist, ranging from augmentation of farm income to stabilizing food prices to ensuring a supply of food in the United States (Knutson *et al.*). Over the subsequent sixty years, the cost of administering agricultural support programs had risen dramatically. This burgeoning expense, coupled with a political climate that sought to balance the federal budget, led to calls for reform of U.S. agricultural policy in 1995 (Orden *et al.*). One large step in the reform process was the enaction of the Federal Agricultural Improvement and Reform (FAIR) Act of 1996.

Dairy farmers are a good example of a group that FAIR impacts in unique ways. In addition to changes in crop markets, FAIR will eliminate dairy price supports after 1999 (Ling and Liebrand). In conjunction with the removal of price supports, the Federal government has eased out of the dairy market by reducing purchases of excess dairy products. As the dairy industry shifts toward a more market oriented pricing structure, more input and output price risk is being be transferred back to dairy producers.

The nature of dairy production provides a unique risk exposure for dairy farmers. Like other livestock producers, dairy farmers are exposed to substantial input and output risk. While most dairy farmers grow their own feed, supplementary market feed purchases are often necessary. On the output side, milk price and production provide substantial risk exposure. Unlike crops, which are typically harvested once per year, milk is produced almost continuously. This flow production schedule complicates risk management because the producer cannot plan for a single harvest, but must plan for a more continual harvest.

A natural result of the increase in risk faced by dairy producers is an increase in demand for risk management products. While traditional strategies for hedging input costs such as crop futures and options have existed for many years, new insurance products have emerged over the past few years and their risk management merits have yet to be analyzed. The most significant of these products available to Pennsylvania producers are multiple peril crop insurance (MPCI), income protection (IP), and group risk plan protection (GRP). Risk management alternatives on the output side are still fairly sparse. The most commonly used strategies include forward contracting, as well as, milk basic formula price (BFP) futures and options.

Research relating directly to the issue of risk management at the farm level has been reported by Bosch and Johnson who examined risk management strategies relating to input costs for dairy producers. The strategies examined in Bosch and Johnson's study are a MPCI-like insurance product and futures contracts. Monte Carlo simulation is used to generate correlated vectors of prices and yields from which farm income is determined under each risk management alternative under consideration.

Another study by Nydene *et al.*, investigates risk management for a diversified hog enterprise considering risk management strategies for both input and output sides of the business. Like Bosch and Johnson, a simulation approach is used. However, the authors utilize a larger group of risk management strategies, including insurance, futures, and options.

Missing in these studies is, however, an in depth analysis of the firm level financial impacts of the specific risk management strategies implemented with regard to profitability, solvency, liquidity, efficiency, and risk reduction. Thus, one of the objectives of this research is to examine the financial impacts of various risk management strategies on each of these broadly defined areas of farm financial performance. In addition, as noted above, some of the risk management products are new and an infinite number of combination strategies are possible. Consequently, a second objective is to examine some risk management products and approaches that have not been examined previously.

Simulation Model and Data

The model developed for this analysis revolves around the simulation of a set of coordinated financial statements. These statements, which include a balance sheet, income statement, and cash flow statement, follow the guidelines set forth by the Farm Financial Standards Task Force. The balance sheet and income statement are calculated on an annual basis, while the cash flow statement tracks revenues and expenses on a monthly basis over a twelve-year planning horizon. Values from the balance sheet and income statement are used to calculate annual measures of financial performance.

Price and yield uncertainty is the major source of risk faced by most farmers, including dairy. Thus, price and yield for significant inputs and outputs are stochastic in the model. There are two stochastic variables on the input side, namely, feed grain yields and forage yields. One fall harvest of feed grain is assumed, while two summer harvests of forage crops are assumed.

Prices for each of these crops are also stochastic in each month because market purchases are possible in any given month. That is, in the event of shortfalls in production during previous time periods, market purchases are necessary at prevailing prices. Yields are only drawn in the months when harvesting is possible. The dairy farm's major source of revenue is obviously milk production. Milk is a flow product that is harvested on a daily basis. However, for the purposes of the model, random milk price and yield are drawn on a monthly basis.

The final stochastic variable is interest rates, which are drawn. Stochastic interest rates are necessary because borrowing at the prevailing rate is required in the event of (monthly) cash shortfalls. Also, existing term debt is assumed to be from variable rate loans with reset occurring on an annual basis at the prevailing rate. All stochastic variables in the model are assumed to be normally distributed.

Numerous modules perform specialized calculations in the model. The loan amortization module takes the initial balance outstanding for land, building, and machinery loans and amortizes them on a monthly basis over the planning horizon (assumed to be twelve years). Interest and principal payments are kept separate due to the tax-deductibility of interest payment. Each loan utilizes a different interest rate, which is a fixed amount above the treasury security yields adjusted to a constant maturity. The loans are re-amortized each January, based on the random interest rate drawn. Another specialized module calculates the farm's tax liability. Tax calculations follow the 1999 Internal Revenue Service Form 1040, Schedules F and SE.

Determination of financial performance includes the calculation of measures of profitability, solvency, liquidity, and efficiency. Profitability measures calculated include net farm income from operations, return on assets, return on equity, and the operating profit margin ratio. Solvency measures calculated are the debt-to-equity ratio (leverage ratio) and the debt-to-asset ratio. Working capital and the current ratio comprise the liquidity measures, while the asset turnover ratio is used to measure the efficiency of the farm.

Data used in the model are primarily obtained from two sources. The 1997 Pennsylvania Agricultural Statistics Service Annual Report provides estimates of the mean prices and yields experienced by Pennsylvania dairy farmers. The 1997 Pennsylvania Dairy Farm Business Analysis provides revenue and expense data, as well as basic production and financial information including farm size, acreage, and initial amount of debt and assets. Production data, such as the amount of feed or forage consumed per cow per month was obtained from a spreadsheet model created by Gary Frank. Interest rate data was taken from the Federal Reserve's Statistical Release H.15.

Risk Management Strategies

Risk management costs and return calculations are central to the model. The first alternative is the naïve or base scenario with no risk management. Input side risk management strategies include three types of insurance (MPCI, IP, GRP), as well as, hedging with futures and options for corn (feed grain). It is assumed that insurance is purchased in March and if an indemnity is to be paid, it is paid in November. Each type of insurance has a unique payoff structure. MPCI protects against unfavorable yields, thus actual production per acre is compared to the level of guaranteed production specified by the insurance policy. If actual production is less than the guaranteed level, an indemnity is triggered. IP, on the other hand, protects against unfavorable prices and yields simultaneously. An IP indemnity is triggered by low total revenue (below a threshold level specified by the insurance). While MPCI and IP are used to insure feed grain harvests (or the revenue associated with such a harvest), GRP is used to insure adequate hay (forage crop) yield. GRP compares a producer's actual yield to a percentage of the producer's expected county yield to determine whether an indemnity is necessary.

Input costs can also be hedged through long positions in corn futures contacts. Hedges are set in February with payout recognized in November. Because a long position is used, payoffs are determined by the difference between the November price and the February price. One or two contracts can be used, depending on the hedge ratio required. Round-trip trading costs are assumed to the $30.00 per contract. Call options on corn futures are another input cost risk management strategy available. To calculate the option premium, Black's option on futures formula is used. Trading commission of $30.00 per contract is added to the premium estimate to arrive at the total cost of the option when the hedge is set. Option payoffs are determined in the conventional way (i.e. by the positive difference between the December futures price and the strike price). The strike price used on the BFP options was $13.00 per hundredweight of milk.

Dairy BFP futures and options can be used to hedge milk price risk; a form of output price hedging. Two sizes of BFP futures contracts are used, namely, 50,000 and 100,000 pound contracts. The smaller of the two contracts represents 42% of an average month's production for the farm used in this analysis. Correspondingly, the larger contract represents 84% of the average month's production. Unlike input hedges, which are set once per year, output hedges are reset each month because of the flow nature of milk production. Short positions in BFP futures contracts are used, thus the payoff is the difference between the price when the hedge is set and the price when the hedge is lifted. Put options on BFP futures can also be used to manage price risk. Black's option on futures formula is also used to find the call premium, and then put-call parity is used to determine the put option premium. Round-trip trading commissions of $30.00 per contract is added to the premium to find the option's total cost. Option payoffs are the positive difference between the strike price and the market price at expiry.

Results and Discussion

Two thousand five hundred iterations of the simulation model were conducted under each risk management strategy including the base scenario. Over a twelve-year planning horizon, monthly cash inflows and outflows were simulated. Annual balance sheet and income statements were then constructed from the information appearing at the end of each year's cash flow statement after making the appropriate adjustments. Given the quantity of information determined, it is impossible to present an exhaustive set of model results. For example, financial performance can be examined across strategies for a given point in time, or over time for a given strategy. Most of the analysis presented here relies on the former method of presentation because this paper's purpose is to compare and contrast financial performance among the various risk management strategies.

Representative profitability results for year 3 are presented in Table 1. The results suggest that each risk management strategy tends to lower profitability by approximately the cost to implement the strategy. This cost varies, but is generally great enough to outweigh the income the strategy generates. The end result is a decrease in profitability to obtain assurance against extremely adverse movements in price, yield, or both.

The most profitable strategy seems to be GRP, which increases the mean net farm income from operations by about $3,500 over the base scenario. This result agrees with conventional wisdom – that GRP provides a good level of protection at an attractive price. This is especially true for a producer who routinely produces less than the county yield. BFP futures and options seem to be the least profitable strategies. It appears that these strategies are penalized for the frequency of hedge resets - there are eleven more transactions involved than when hedging input costs. These eleven extra trades result in transactions costs of $330. Because option premia tend to be fairly expensive, monthly BFP option resets result in greatly decreased profitability and high variability.

In general, liquidity is fairly stable across strategies (see Table 2). This is partly a result of excellent liquidity provided by the initial conditions. Under all strategies, the farm's liquidity is quite good – the working capital is always greater than $200,000 and the current ratio is at least 20. This indicates that risk management is not eroding liquidity significantly over time. However, it is apparent that BFP options do decrease the mean level of liquidity somewhat. This is due to the relatively large monthly cash outflows that are required when purchasing these options. Cash expenses such as this decrease current assets, which lowers working capital and the farm's current ratio. It should be noted that the relatively strong initial liquidity position is purely a function of the data for Pennsylvania farms. Relaxing the strength of the initial liquidity position may provide better information regarding the impact of each risk management strategy on this aspect of financial performance.

Solvency and efficiency, like liquidity, are fairly consistent (and constant) across strategies. The solvency measures are in the acceptable range for all of the strategies. Again, BFP options do the worst in terms of solvency. Over time, mean solvency increases but the variability also increases. Again, this result is most likely strongly tied to the initial position of the farm business with regard to solvency and liquidity. Additionally, no expansion takes place over 12 year planning horizon so on average the firm sees a steady decline in term debt. Given the strong initial liquidity position, the farm also makes use of very little short term borrowing to meet cash flow pressure.

Two caveats when using mean-variance criteria to evaluate risk management strategies are in order. First, many of the strategies have non-linear payoffs and second, the empirical distributions of income can cross. Visual examination of the net farm income distributions in Figure 1 indicates it is extremely difficult to choose one strategy as the best. Further, over time the skewness of many distributions increases as mass is added to the right side of the distribution. The addition of mass to the right side of the distribution occurs because risk management results in more realizations in that section of the distribution. Alternatively stated, most of the risk management strategies truncate the left tail of the distribution. These realizations accumulate over time, resulting in a more negatively skewed distribution in later time periods (see Figures 1 and 2).

This tendency toward more negative skewness over time makes it difficult to use standard measures of variance to assess the risk reducing abilities of risk management alternatives. This difficulty is demonstrated when examining the variability of profitability. Risk management appears to increase the variability of profitability at least as measured by variance. However, the more likely scenario is that the type of variabiity is being misrepresented. Traditional measures of variance treat upside and downside variability equally. Thus, when a risk management strategy results in a large positive payoff, it is increasing the variability of farm profitability. What is needed is an alternative measure of variance, such as semi-variance, that does not penalize for upside variability.

Stochastic dominance might offer a means of further investigating the empirical distributions of net income. However, as noted by Gloy and Baker, stochastic dominance can have problems in the present setting because of the difference of means and lower tail crossing problems. The difference of means problem stems from the requirement that the dominating solution have a higher mean that the dominated solution. This problem is especially acute when evaluating risk management strategies, because the means under risk management tend to be lower than without risk management. Use of standard stochastic dominance techniques would result in dominance of the base scenario. Gloy and Baker present a stochastic dominance framework that utilizes a risk-free asset to avoid many of these pitfalls.

Conclusions and Implications for Future Research

A simulation model was created for a representative Pennsylvania dairy farm. Various risk management strategies were imposed and the ramification of the strategies upon financial performance calculated. It was found that risk management tends to marginally lower some measures of financial performance for dairy farms (e.g. profitability). This was especially true for production hedging, largely due to the more frequent resetting (monthly) resetting of hedges. Other simulated financial performance measures indicate liquidity, solvency, and efficiency are not greatly impacted by the selection of risk management strategy. This result, however, is more tied to the data used in the analysis and should not be extrapolated to all farming operations in general.

The results presented here need to be refined and extended in several ways to offer more insight into risk management for dairy producers. First, use of an alternative measure of variance needs to be explored. Semi-variance is the most likely measure to be used. Such a statistic will improve on variance by including only downside risk, which is the type of risk most producers are concerned with. Upside variability is less of a concern because it does not threaten the financial viability of the farm.

Additionally, the sensitivity to starting conditions needs to be addressed by weakening the farm's liquidity and solvency positions. Farms experiencing liquidity and/or solvency pressure would likely see the most benefit from risk management. Also, the distributional assumptions could be improved upon by at least making the vector of random variables correlated.

Another extension of this research is to make use of stochastic dominance with a risk-free asset to rank the risk management alternatives. This analysis technique should eliminate many of the problems encountered when applying stochastic dominance techniques to risk management problems. Analyzing the distributions in this fashion should allow for an ordinal ranking of which risk management strategies are best under various levels of risk aversion. Rankings of this type would provide much more lucid representation of results when compared to the current entanglement of probability density functions illustrated in Figures 1 and 2.

Table 1. Year 3 Profitability Summary Statistics

Strategy		NFIO	ROFA	ROFE	COFD	OPMR
Base - No Risk Management	Mean	$33,475.89	3.64%	1.78%	8.72%	0.11
	Std Deviation	$11,155.51	1.58%	2.36%	2.53%	0.04
1 Corn Futures	Mean	$33,392.30	3.63%	1.76%	8.72%	0.10
	Std Deviation	$11,388.10	1.63%	2.41%	2.55%	0.04
2 Corn Futures	Mean	$31,750.83	3.39%	1.42%	8.71%	0.10
	Std Deviation	$12,792.17	1.86%	2.73%	2.56%	0.05
500 cwt BFP futures	Mean	$32,973.83	3.57%	1.68%	8.72%	0.10
	Std Deviation	$11,221.69	1.58%	2.38%	2.51%	0.04
1000 cwt BFP Futures	Mean	$32,869.33	3.56%	1.66%	8.72%	0.10
	Std Deviation	$11,571.65	1.68%	2.46%	2.53%	0.05
1 Corn Option	Mean	$31,575.08	3.37%	1.39%	8.71%	0.10
	Std Deviation	$11,253.17	1.60%	2.40%	2.57%	0.04
2 Corn Options	Mean	$32,689.49	3.53%	1.62%	8.71%	0.10
	Std Deviation	$11495.95	2.00%	2.00%	3.00%	0.04
500 cwt BFP Option	Mean	$26,994.19	2.70%	0.41%	8.68%	0.08
	Std Deviation	$11,490.29	1.67%	2.51%	2.57%	0.05
1000 cwt BFP Option	Mean	$22,282.71	2.02%	-0.64%	8.61%	0.06
	Std Deviation	$12,195.88	1.80%	2.72%	2.48%	0.05
GRP	Mean	$37,033.30	4.15%	2.51%	8.72%	0.12
	Std Deviation	$10,529.85	1.49%	2.19%	2.53%	0.04
IP	Mean	$31,954.48	3.42%	1.46%	8.71%	0.10
	Std Deviation	$11,188.45	1.59%	2.39%	2.54%	0.04
MPCI	Mean	$31,608.14	3.37%	1.39%	8.71%	0.10
	Std Deviation	$11,379.68	1.62%	2.43%	2.56%	0.04
1 Corn Futures, 500 cwt BFP Futures	Mean	$32,903.57	3.56%	1.66%	8.72%	0.10
	Std Deviation	$11,280.42	1.61%	2.40%	2.58%	0.04
2 Corn Futures, 1000 cwt BFP Futures	Mean	$31,162.38	3.31%	1.30%	8.70%	0.09
	Std Deviation	$13,227.01	1.95%	2.84%	2.53%	0.05
GRP, 1000 cwt BFP option	Mean	$25,572.60	2.51%	0.09%	8.65%	0.07
	Std Deviation	$12,011.35	1.74%	2.63%	2.55%	0.05

Table 2. Year 3 Liquidity and Solvency Summary Statistics

Strategy		Liquidity Measures		Solvency Measures	
		Working Capital	Current Ratio	Debt to Asset Ratio	Debt to Equity Ratio
Base	Mean	$223,434.60	31.54	0.266	0.362
	Std Deviation	$11,871.03	11.51	0.007	0.014
1 Corn Futures	Mean	$223,232.80	31.68	0.266	0.362
	Std Deviation	$12,485.37	11.89	0.008	0.014
2 Corn Futures	Mean	$219,807.50	31.42	0.268	0.367
	Std Deviation	$14,381.02	14.40	0.010	0.019
500 cwt BFP futures	Mean	$221,952.20	31.61	0.266	0.363
	Std Deviation	$12,098.65	11.54	0.008	0.014
1000 cwt BFP Futures	Mean	$221,106.30	31.32	0.267	0.364
	Std Deviation	$12,790.98	12.25	0.008	0.016
1 Corn Option	Mean	$219,691.30	30.97	0.268	0.367
	Std Deviation	$12,480.06	12.52	0.009	0.018
2 Corn Options	Mean	$221,875.90	30.97	0.267	0.365
	Std Deviation	$12,669.88	12.56	0.009	0.017
500 cwt BFP Option	Mean	$211,124.20	27.90	0.274	0.378
	Std Deviation	$13,311.33	14.16	0.013	0.025
1000 cwt BFP Option	Mean	$201,802.10	21.10	0.284	0.397
	Std Deviation	$14,900.47	14.82	0.017	0.035
GRP	Mean	$230,432.30	29.73	0.263	0.357
	Std Deviation	$11,237.80	10.04	0.007	0.013
IP	Mean	$220,455.70	31.28	0.267	0.365
	Std Deviation	$12,159.77	12.18	0.009	0.016
MPCI	Mean	$219,775.70	31.42	0.268	0.366
	Std Deviation	$12,136.66	12.17	0.009	0.016
1 Corn Futures, 500 cwt BFP Futures	Mean	$221,725.90	31.71	0.267	0.364
	Std Deviation	$12,524.15	11.93	0.008	0.015
2 Corn Futures, 1000 cwt BFP Futures	Mean	$217,472.10	31.09	0.270	0.369
	Std Deviation	$14,680.55	15.16	0.011	0.021
GRP, 1000 cwt BFP option	Mean	$208,868.90	22.85	0.279	0.388
	Std Deviation	$14,023.87	14.18	0.016	0.032

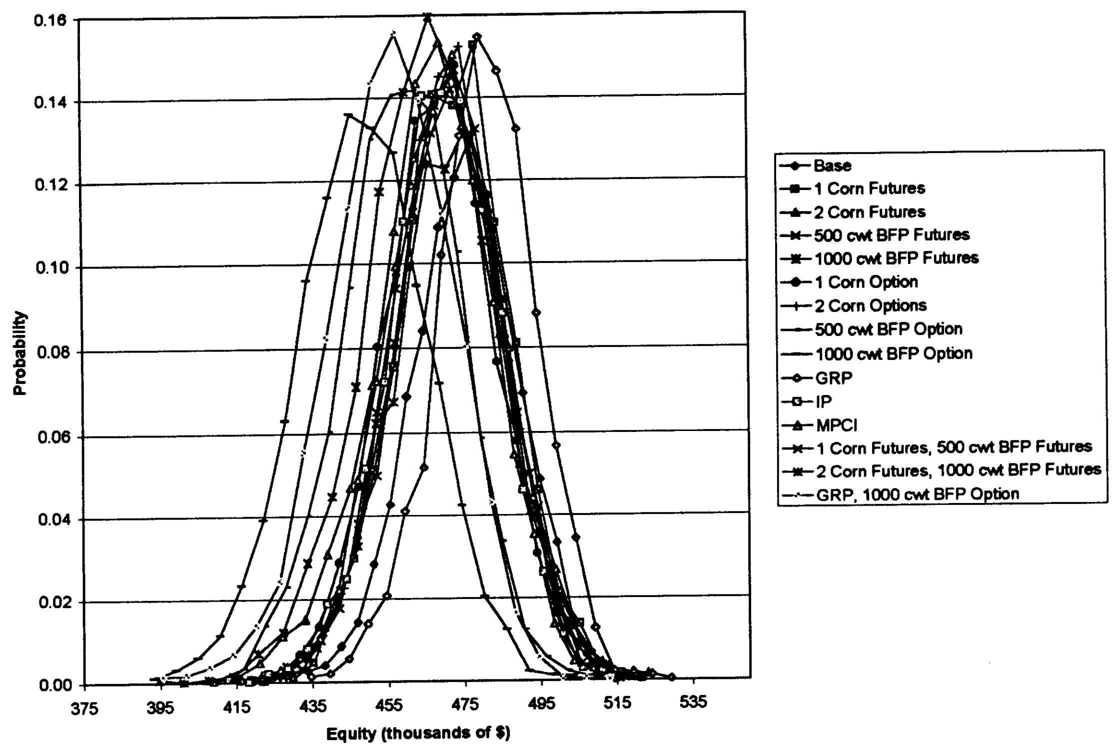

Figure 1. Year 3 Ending Equity Probability Density Function

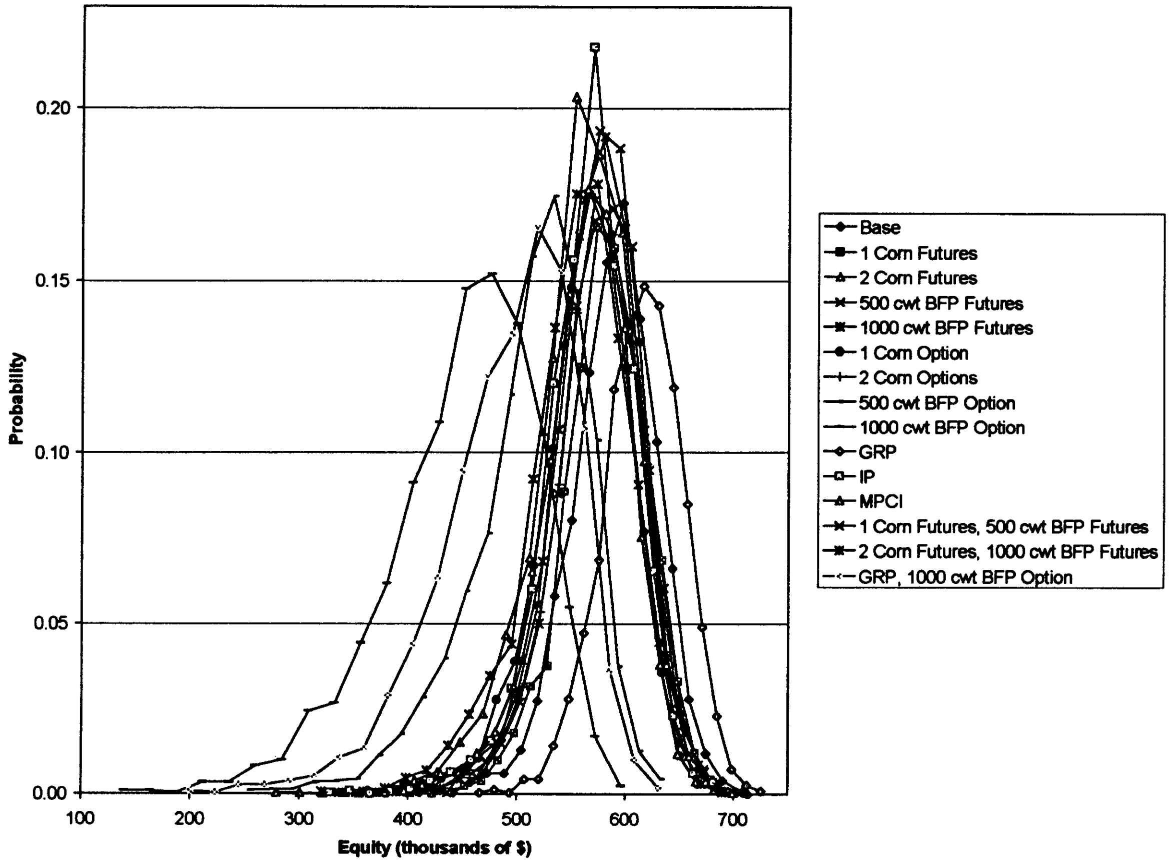

Figure 2. Year 12 Ending Equity Probability Density Function

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