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PRICE RISK MANAGEMENT: ARE FUTURES MARKETS ADEQUATE?*

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Do futures markets provide agricultural producers with an adequate method of managing price risk? The answer depends on how one defines the term price risk.

My interpretation of what most writers mean by the term "price risk" is simply that product prices vary randomly over time. Therefore, prices at some future point in time cannot be known with certainty. These writers equate price risk with uncertainty about future prices. If one equates price risk with price uncertainty, then the answer to the above question is -- no, the futures markets are not adequate. Because futures markets do not, and cannot be expected to, remove all variation in market prices.

However, the problem here is not with the inadequacy of futures markets. Rather the problem is with the definition of price risk. The root of the problem is the failure to distinguish between price risk and price uncertainty. Unfortunately, this is a widespread problem with much of the literature on risk and uncertainty. Because of the failure to distinguish between risk and uncertainty, economists have coined some inappropriate terms like "risky markets." There were at least two invited papers at the AAEA meetings this past summer dealing with something called risky markets (Buccola, and Antonovitz and Roe). I submit there is no such thing as a risky market. There are risky decisions that involve operating in markets with uncertain prices. But,

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there are no such things as risky markets. I will return to this point later.

Perhaps this sounds like nit-picking about unimportant definitions. However, the failure to distinguish between risk and uncertainty is a serious shortcoming with much of the literature on risk that often leads to development of inappropriate analysis and conclusions about risk and how decision makers can effectively deal with risk.

There is an important distinction between risk and uncertainty. It is imperative that we understand this difference and keep it in mind as we examine decision problems and develop methods for helping decision makers cope with uncertainty.

Let's begin with a definition of uncertainty.

Uncertainty exists because (1) the decision maker does not have complete control of the process that determines the outcome of a particular action, (2) there is more than one possible outcome associated with an action, and (3) each of those possible outcomes has some non-zero probability of occurring. Uncertainty exists because the decision maker is unable to determine with certainty the outcome that will be realized from the action being initiated by the decision maker.[1]

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[1]Uncertainty is not removed by providing the decision maker with knowledge about the probability distribution of possible outcomes. Even with this knowledge, the outcome of a particular action cannot be predicted with certainty. Knowledge of the probability distribution enables the decision maker to calculate the "expected value of the outcome" for each action. But, it does not remove uncertainty.

What about a definition of risk? Risk of what? Is the decision maker concerned about the risk of losing more than $50, the risk of losing more than $1,000, the risk of earning less than a 10 percent rate of return on his investment over a 10 year period, or the risk of bankruptcy? The existence of uncertainty about the realized outcome of his project may expose the decision maker to all of these kinds of risk -- and perhaps other kinds of risk as well.

The decision maker exposes himself to risk by selecting a course of action that has uncertain outcomes. But for risk to exist there must be a subset of possible outcomes that is classified by the decision maker as undesirable. Risk is the probability that the outcome of the selected action will fall in the subset of possible outcomes defined as undesirable by the decision maker.[2] Thus, the term price risk has meaning only after the decision maker has defined the subset of undesirable outcomes in terms of some critical value (for example all profit levels $\leq$ some value k). The critical value will depend on the types of risk being considered and may vary between decision makers for the same type of risk, even though they are exposed to the same set of uncertainties.

For example, consider two hog producers who have identical management skills, identical price forecasting skills, and identical costs of

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[2] If all possible outcomes are classified as undesirable, then there is no risk. We are certain that an undesirable outcome will occur. However, there is uncertainty about exactly which undesirable outcome will occur. Similarly, there is no risk if all possible outcomes are classified as desirable. In this case, we are certain that a desirable outcome will occur. But, we are uncertain about which outcome will actually be observed.

production. Each hog producer has just purchased 100 feeder pigs of identical size and quality and has prepaid all expenses required to produce 230 pound slaughter hogs 90 days from now. Based on their predictions of slaughter hog prices at the end of the feeding period, the feeders expect to make a $15 per head profit on this feeding project. However, the hogs are not under forward contract. Thus, the producers are uncertain about the price (and hence profit) they will actually receive at the end of the feeding period. The uncertainty about realized profits for this project is illustrated in Figure 1.

The distribution of possible outcomes (realized profit per head) about the predicted profit is represented by g(x) in Figure 1.[3] There clearly is price uncertainty involved in these hog feeding projects since the actual price of slaughter hogs at the end of the feeding period is unknown.[4] The mean and variance of g(x) describe the nature of that uncertainty. However, contrary to much of the literature on risk analysis, the mean and variance do not describe the various types of price risk faced by the two hog producers.

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[3] g(x) is unique to each price forecaster. (Recall we have assumed that the two producers have identical price forecasting abilities.) g(x) reflects the price forecasting ability of the decision maker. In this example g(x) has a central tendency at $\hat{x}$ reflecting that the decision maker has an unbiased forecasting system and realized prices tend to be clustered around his forecasted price. It is possible that $\hat{x}$ could be in one of the tails of g(x) indicating that the producer is always overly optimistic or overly pessimistic about future prices. As we will see, futures markets will be of little help in managing risk for producers who are consistently unrealistically optimistic about futures prices.

[4] We are, of course, ignoring all possible impacts on profit of feedlot performance of the hogs (production risk) in order to focus on price uncertainty and price risk.

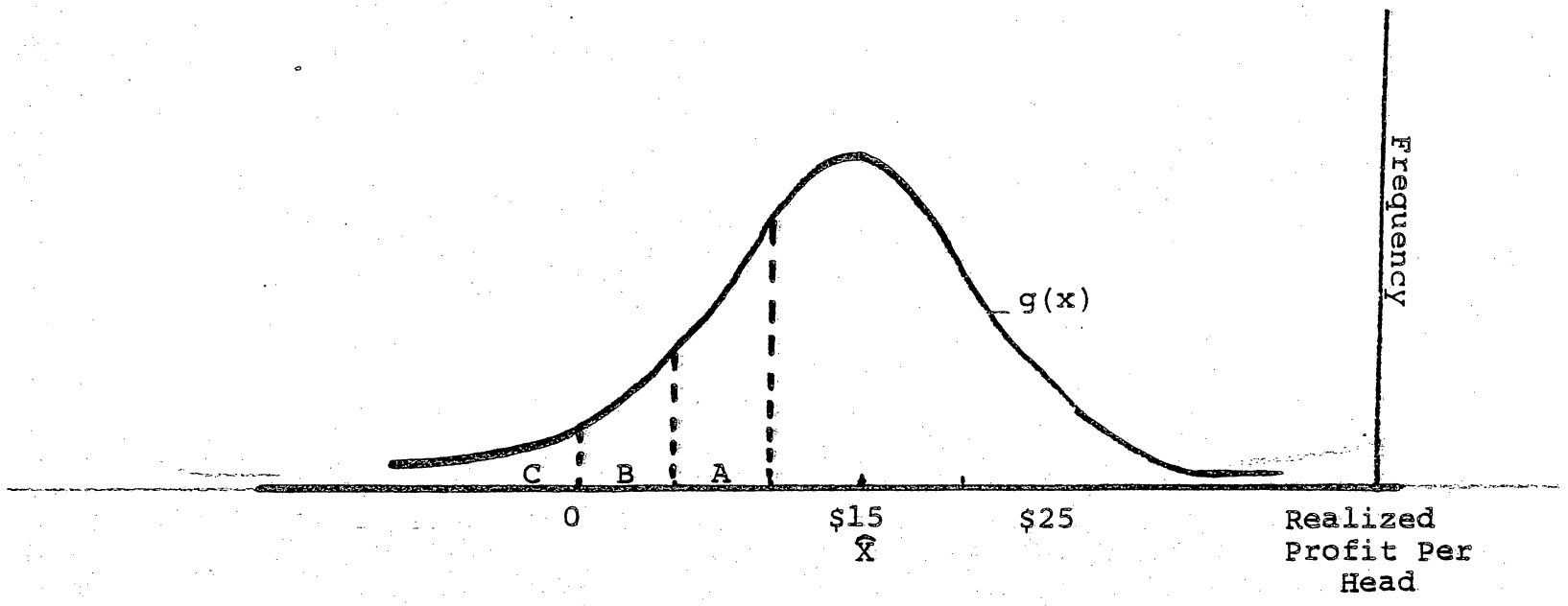

Figure 1. Distribution of Realized Profit Per Head About the Predicted Profit of X = $15.

Suppose the producers are concerned about the risk of loss (i.e., the risk that realized profit will be ≤ zero). Price risk of loss is then defined as the probability that realized profit will be ≤ zero because realized price of slaughter hogs at the end of the feeding period turns out to be more than $6.52/cwt below what our producers predicted when they placed the hogs in the feedlot. Price risk of loss is then the area C in Figure 1. Price risk exists because the variance of g(x) is not zero. Price risk is the probability that realized prices and, hence, profits will fall within some specified unfavorable range. Also, note that the critical values defining the undesirable set of outcomes are identical for both our producers, if we are considering price risk of loss (i.e., all profits ≤ 0).

Risk of loss is not the only risk to which our feeders have exposed themselves by taking on this hog feeding project. They both borrowed 90 percent of the funds necessary to finance the feeding project. Because of different financial conditions and family income situations, producer Smith will incur debt repayment problems if his realized profit falls below $10 per head. However, producer Brown will incur debt repayment problems only if realized profits are below $5 per head. Thus, price risk of repayment problems is area (A + B + C) for producer Smith but only (B + C) for producer Brown even though they are exposed to the same amount of price uncertainty (Figure 1).

This simple example clearly demonstrates that we must answer the question "price risk of what?" before we are in a position to compare the riskiness of alternative decisions although all of the decisions may involve the same degree of price uncertainty.

This example also provides an illustration of why there are risky decisions, but there are no such things as "risky markets." The decision maker exposes himself to risk because he is unable to predict the outcome of his action with certainty. Decisions are risky. Realized market prices are uncertain.

Variability in observed market prices that is not the source of uncertainty in decision making. Rather, the source of uncertainty is the decision maker's inability to predict changes in prices. Suppose, for example, that observed market prices are quite variable from one time period to the next. If our decision maker has at his disposal a price forecasting system that predicts those variable prices with perfect accuracy, there would be no price uncertainty for him (and hence no price risk), although there is considerable variability in market prices. However, for another producer selling products in the same market, there will be substantial price risk associated with his decisions because only 50 percent of his price forecasts turn out to be within ± one dollar of the observed market price. The magnitude of price risk is determined by the accuracy with which the decision maker can predict prices -- not by the variation in observed market prices over time. Consequently, computation of the mean and variance of historical price series generated by the market in which the producers are selling their produce provides no information about either the nature, or the magnitude, of price risk associated with their decisions. However, in a large part of the literature on price risk one finds that the mean and variance of a time series of observed market prices used as the indicator of price risk. Moreover, the analyses assume that all

decision makers in that market are exposed to the same amount of price uncertainty and price risk.

Note that the distribution of realized profit in Figure 1 [i.e., g(x)] is defined as the distribution of realized profits about profit levels predicted at the time the project is initiated. Keep in mind that the decision maker's action is based on his best estimate of what the price will be at the end of the feeding period. Thus, a decision maker with a very accurate price forecasting system will have a distribution of realized profit with a small variance about expectations. One the other hand, a decision maker with a less accurate forecasting system will have a much larger variance of realized outcomes relative to his expectations. Therefore, price risks increase as the decision maker's ability to forecast prices decreases, ceteris paribus.[5]

Let's now return to our original question. Are futures markets adequate for management of price risk? The answer is yes, provided that the following are true:

1) There is a futures contract in existence that producer can use to establish a hedge,
2) The variance of the expected basis for the producer on day of settlement is less than the variance of the unhedged returns, and,

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[5]Recall that in using g(x) in Figure 1 to describe the distribution of possible outcomes for both producer Brown and producer Smith we assumed they had identical price forecasting abilities. I hope the reason for that assumption is now clear.

3) Producers are not so uninformed or naive as to have completely ignored the information about possible prices at the end of the feeding period provided by the futures market at the time the hogs were placed on feed.

This last condition simply states that the price of the futures contract the producers are to use in establishing the hedge is reasonably close to the predicted price the hog producers used in calculating the expected profit from the project.[6] If the producer has made an "unreasonable" price prediction, we could not logically expect g(x) to have a central tendency about $15 per head as illustrated in Figure 1. We would expect most well informed hog producers to use predicted prices in making production decisions that are fairly close to those observed for the relevant futures contract. That is, we would not expect the predicted profit level ($\hat{x}$) to be located in one of the tails of g(x). If there is a high price risk of loss from the feeding project because the feeder was uninformed about the most probable range of future prices based on current information, we should not expect the futures market to provide a mechanism for managing this type of risk. For example, we cannot expect futures markets to provide an opportunity to manage the various types of price risk for a hog feeding project that requires $65 slaughter hog prices to break even, when all information available indicates that prices will most likely be in the 45-50 dollar range.

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[6] Numerous studies (including Just and Rausser) have shown that even though futures markets do not provide perfect predictions of prices at distant points in time, futures prices are no less accurate price forecasts than econometric models or other types of price forecasts.

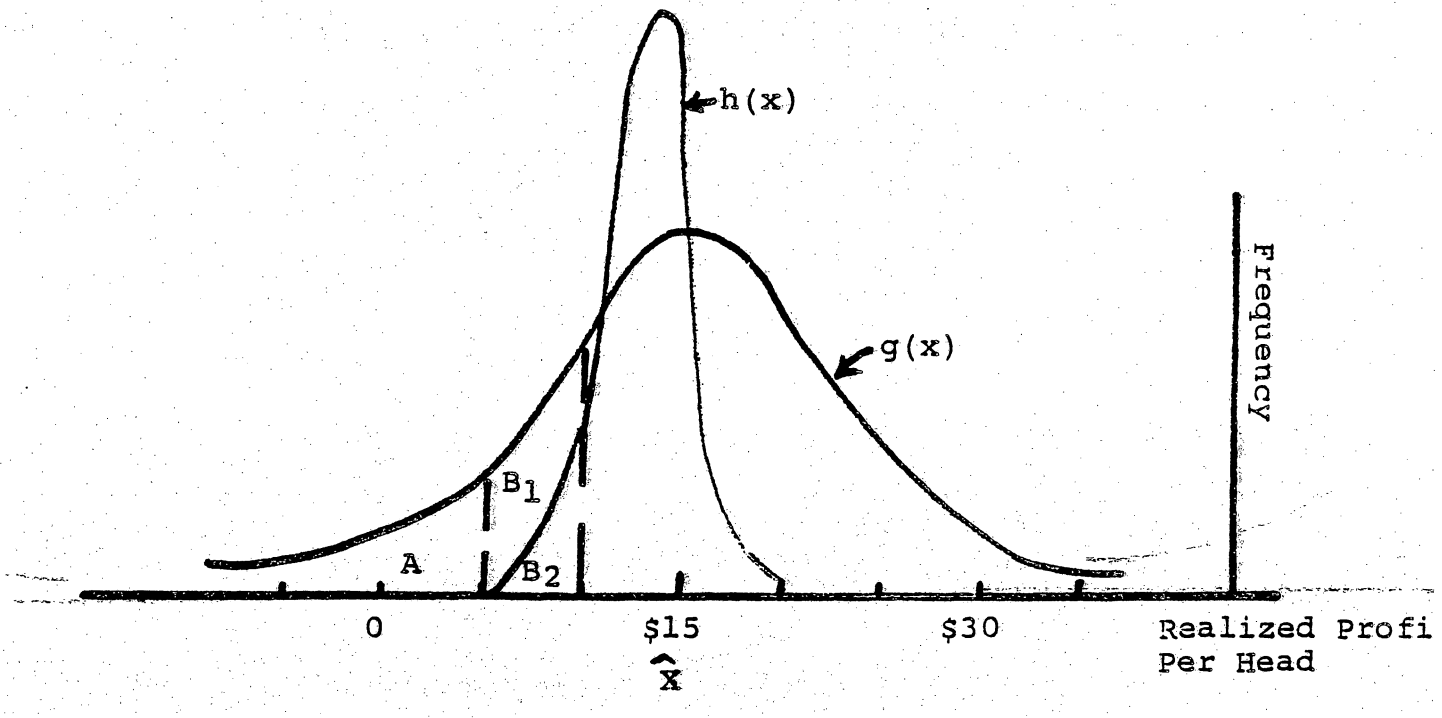

Figure 2. Comparison of Price Risk of Loan Repayment Problems for Hedged and Unhedged Hog Feeding Operations.

Figure 2 illustrates how the producers can use the futures market to manage (i.e., reduce or eliminate) the price risk of loan repayment problems because of an unexpected shortfall of slaughter hog prices relative to their predictions. The distribution of realized profits from a hedged feeding project h(x) will be centered at the profit level associated with the current futures price minus the expected basis. The range of possible profits under h(x) will be associated with the variance in the basis on the date the hogs are to be slaughtered. Note that h(x) need not be centered at the same expected profit level as g(x).

The existence of the futures market enables both producers to manage the price risk of loan repayment problems. The existence of the futures markets permits the hog producers to trade an unhedged project with a distribution of realized profits represented by g(x) for a hedged project with a distribution of possible outcomes h(x). Thus, in trading projects, the feeders reduce the range of possible outcomes by eliminating the possibility of observing a portion of the undesriable outcomes. In our example, the use of the futures market enables producer Brown to completely eliminate the price risk of loan repayment problems from his feeding project. (Recall Brown's critical level of realized income was \$5/head.) Producer Smith is able to reduce his price risk of loan repayment problems from the area of $A + B_1 + B_2$ to only B_2 since he has a critical level of \$10/head.

Similar lines of reasoning can be used to demonstrate that futures markets are indeed adequate for managing other types of price risk, -- provided the projects for which the risk is to be managed are based on

price predictions that are consistent with prices of existing futures contracts.

Figure 3 provides an illustration of how the options market will provide producers another tool for managing price risks. When the producer trades the unhedged project [outcomes described by g(x)] for a hedged project [outcomes described by h(x)] he gives up the possibility of better than originally expected outcomes lying to the right of Z in Figure 3. Producers are sometimes reluctant to give up these possibilities in order to avoid certain types of price risk. The options market will provide the producer with an opportunity to enjoy the best of both worlds for the price of an options contract.

Purchase of an options contract provides the producer with an opportunity to purchase a futures contract at a later date, if prices move against the producer. However, the producer can take advantage of higher prices simply by not exercising his option to purchase the futures contract. Thus, the options market will enable the producer to trade an unhedged project g(x) for a project with outcomes distributed by the solid line in Figure 3.

There are, however, limits to the extent that futures and options markets can be used to manage price risk. Futures markets obviously provide no opportunity for managing price risks associated with uncertainty about prices beyond the 12-15 months for which contracts are traded. I have suggested elsewhere that futures markets for some commodities should be extended to cover periods of 2-3 years (Bullock). Extending the market for futures contracts 2-3 years into the future would 1) provide an institutional mechanism for focusing production decisions over longer time periods, and 2) provide producers with an

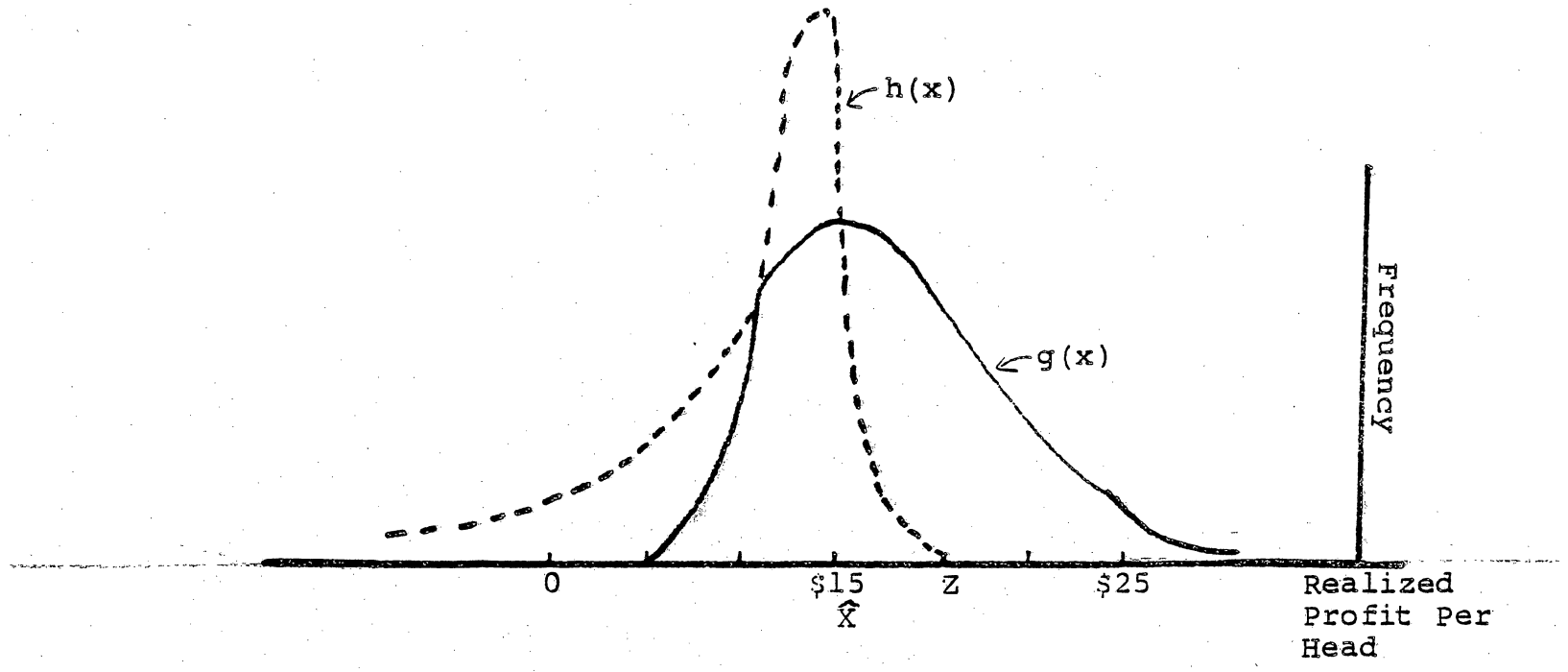

Figure 3. Illustration of Potential for Options Market as Price Risk Management Tool

opportunity to manage various types or price risks over periods more consistent with the length of the project.[7]

Information is the fuel on which effective markets operate. Futures markets are simultaneously heavy consumers and producers of imperfect information about the future. But, in an uncertain world, even imperfect information has value. Organized futures markets provide a mechanism for gathering and processing information and more importantly providing individuals with opportunities to make decisions based on that information. Moreover, the markets provide decision makers an opportunity to incorporate reduced price risk into those decisions.

Because of the public good nature of information and because the private discount rate is probably higher than the social discount rate, it is not obvious that the extended futures markets would be viable without a public agency functioning as the base speculator. At a minimum, the government would be expected to be the primary generator of baseline forecasts and of information about future supplies and demands as it currently does for existing markets. That is, USDA projections would need to be extended 2-3 years into the future. However, it may also be necessary for a public agency to take a speculative position based on that information in order to create a market in which those forecasts can systematically be exposed to information from other sources and to generate prices that (1) provide long term signals to

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[7]The lengthening of the period covered by futures contracts would also develop an appreciation and a demand for long term forecasting.

producers and consumers and (2) provide them with opportunities to manage various types of price risk associated with longer run price uncertainty.

What would be the objective of this government agency created to perform this base speculator role? Would it have a profit objective?

The purpose of the agency would be to "make a market" based on the best information available about market clearing prices in the future. To accomplish this, the agency would stand ready to purchase or sell unlimited quantities of target contracts 2-3 years in the future at a predetermined interval (say ± 50¢) around the forecasted market clearing price for that period based on the best information available. If the forecasts are high compared to realized prices about as often as they are low (i.e., we develop a more or less unbiased price forecasting system), then we would expect the agency to about break even in its trading operations over time -- ignoring operating costs. The agency would liquidate its long or short positions in an orderly manner over the life of the contract as it became evident that the forecasts were incorrect. Profits and losses would be taken accordingly. By liquidating their position prior to delivery date, the government would acquire no stocks as a result of their trading program. The existence of this market would, however, provide the type of long term information and risk management opportunities needed for longer term agricultural investment and management decisions.

Summary

This paper has been as much a critical review of concepts and definitions used in the risk and uncertainty literature as it has been an examination of the question posed in the title. I hope I have been at least partially successful in establishing the following points.

1. There is a difference between risk and uncertainty:

   uncertainty exists because the decision maker cannot predict with certainty the final outcome of his project,

   risk is the probability that the realized outcome will fall in the subset of possible outcomes defined by the decision maker as undesirable.

2. There are no risky markets. Decisions are risky. Market prices are uncertain.

3. Price risks exists because of the decision maker's inability to predict prices into the future with perfect accuracy.

4. Futures markets are an adequate mechanism for managing price risk

   a) provided an appropriate futures contract exists, and

   b) provided the decision maker has not totally ignored the price information provided by futures marekts as he selected his project.

5. Futures markets cannot be used to manage price risks that are generated by the decision maker's failure to recognize and accept market realities.

6. Futures markets for agricultural products should be extended 2-3 years into the future in order to provide opportunitites

to manage price risks over longer periods than is currently possible.

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