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Dairy Farmer's Valuation of Market Security Offered by Milk Marketing Cooperatives

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Dairy farmers often rank the benefit from a secure market as a major reason for belonging to a milk-marketing cooperative. This paper proposes a technique for valuing this decreased market risk through development of a willingness-to-pay measure.

A Proposed Technique for Assessing Dairy Farmer's Valuation of Decreased Market Risk Offered by Cooperatives

A cooperative is an economic institution through which autonomous economic units can jointly carry on activities common to their individual economic pursuits. Many dairy farmers belong to milk marketing cooperatives that allow them to take advantage of economies of scale in milk marketing, integrate forward into milk packaging and processing, and increase their bargaining power. Further, the presence of an assured market or decreased market risk is often cited by dairy farmers as being the most common reason for cooperative membership (Jensen 1990).

A loss of market access by a dairy farmer who has large capital investments in nonliquid assets can be financially devastating because production costs are sunk at the time of the transaction and milk is highly perishable (Staatz 1987). Provision of secure and long-term access to output markets is a main advantage of the cooperative over an investor-owned milk handler. A recent national survey of milk marketers reported that 95% of the surveyed cooperatives guaranteed a market for their dairy farmers versus 51% of the investor-owned processors (Schrader, et al. 1985). Both the processors and Grade A dairy farmers rated market guar-

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antees as being very important. These results were consistent with an early study where 87% of the cooperative cheese plants surveyed guaranteed a daily market for farmers' milk, versus only 76% of the non-cooperative firms (Babb 1980).

Despite the acceptance of market risk as a primary cooperative benefit, its economic value "defies quantification" (Mengel 1988). Quantification of this market security benefit offered by cooperatives has value to cooperatives that are in a business environment with many competitors. Dairy marketing cooperatives are continually competing for a producer's milk with investor-owned firms. The package of benefits that the cooperative offers is often the deciding factor in the farmer's decision. Benefits from cooperative endeavors can only be listed, but no dollar value can be tied to each benefit. Quantifying the value of market security will allow the cooperative and prospective member to place a dollar value on an important benefit to membership. Further, a documented reduced risk due to cooperative membership would have implication for agricultural lenders. If cooperative membership reduces income variance, then the member would be a more attractive loan applicant.

Economists, until now, have been unable to develop a technique for estimating this illusive yet crucial benefit. In this paper, a tractable technique is presented that allows valuation of decreased market risk by using a willingness to accept (or pay) measure. This is the first published attempt to establish a rigorous procedure for measuring the benefit of decreased market risk. The technique calls for the use of data that are not yet available. The value of publishing the technique is that researchers will have guidance on what data is needed for future research.

Market Uncertainty

As mentioned before, loss of market access is a real threat for many dairy farmers. The marketing choice for the farmer is generally two dimensional—either sell through a cooperative or through an investor-owned handler. This choice of market outlet affects the market risk to the farmer. In times of milk surplus, an investor-owned handler has been known to "cherry pick." In this practice, producers who are small, inconveniently located, or have other nonprofitable characteristics are dropped as suppliers. Besides cherry picking, an investor-owned handler may go out of business, leaving all its former suppliers without a milk market. Since most individual farmers do not have the storage capacity for their milk, a farmer that does not have a market will have to dump milk until a new market is obtained. Cooperatives also go out of business on occasion, but the member-controlled nature of the business allows members to know in advance about the difficulties, allowing them to find other outlets for their milk. Some investor-owned handlers who are going bankrupt continue to collect milk, and farmers are not informed of the bankruptcy until their checks are returned for insufficient funds.

The proposed valuation technique is, in this paper, based on the assumption that decreased market risk is related to the difference between the income probability distribution that the farmer would face marketing through a farmer cooperative (co-op) versus marketing through an investor-owned handler (IOF). The cooperative, through the guaranteed market, reduces the variance of possible incomes received by the farmer.

To further explain this concept, consider two hypothetical dairy farmers located adjacent to each other. Assume their scale is approximately the same, as is input use and technology. The expected income from a co-op or an IOF for each farmer is essentially identical, and each farmer makes the choice between a co-op or an IOF based on this same expected value. Yet one farmer may choose the cooperative and the other the investor-owned handler. The different choices must be related to differences in individual risk preferences. The farmer who is more risk averse will give more weight to income variance differences than the less risk averse farmer.

A technique for measuring the value of decreased market risk must incorporate risk preferences in the evaluation of alternative income distributions. The next section develops this technique by deriving the amount of money a farmer would accept to be indifferent between two income distributions.

Measure Development

A viable technique must be able to rank income distributions, and several methods are available in the literature. First and second degree stochastic dominance are commonly used, although they rarely result in complete orderings of distributions (King and Robison 1981). Elicited utility functions are also used as ordering criteria. The practical difficulties in obtaining complete and accurate utility functions make this technique susceptible to error. Stochastic dominance with respect to a function (SDWRF) provides an intermediate option.

SDWRF uses the Pratt-Arrow absolute risk aversion coefficient. This coefficient is defined as $r(x) = -u''(x)/u'(x)$ where x in this case is income and u is a von Neumann-Morgenstern utility function. A value of $r=0$ represents an individual with constant marginal utility of income and absolute risk neutrality. This individual would choose between two income distributions based only on expected income. The coefficient is positive for all risk averse decision makers (declining marginal utility of income) and a higher value indicates a greater degree of risk aversion.

SDWRF requires only the assumption that the farmer's absolute risk aversion coefficient is within an upper and lower bound. The effectiveness of SDWRF depends on the width of the intervals being used. Several researchers (Wilson and Eidman 1983; King and Robison 1981; Tauer 1986) have researched feasible upper and lower bounds for ordering different income distributions. Raskin and Cochran (1986) further investigated the sensitivity of marginal utility to risk coefficients.

Much literature relates to SDWRF, but of particular interest is previous work by Bosch and Eidman (1987) who used SDWRF to choose between an income distribution with and without information. They then estimated an amount that would make the two distributions stochastically equal. This is relevant because market security can be viewed as a similar problem. The amount that would make the farmer indifferent between the income distribution from a relatively guaranteed market and that from a more uncertain market is a measure of the value of market security.

Hypothetical distributions are used for exposition. Consider a farmer choosing between two income distributions, each with five possible outcomes. Distribution C is associated with a farmer marketing through a cooperative, and distribution H is associated with marketing through an investor-owned handler. The hypothetical distributions, chosen for exposition purposes and each outcome having an equal probability of occurrence, are

Cooperative Distribution (C)	**Independent Handler Distribution (H)**
22,000	19,000
24,000	22,000
24,000	25,000
25,000	27,000
26,000	28,000

The expected value of each income distribution is $24,200; a risk neutral individual ($r=0$) would be indifferent between the two distributions, and decreased market risk would have no value to this individual. However, the standard deviation for C is $1,483 and for H is $3,701. The hypothetical distributions have equal expected values to isolate the variance-reducing effect of a secure market. In the following sections, SDWRF is used to rank these distributions and then to derive the amount that would make the farmer indifferent between them.

Define the cumulative distribution function (CDF) of distribution C as C(x) and the CDF of distribution H as H(x). Following Meyer (1977), the solution procedure for ordering income distributions using SDWRF identifies the utility function that minimizes:

$$\int_{-\infty}^{\infty} [H(x) - C(x)]u'(x)dx \qquad (1)$$

subject to

$$r_1(x) \leq -u''(x)/u'(x) \leq r_2(x). \qquad (2)$$

If (1) is positive for a given set of decision makers, then members of this set unanimously prefer C(x) to H(x). If (1) is zero, then neither distribution is unanimously preferred since an individual in the set of decision makers is indifferent between the distributions. If (1) is negative, C(x) is not unanimously preferred to H(x), and a new equation

$$\int_{-\infty}^{\infty} [C(x) - H(x)]u'(x)dx \qquad (3)$$

is minimized subject to the same constraint. If (3) is positive, then H(x) is unanimously preferred to C(x) for all decision makers with absolute risk coefficients in the interval $[r_1, r_2]$. If (3) is negative, then SDWRF cannot order the distributions.

Meyer developed an optimal control methodology for ordering distributions using SDWRF. His theorem states

$$r=\begin{cases} r_1(x) \text{ if } \int_{-\infty}^{\infty} [H(x)-C(x)]u'(x)dx<0 \\ r_2(x) \text{ if } \int_{-\infty}^{\infty} [H(x)-C(x)]u'(x)dx\geq 0. \end{cases}$$

To understand more fully, consider a farmer facing the distributions presented above whose risk coefficient is within the closed interval of $r_1=0.00005$ and $r_2=0.0001$. To solve the optimal control problem set up by Meyer, a negative exponential form of utility, $u(x)-e^{-rx}$ can be assumed. This provides constant upper and lower bounds on r. Since the objective function has a value of 0 above \$28,000, the upper limit of integration becomes \$28,000. An intermediate value of the objective function is calculated each time the value of $[H(x)-C(x)]$ changes. According to Meyer's theorem, the control value is initially 0.00005. The first interval of integration is \$27,000 to \$28,000. The value of the objective function over this range is

$$\begin{aligned} &\int_{27,000}^{28,000} [H(x)-C(x)]u'(x)dx \\ &=\int_{27,000}^{28,000} (-1/5)(0.00005)e^{-0.00005x}dx \qquad (4) \\ &= -0.002529. \end{aligned}$$

Since this value is negative, the control value remains at 0.00005. The integral from \$26,000 to \$27,000 is -0.005317, and the integral from \$24,000 to \$26,000 is -0.005732. The intermediate value of the objective function from \$24,000 to \$28,000 is -0.013578.

The final non-zero interval of $[H(x)-C(x)]$ is \$19,000 to \$24,000. The intermediate value of the objective function over this range is 0.021075. Since this is greater in absolute value than -0.013578, the control value will change somewhere between \$19,000 and \$24,000. Iterations indicate the objective function changes sign at approximately \$19,935. Thus, 0.0001 is the control value from \$19,935 to \$19,000. The intermediate value of the objective function integrated over this interval is 0.002670. Since the value of the minimized objective function is positive, H(x) is preferred to C(x) by all decision makers whose risk aversion coefficient is always between 0.00005 and 0.0001. Further, the utility function that minimizes the objective function is defined by:

$$r=\begin{cases} 0.00005 \text{ when } x\geq \$19,935 \\ 0.0001 \text{ when } x<\$19,935. \end{cases} \qquad (5)$$

Willingness to Accept (or Pay)

A farmer paid the willingness to accept (WTA) amount is hypothetically indifferent between marketing through an independent handler (and receiving the WTA amount) and belonging to a cooperative.

When the value of (1) is zero, an individual in the relevant risk aversion coefficient range is indifferent between the two distributions. WTA is calculated as the amount of money added to each possible outcome in distribution H such that the overall value of the objective function becomes zero. When the value of (1) is zero, a value for (3) must also be calculated. When the value of (3) is also zero, an individual in the relevant risk coefficient range is indifferent between the two distributions. Estimates of WTA can be obtained by solving for ϵ_1 and ϵ_2 in the following:

$$\int_{-\infty}^{\infty} [C(x) - H(x+\epsilon_1)]u'(x)dx = 0 \tag{6}$$

$$\int_{-\infty}^{\infty} [H(x+\epsilon_2) - C(x)]u'(x)dx = 0. \tag{7}$$

Rewrite (6) and (7) as follows

$$\int_{-\infty}^{\infty} C(x)u'(x)dx - \int_{-\infty}^{\infty} H(x+\epsilon_1)u'(x)dx = 0 \tag{8}$$

$$\int_{-\infty}^{\infty} H(x+\epsilon_2)u'(x)dx - \int_{-\infty}^{\infty} C(x)u'(x)dx = 0. \tag{9}$$

Note that (8) and (9) are differences between the expected utilities of the two distributions. These equations can also be written as

$$\int_{-\infty}^{\infty} c(x)u(x)dx - \int_{-\infty}^{\infty} h(x+\epsilon_1)u(x)dx = 0 \tag{10}$$

$$\int_{-\infty}^{\infty} (h(x+\epsilon_2)u(x)dx - \int_{\infty}^{\infty} c(x)u(x)dx = 0 \tag{11}$$

where h(x) and c(x) are probability density functions.

The income probability distributions presented in the previous example are discrete. (10) and (11) can be written in discrete form as:

$$\sum_{j=1}^{m} c(x_j)u(x) - \sum_{i=1}^{n} h(x_i+\epsilon_1)u(x) = 0 \tag{12}$$

$$\sum_{i=1}^{n} h(x_i+\epsilon_2)u(x) - \sum_{j=1}^{m} c(x_j)u(x) = 0. \tag{13}$$

In the example $m = n$ but the WTA expression is developed for the general case of $m \neq n$.

By assuming the negative exponential form of the utility function, (12) can be rewritten as

$$\sum_{j-1}^{m} [1/m][-e^{-rx_j}] - \sum_{i=1}^{n} [1/n][-e^{-r(x_i+\epsilon_1)}] = 0 \tag{14}$$

and solving for ϵ_1

$$\epsilon_1 = (-1/r) * LN \left\{ \frac{(\sum_{j=1}^{m} - e^{-rx_j})(n)}{(\sum_{i=1}^{n} - e^{-rx_i})(m)} \right\} \tag{15}$$

A similar expression defines ϵ_2 except that the other bound on the risk coefficient would be used. Thus, two estimates for willingness to accept are obtained by this procedure.

The validity of (15) is contingent on the value of the objective function not changing sign and thus the same control value being used. If this is not the case, (10) and (11) would be solved by iterating the WTA value until equality holds.

Equation (15) is used to obtain WTA values for the simulation. First, r is 0.00005 and calculations yield a value of $235 for WTA. Using a r value of 0.0001, a value of $476 is obtained. The lower bound value of r gives the lower estimate of WTA and the upper bound value of r results in the higher estimate of WTA.

The sensitivity of WTA is explored by defining different intervals of risk coefficients. The schedule below shows that the annual WTA estimates become relatively significant when r is in the range of values used by previous researchers (Tauer 1986; King and Robison 1981):

Risk Coefficient Interval	Low Estimate of WTA	High Estimate of WTA
0.00001 to 0.00003	$ 46	$139
0.00003 to 0.00005	$139	$235
0.00005 to 0.0001	$235	$476
0.0001 to 0.0002	$476	$953
0.0002 to 0.0003	$953	$1388
0.0003 to 0.0005	$1388	$2050
0.0005 to 0.001	$2050	$2760

Conclusions

Past research has documented that dairy farmers consider the benefit of decreased market risk as the primary reason for belonging to a dairy marketing cooperative. Economists have, until the technique presented in this paper, been unable to quantify the value of this important benefit. The value of market security to an individual farmer can now be estimated and a reasonable estimate of market security obtained.

A farmer obviously makes the choice between the cooperative and the investor-owned handler based on individual risk preferences. Cooperatives, offering market security, are less risky alternatives. This generates the hypothesis that farmers with a greater degree of risk aversion are more likely to prefer cooperative membership. Under this hypothesis, the benefit of decreased market risk can be calculated as the amount that would have to paid to the farmer to be indifferent between selling to an investor-owned handler and to a cooperative. The WTA amount can be calculated by employing Meyer's technique for choosing between two stochastic functions. Stochastic dominance with respect to a function can be used to first rank income distributions and to then derive the annual amount that a farmer would accept to be indifferent between distributions.

The example used to aid in exposition of the technique was two distributions with equal expected values but different variances. A conservative interval on the absolute risk coefficient of 0.00005 to 0.0001 was used to derive estimates of $235 and $476 for WTA. Further investigation indicates that higher risk coefficient ranges result in more significant WTA amounts.

Empirical Extension

Now that a technique is available, market security's actual value to dairy farmers is the next research step. An empirical extension of this work will require primary data collection. Of interest is to estimate two income distributions—one for cooperative members and one for producers who do not belong to a cooperative. One possible strategy for data collection would be to identify two samples of dairy producers within a region. Initially, scale or pounds of milk produced should be held constant. Therefore, all producers in the sample should be of similar scale. One sample would be cooperative members and the other non-members. Each producer in the sample would be followed over time. Data on milk income would be the focus of the information collected. Researchers would be able to determine variance in income for the two groups. Income distributions can then be estimated (initially for the average producer), which will be used to test the hypothesis that cooperatives do indeed provide a lower variance in income. Upper and lower bounds on the value of decreased market risk can then be estimated.

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