An Analysis of the Risk Aversion of Farm Operators: An Asset Portfolio Approach

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The absolute and relative risk aversion characteristics of a large sample of farm operators were estimated from the observed portfolio responses to changes in wealth. Regression estimates suggest that farm operators display decreasing absolute risk aversion. Relative risk aversion varies by type of farm. However, the definition of risky assets has an important bearing on relative risk aversion characteristics. Non-wealth variables are also important in explaining the holding of risky assets by farm operators.

The realization that risky events can substantially alter the actions of decision-makers is not new. Bernoulli's Principle is an excellent procedure for incorporating the decision-maker's personal beliefs and the valuation of uncertain events into the decision process [Dillon]. During the 1950's and 1960's considerable effort was devoted to agriculturally-related research which incorporated uncertain events. These efforts considered the uncertainty problem from several viewpoints including use of optimization techniques [Day], games against nature [Dillon and Heady], portfolio theory [Fruend], and the expected utility theorem [Von Neuman-Morganstern].

Although risk and uncertainty are not new topics, considerably more research attention was devoted to these factors in the 1970's. Several explanations for this increased attention could be hypothesized. First, the inadequacy of the profit maximization assumption in many situations was more widely recognized and documented [Barry and Baker; Lin, Dean, and Moore]. Second, the events of the early 1970's which precipitated large fluctuations in levels of production and prices increased the perceived need for risk-related research, especially in the United States [Just and Pope, Robison and Brake]. And third, improved methodologies to evaluate risky situations enhanced the capability of researchers to conduct such research activities.

Despite the recent emphasis of risk-related research, little data exists relating to the actual willingness of agricultural producers to bear risk. The findings of several studies which attempted to measure the risk preferences of farmers were recently summarized [Young, et al]. Although this review is not exhaustive, the studies identified in this extensive review measured the risk preferences of less than 500 agricultural producers in the world. This void of empirical risk preference data is particularly true for producers in developed nations. Studies encompassing only 144 producers were identified in these nations [Young, et al]. A broader base of risk preference data is needed. Such data could help in understanding farmers' responses to changing levels of risk.

The purpose of this paper is to empirically investigate the absolute and relative risk aversion characteristics of a large sample of agricultural producers in the United States.

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The paper has four parts: the first section reviews alternative methods of measuring risk preferences and relates risk aversion properties to selected utility functions, the second discusses the data and models used in the empirical investigation, the third section summarizes the findings, and the fourth section presents concluding comments.

Measurement of Risk Preferences

Working independently, [Pratt and Arrow] developed the concepts of absolute and relative risk aversion:

(1) Absolute risk aversion = $-U''(W) / U'(W)$

(2) Relative risk aversion = $-WU''(W) / U'(W)$

where

W = argument in the utility function (U), (normally wealth or income),

U'(W) = marginal utility (first derivative), and

U''(W) = rate of change in marginal utility (second derivative).

A common usage of these concepts is to measure risk preferences of decision-makers as a function of their wealth positions.

In many risk-related research efforts, it is necessary to specify either the form of the decision-maker's utility function or that individual's attitude toward risk. However, for many commonly used utility functions, the properties of absolute and relative risk aversion are implicitly restrained by choice of the utility function [Wolgin] or by utilization of a methodology which requires the assumption of a specific utility function [Brink and McCarl]. In Table 1, the absolute and relative risk aversion properties of several commonly used utility functions are presented. Note that none of the functions allow for both increasing and decreasing risk aversion for different levels of wealth.

The linear utility function implies no absolute or relative risk aversion. The quadratic function, however, implies *increasing* absolute and relative risk aversion. The semilog and log linear utility function both imply *decreasing* absolute risk aversion and *constant* relative risk aversion. In contrast, the exponential utility function implies *constant* absolute risk aversion, but *increasing* relative risk aversion. It is important to note that all of these utility functions *implicitly* specify their absolute and relative risk aversion properties.

It has been argued that the risk aversion properties of decision makers is an empirical question and should not be predetermined by the functional form of the utility function [Lin and Chang]. They proposed a generalized functional form (Table 1). Maximum likelihood estimation can be used to determine empirically the value for λ, and consequently the properties of the utility function. Like other utility functions, this procedure requires measures of a utility index. But, construction of a utility index is probably economically feasible only for a relatively small sample of decision-makers. In addition to cost considerations, a researcher must determine which of the alternative processes for measuring risk attitudes is most appropriate for the situation considered.

Three approaches have been utilized to attempt to measure the risk attitudes of individuals [Young, et al]. These methods can be classified as:

1) direct elicitation of utility function,
2) experimental procedures, and
3) direct observation of economic behavior.

Direct elicitation of individual utility functions in an interview setting have been conducted [Dillon and Scandizzo; Lin, Dean, and Moore; Officer and Halter; and Webster and Kennedy]. These interview procedures typically attempt to determine points of indifference between certain outcomes and uncertain outcomes — outcomes conditioned on games of chance. Despite efforts to cast

TABLE 1. Risk Aversion Properties of Alternative Utility Functions

Utility Function	Absolute Risk Aversion		Relative Risk Aversion	
	Absolute Risk Aversion Coefficient	Properties of Coefficient	Relative Risk Aversion Coefficient	Properties of Coefficient
Linear:				
$U_{(W)} = a + bW$	0	Constant for all W	0	Constant for all W
Quadratic:				
$U_{(W)} = a + bW + cW^2$	$\frac{-2c}{b+2cW}$	Increasing for $c<0$ $W>0$	$\frac{-2cW}{b+2cW}$	Increasing for $b>0$ $c<0$ $W>0$
Semi-log:				
$U_{(W)} = a + b\ln W$	$\frac{1}{W}$	Decreasing for $W>0$	1	Constant
Log Linear:				
$\ln U_{(W)} = a + b\ln W$	$\frac{1-b}{W}$	Decreasing for $b<1$ $W>0$	$1-b$	Constant
Exponential:				
$U_{(W)} = -e^{-aW}$	a	Constant	$a \cdot W$	Increasing for $a>0$
Generalized:		Decreasing for $\lambda < i$ Increasing for $\lambda>1$ if		
$\frac{U_{(W)}^{\lambda}-1}{\lambda} = \alpha + \beta\frac{W^{\lambda-1}}{\lambda}$	$-(\lambda-1)\left[\frac{1}{W} - \frac{1}{U_{(W)}} \cdot \frac{\partial U_{(W)}}{\partial W}\right]$	$\frac{1}{W} > \frac{1}{U_{(W)}} \cdot \frac{\partial U}{\partial W}(W)$	$-(\lambda-1)\left[\frac{1}{W} - \frac{1}{U_{(W)}} \cdot \frac{\partial U_{(W)}}{\partial W} \cdot W\right]$	Decreasing for $\lambda<1$ Increasing for $\lambda>1$

the decision situation in terms that are familiar to the decision maker, both the certain outcome and the gains or losses from the games of chance are hypothetical rather than real for the individual being interviewed. Utility functions and the resulting risk aversion coefficients obtained through direct elicitation methods are vulnerable to "interviewer bias" and are "situation specific," and hence not scientifically replicable or reliable [Musser and Musser, Kahnerman and Tversky, Thaler]. Whittaker and Winter have also shown the extreme sensitivity of the results of utility functions obtained by direct elicitation.

The direct elicitation method is technically difficult to administer in a manner which does not bias results. This concern led to an "experimental" method [Binswanger]. Because his research dealt with a peasant economy (that of Indian agriculture), Binswanger was able to provide actual financial compensation to the subjects of the interview procedure. This research indicated that measurements of risk preference are substantially affected by whether the decision-maker is evaluating actual or hypothetical gains or losses.

In the experiment effort, care must be taken to ensure that the compensation level is a significant amount for the subjects interviewed. Such an experiment in a developed nation, however, would require a considerable amount of prize money. Even if funds were available, the game setting would probably not replicate the actual decision framework for agricultural producers.

To overcome the game problem, an alternative approach is to infer relative risk preferences of individuals by observing their actual economic behavior. Studies of this nature have either focused on input utilization or output supply of the individual [Brink and McCarl; Moscardi and de Janvry; Wiens; and Wolgin]. The difference between actual behavior and the behavior predicted by a theoretical model (predicted on a profit maximization assumption) is considered a measure of risk preference. A serious difficulty with this approach is that the influence of all factors which inhibit attainment of profit maximization are typically included in the measurement of risk preference. Factors such as the desire for leisure, lack of knowledge, or divergence between values of the model coefficients and those actually used by the farmer may also explain apparent non-profit maximizing behavior, but these elements are not part of the individual's attitude towards uncertainty.

In summarizing past research, [Young et al] showed that studies have found that farm operators in developing nations tend to be risk averse as opposed to risk neutral or risk seekers. They indicate that insufficient research has been done for farmers of developed nations to infer any risk aversion tendencies. Even if farmers in developed nations could be assumed to be risk averse, the question of the risk aversion characteristics of those farm operators would be left unanswered. Although the concepts of absolute and relative risk aversion are well developed, measurement of these concepts in the absence of utility functions is not.

The development by Pratt and Arrow of the concepts of absolute and relative risk aversion was done in the context of a decision-maker's asset portfolio. Ideally, one would like to measure individual utility functions, but the problems previously described would surface. Therefore, an alternative phenomenon to observe, in order to study risk aversion, is the composition of asset portfolios. This approach has been utilized by [Cohn, et al] for a sample of stock market investors. Although data limitations forced that study to utilize total assets rather than equity as a measure of wealth, the analysis did indicate the potential feasibility of this approach. In this study, a similar approach is used to relate the composition of farmers' asset portfolios to their risk aversion. A weakness of the asset portfolio approach is the general lack of data to measure the variance and covariance of returns of individual portfolios across time. These problems are not overcome in this study, consequently

results should be viewed as tentative. A detailed presentation of the data source and the method used is given in the following section.

Sample Characteristics and Method of Analysis

This study utilizes the direct observation of economic behavior for investigating the risk attitudes of farmers. In this instance the relationship between wealth and the holding of risky assets for farm operators is investigated, thereby providing insights to the absolute and relative risk aversion properties of farm operators.

The Sample:

Data for this study came from the 1975 Farm Production Expenditures Survey (FPES). The 1975 FPES data were selected because: (a) the survey contained information on farm operator characteristics as well as balance sheet data for the farm operators, (b) the survey results are available in primary form in contrast to Census data which are available only in aggregate form, and (c) the survey was national in scope and provided sufficient sample size to disaggregate by farm type, size, and other characteristics. Data from state farm record keeping programs were judged to be less adequate for this study because of the limited scope of that data and because of missing data on the wealth variable.

The design of the FPES was a multiframe sample. Estimating production expenditures was the major objective, and consequently large producers with high production expenditures were sampled more heavily. Responses from over 5600 respondents were deemed usable in part or total.

One set of questions on the FPES related to component parts of the farm operator's balance sheet. Failures to respond on this part of the survey reduced the usable sample to 3,637 operators. This sample constitutes the observations used in our analyses. Even for these operators, the balance sheet data may not be complete in that questions relating to assets in nonfarm businesses were incomplete.

Selected characteristics of the sample operators are shown in Table 2. The sample contains substantial dispersion by operator age, net worth, type of farm, financial assets, non-financial assets, geographical location, leverage ratios and gross farm sales. The asset portfolio of the sample was broken into two components — financial and nonfinancial. As expected, nonfinancial assets dominate since land is a major asset in the balance sheet of farm operators. Other important non-financial assets include crop and livestock inventories and machinery. The leverage ratio — debt divided by equity — was also relatively low with few operators having a leverage ratio exceeding one. This finding is consistent with aggregate statistics published in the *Balance Sheet of the Farming Sector*.

Correlation coefficients reveal a high correlation among the amount of nonfinancial assets and total wealth. This result is not surprising given the relatively low leverage ratios and the fact that farmland is a major asset in the portfolio of many owner operators. Gross farm sales, net worth and nonfinancial assets are also positively correlated at about the .5 level. Other correlations are relatively low.

Method of Analysis

The measures of absolute and relative risk aversion developed by Pratt and Arrow can be used to test hypotheses on how a risk-averse decision maker allocates wealth among risky and safe assets as his level of wealth changes. Lacking data on a time series of portfolio responses by individual farmers, the analysis here is based upon the cross-sectional data described above.

As [Barry and Baker, p. 54] point out: "An investor exhibits decreasing (increasing) *absolute* risk aversion if the *amount* of wealth invested in risky assets increases (decreases) with wealth. An investor exhibits decreasing (increasing) *relative* risk aversion if the *proportion* invested in risky assets increases (de-

TABLE 2: Selected Characteristics of a Sample of 3,637 Farm Operators

Characteristics	Category	Number of Farm Operators
1. Age (Years)	<40	830
	40 – 49	923
	50 – 59	1,020
	60 +	864
2. Net Worth (Dollars)[a]	<150,000	1,533
	150,000 to 299,999	884
	300,000 to 449,999	474
	450,000 +	746
3. Financial Assets (Dollars)[b]	1 to 2,499	1,468
	2,500 to 4,999	479
	5,000 to 9,999	466
	10,000 to 19,999	453
	20,000 +	771
4. Nonfinancial Assets[a] (Dollars)	<50,000	400
	50,000 to 100,000	607
	100,000 to 200,000	817
	200,000 to 400,000	850
	400,000 +	963
5. Nonfinancial Assets/ Total Assets	<.75	196
	.75 to .85	212
	.85 to .90	262
	.90 to .95	481
	.95 +	2,486
6. Leverage Ratio	0	1463
	0 to .1	795
	.1 to .2	454
	.2 to .5	497
	.5 to 1.0	362
	>1.0	66
7. Gross Farm Sales (Dollars)[a]	0 to 2,499	694
	2,500 to 4,999	284
	5,000 to 9,999	329
	10,000 to 19,999	366
	20,000 to 39,999	508
	40,000 to 99,000	740
	100,000 +	716
8. Type of Farm[c]	grain	881
	tobacco	190
	cotton	57
	poultry	82
	dairy	377
	cattle & calves	882
	hogs & sheep	322
	other	846

TABLE 2: Continued

Characteristics	Category	Number of Farm Operators
9. Geographical Location	Northeast	304
	Lake States	397
	Corn Belt	840
	Northern Plains	399
	Appalachian	437
	Southeast	221
	Delta States	168
	Southern Plains	272
	Mountain	248
	Pacific	351

Correlations on Selected Items

	1	2	3	4	5	6
1. Age	1.00					
2. Net Worth	.01	1.00				
3. Nonfinancial Assets	−.03	.96	1.00			
4. Financial Assets/Nonfinancial Assets	−.21	.03	.10	1.00		
5. Leverage Ratio	−.31	−.03	.06	.16	1.00	
6. Gross Farm Sales	−.04	.49	.53	.03	.05	1.00

[a]Dollar amounts are in nominal current market values.

[b]Includes U.S. savings bonds, other bonds and stock owned, money in checking accounts, money in savings and loan associations or other savings accounts.

[c]Classified in a given category if 50 percent or more of gross farm sales were in that category.

creases) with wealth". Therefore, to test for the absolute and relative risk aversion characteristics of the farm operators in the FPES sample, we propose the following estimating equations:

$$(3) \quad RA = a_0 + a_1 W + \sum_{i=2}^{n} a_i X_i + e_1$$

$$(4) \quad RRA = b_0 + b_1 W + \sum_{i=2}^{n} b_i X_i + e_2$$

where

RA = risky assets,

RRA = the proportion of all assets which are classified as risky assets,

W = net worth (wealth)

X_i = nonwealth variables which determine one's ability and/or willingness to hold risky assets

a_i and b_i = coefficients of regression parameters,

e_1 and e_2 = random errors.

Equation 3 allows one to determine the impact on the *amount* of risky assets held as wealth changes. The hypothesis to be tested is: (H_0) $a_1 = 0$ against (H_1) $a_1 > 0$, and (H_2) $a_1 < 0$. A positive and significant a_1 is consistent with decreasing absolute risk aversion while a negative and significant a_1 is consistent with increasing absolute risk aversion. If a_1 is not significantly different from zero, one cannot reject the hypothesis that absolute risk aversion is constant.

Equation (4) provides a means for examining the relationship between the *proportion* of risky assets held and the level of wealth. The hypothesis to be tested is: (H_0) $b_1 = 0$ against (H_1) $b_1 < 0$, and (H_2) $b_1 > 0$. Interpretation of the regression results is similar to that outlined above for absolute risk aversion.

Studies by [Binswanger, Moscardi and de-

Janvry, Dillon and Scandizzo, and Halter and Mason] have all demonstrated the importance of nonwealth factors in explaining risk aversion characteristics of farm operators. The nonwealth factors included in this study include: age of operator, size of farm as measured by gross sales, form of business organization, percent of total land area operated which is rented, off-farm income, and the leverage ratio of the operator. Each variable is hypothesized to influence the amount and/or proportion of risky assets in the portfolio of farm operators. Inclusion of the nonwealth variables is due to their perceived role in explaining the holding of risky assets. However, they are of secondary interest in this study. Hence we report results related to these variables without great elaboration.

Limitations of the Analysis

If one develops the theoretical choice of risky assets according to expected utility theory, then one would include measures of business and financial risk. The inclusion of the leverage ratio is a proxy for financial risk, but measures of business risk — such as the variance of returns on risky assets — are not available because of the cross-sectional nature of the data used here. However, we know of no other large scale data set which contains wealth data plus the time series data needed for measuring business risk.

The inability to measure business risk directly is partially offset by grouping observations by type of farm to eliminate the business risk associated with differing farm enterprises. But even within a given farm type — say cash grain — there can be a substantial difference in business risk among farm operators because of differences in crop mix and the use of forward contracting, hedging, crop insurance and other risk reduction strategies. To some degree, however, these differences are likely to be reflected in the asset composition and wealth position of the operators.

Application of the concepts of absolute and relative risk aversion requires one to identify which assets are "risky" and which are "risk free". Investments in financial assets such as time deposits offer a fixed return with a very low probability of loss. As such, financial assets have often served as a proxy for "risk free" assets for empirical analyses. However, fixed return financial assets are risky in terms of the real return they generate during inflationary periods.

The relevant criteria for defining risk-free assets is not so much the certainty of returns, but rather the perceived risk on the part of the holder of the asset. Thus any classification of risky versus risk-free assets is an empirical issue. Lacking empirical evidence on what farm operators perceive to be assets with little or no risk, we tested two alternative classification schemes. In the first scheme, classification of financial assets as "risk free" was used. In the second, we included farmland in the definition of risk free assets. Farmland was included because of the belief by some that "farmland is one of the safest assets you can own".[1]

Factors other than risk aversion can affect portfolio decisions as wealth changes. For example, as wealth increases, an investor could place a greater proportion of wealth into safe financial assets such as certificates of deposit, not out of the fear of investing in risky assets, but rather out of the desire to hold investments which allow the investor to maximize leisure time. The data available for this study do not allow measurement of this kind of effect on portfolio decisions.

It should also be recognized that the sample used in this study could include risk preferring, risk neutral, and risk averting farm operators. There is no way to segregate the sample to avoid this problem. Dillon has argued that *most* farm operators are risk averters. But even if there is only a small percentage of risk neutral or risk preferring operators in the sample, regression estimates could be affected. For a given level of wealth, risk

[1]Two reviewers of an earlier draft expressed doubts that "farmland can be construed as a risky asset". Farmers in western Iowa who experienced a drop in land values of 15 percent in early 1980 would probably not agree.

preferring farm operators would likely hold more risky assets than risk averting farm operators. This would tend to increase the size of the a_1 and b_1 regression coefficients — i.e., increase the chance of finding both decreasing absolute and relative risk aversion. Consequently, inferences from the regression results must be drawn with care.

Empirical Results With Financial Assets Defined As Risk Free

The riskiness of farming operations varies considerably among the various types of farming enterprises. Crop producers face considerable risk because of weather uncertainties and yield fluctuations. Livestock producers not covered by government programs face considerable price uncertainty. Dairy operations, however, are typically thought to experience less production and price risk than other types of farms, partly because of price support programs and Federal milk marketing orders. Because of these considerable differences in business risk we estimated equations 3 and 4 by type of farm. Results are reported in Table 3.

Absolute Risk Aversion by Type of Farm

As shown in the top half of Table 3, the regression coefficients for the net worth variable are positive and significantly different from zero. These regression estimates are consistent with decreasing absolute risk aversion for all farm types. The findings are also consistent with the high positive correlation between the holding of nonfinancial assets and net worth. However, the results do not imply that *all* farmers have decreasing absolute risk aversion, only that *as a group* farmers exhibit decreasing absolute risk aversion.[2]

The regression coefficient on the leverage ratio variable is positive and significant for all farm types, indicating that borrowed funds are often used to acquire risky assets. In addition, the amount of risky assets held as a function of gross sales varies by type of farm. For all farm types, except cotton and poultry, an increase in gross sales is associated with a larger amount of risky assets held in the portfolio.

As shown in Table 3, the age of the farm operator is a significant factor in explaining the amount of risky assets held by farm operators for only one farm type — grain. For all farm types but poultry, the regression coefficient was negative. The finding of negative coefficients on the age variable is consistent with that found by Halter and Mason for 44 grass seed growers in Oregon. The linear regression model, however, could easily conceal a non-linear relationship in the age variable.[3] Consequently, the sample was divided into 4 different age groups and the model reestimated. In all cases, the negative relationship between age and the holding of risky assets was maintained.

To examine the effects of the form of business organization on the holding of risky assets a variable coded 1 for proprietorships, 0 for partnerships or corporations was included. A negative regression coefficient would suggest that sole proprietors hold less risky assets than partnerships and corporations. Results were mixed. For cattle and calves and cotton farms the regression coefficient was negative and significantly different from zero. For tobacco farms the coefficient was positive and significantly different from zero.

Many farm operators rely on rented land to support their farming operations. For all farm types, except poultry, the regression coefficient on the percent of land rented was negative suggesting that increased reliance

[2]It should be recognized that our sample consists of both owner operators and tenants. Since land is defined as a risky asset in this section, the holding of this risky asset by owner operators, will increase as the value of land increases, unless the operator takes specific action to dispose of some of the land.

[3]Our initial hypothesis was that the holding of risky assets would increase up to middle age (40-50) and then decrease. Regression estimates fail to confirm that hypothesis.

TABLE 3. Regression Estimates of Absolute and Relative Risk Aversion Characteristics of Farm Operators by Farm Type, Financial Assets Defined as Risk Free.[a]

Type of Farm/ Risk Aversion	Constant	Regression Coefficients for Explanatory Variables: Net Worth	Leverage Ratio	Gross Sales	Age of Operator	Form of Business Organization	Percent of Land Rented	Off-Farm Income	Sample Size	R^2
Absolute Risk Aversion										
Grain	100,359	1.03*	67,370*	.33*	−1,573*	−11,948	−46,245*	−.82*	881	.96
Tobacco	−32,075	1.03*	99,315*	.41*	−231	28,736*	−12,473*	.21	190	.99
Cotton	98,149	1.11*	137,752*	−.29*	−714	−59,375*	−44,762*	−.29	57	.97
Poultry	−151,448	1.20*	535,182*	−.03*	1,039	−3,804	31,940	1.58	82	.97
Dairy	7,388	1.00*	129,763*	.34*	−165	−6,401	−27,687	−.52	377	.98
Cattle & Calves	147,248	.82*	323,187*	.85*	−349	−124,214*	−31,724*	−1.03**	882	.92
Hogs & Sheep	−6,615	1.00*	114,250*	.57*	−288	7,277	−29,481*	−.26	322	.98
Relative Risk Aversion[b]										
Grain	1.06	$.82^{(-8)}$	$.17^{(-1)*}$	$.69^{(-8)}$	$-.19^{(-2)*}$	$.46^{(-3)}$	$-.59^{(-1)*}$	$-.80^{(-6)*}$	881	.10
Tobacco	1.08	$.73^{(-7)}$	$.72^{(-1)*}$	$.73^{(-7)}$	$-.24^{(-2)*}$	$-.15^{(-1)}$	$-.70^{(-1)*}$	$-.16^{(-5)**}$	190	.16
Cotton	1.02	$.13^{(-6)*}$	$.63^{(-1)}$	$-.21^{(-6)**}$	$-.18^{(-2)}$	$.53^{(-2)}$	$-.11^{*}$	$.12^{(-5)}$	57	.20
Poultry	1.02	$.46^{(-8)}$	$.46^{(-1)}$	$.97^{(-9)}$	$-.13^{(-2)*}$	$-.76^{(-2)}$	$-.42^{(-1)}$	$.13^{(-6)}$	82	.09
Dairy	1.05	$.24^{(-8)*}$	$.10^{(-1)}$	$.63^{(-8)}$	$-.14^{(-2)*}$	$-.62^{(-2)}$	$-.23^{(-1)*}$	$-.66^{(-6)**}$	377	.11
Cattle & Calves	1.10	$-.11^{(-7)*}$	$.37^{(-1)*}$	$.14^{(-7)}$	$-.21^{(-2)*}$	$-.35^{(-1)*}$	$-.68^{(-2)}$	$-.19^{(-5)**}$	882	.16
Hogs and Sheep	.97	$.28^{(-7)*}$	$.71^{(-1)*}$	$-.56^{(-8)}$	$-.11^{(-3)}$	$-.14^{(-1)}$	$-.36^{(-1)*}$	$-.88^{(-6)*}$	322	.10

[a]Significance levels are denoted by * = significant at the 1 percent level, ** = significant at the 5 percent level.

[b]$.82^{(-8)}$ is equal to $.82 \times 10^{-8}$. Other coefficients can be interpreted in the same manner.

on rental land reduces the holding of risky assets. This result is not surprising since owned land is considered a risky asset. Again this result is consistent with the findings of Halter and Mason.

With the exception of grain farms and cattle and calves farms, off-farm income was found to have no significant impact on the holding of risky assets. This result may seem surprising in that off-farm income is frequently viewed as a stable source of income which can be used to finance the purchase of risky farm assets. However, it should be recognized that the sample used here contains part-time farmers who may hold small amounts of farm assets and obtain substantial off-farm income from wages and salaries. Therefore, the negative coefficient may be a reflection of less reliance on agricultural investments to provide income for these farm operators.

Relative Risk Aversion by Type of Farm

Regression estimates to test for relative risk aversion characteristics are reported in the bottom half of Table 3. The signs and significance of the regression coefficients on the net worth variable are mixed. For cattle and calves farms, the regression coefficient is negative and significant, suggesting *increasing* relative risk aversion for this group of farmers. For grain, tobacco, poultry, and dairy farms the regression coefficient is insignificant so one cannot reject the hypothesis of *constant* relative risk aversion. For cotton farms and hog and sheep farms the coefficient is positive and significant, a finding consistent with *decreasing* relative risk aversion. The R^{2}'s for the relative risk aversion models are much lower than for the absolute risk aversion models, probably because the proportion of risky assets is very high and not highly variable.

The regression coefficients on the leverage ratio were positive for all farm types and significantly different from zero for four farm types. As expected, increases in borrowings which may raise the leverage ratio seem to be much more likely to be used in purchasing risky assets rather than safe (financial) assets. In most cases the level of gross sales and the form of business organization were found to have no significant impact on the proportion of risky assets held by farm operators.

Age of operator was found to be a significant variable for all types of farms, except cotton and hogs and sheep. The negative coefficient suggests that as age increases, farm operators hold a greater proportion of assets in the form of safe (financial) assets. Again the sample was divided into subgroups by age to test for a nonlinear relation. In this case a positive (but not significant) coefficient was found for farmers under age 40. Younger farm operators may hold a greater proportion of their assets in the form of risky assets because they desire to expand their scale of operation.

Empirical Results With Financial Assets and Land Defined as "Risk Free"

Risk for farm operators is most often measured by researchers in the context of variance or standard deviation of yields and returns, probability of loss, or the probability that returns will fall below some critical level. In almost all cases, measures involving dollar values are constructed with *nominal* data. Farmers, however, often think of risk in the context of loss of purchasing power, or the *real* value of assets or income. Financial assets such as cash or savings may decrease in real value due to inflation. In the context of real value, no asset is risk free. Farmland, however, is often viewed as a good hedge against inflation. Therefore it seems useful to examine the holding of assets which farmers appear to view as low risk versus those viewed as high risk.

In Table 4 we present regression estimates of equations 3 and 4 with farmland plus financial assets defined as the "risk free" assets. Under this definition risky assets consist primarily of crop and livestock inventories plus farm machinery. Absolute risk aversion properties change little due to the change in

definition of risk free assets, while relative risk aversion characteristics change substantially.

Absolute Risk Aversion

Regression coefficients on the net worth variable are positive and significantly different from zero for all farm types. As before, this finding is consistent with decreasing absolute risk aversion. Hence, it appears that the finding of decreasing absolute risk aversion is not sensitive to the definition of risky assets.

Redefining risk free assets caused the leverage ratio to be insignificant in several regressions. Redefining risk free assets also leaves the conclusions regarding age of operator unchanged. Regression coefficients on the age variable are negative for all farm types, but several are not significantly different from zero. Coefficients on the variables total sales, form of business organization, and off-farm income change, but conclusions reached previously are not affected by the change in definition.

The biggest change occurs in the regression coefficient on the variable "percent of land rented". In most cases the sign on the variable was reversed. This result is expected, however, since land was changed from a classification of risky to risk free.

Relative Risk Aversion

When land is included as a risk free asset farm operators display increasing relative risk aversion. For all farm types, with the exception of poultry farms, the regression coefficient for net worth is negative and significantly different from zero. This suggests that as wealth increases, farm operators as a group hold a decreasing proportion of their wealth in the form of risky assets. Hence the estimates of relative risk aversion developed here are quite sensitive to the definition of risky assets.

The regression coefficient for size of farm, as measured by gross farm sales, is positive and significant for most farm types. The results suggest that as size increases, a larger percent of total assets are held in the form of risky assets.

For all farm types, the regression coefficient on age of operator is negative and significantly different from zero. The result suggests that as age increases, farm operators decrease the proportion of risky assets held. As with previous results, the form of business organization and off-farm income are seldom significant factors in explaining the proportion of risky assets held by farm operators. But as the percent of land rented increases, the proportion of total assets which are risky also increases.

Concluding Comments

Knowledge of responses to risk is crucial to the understanding of the production, marketing, and financial decision-making of farm operators. Models purporting to explain such behavior are frequently based upon some underlying utility function. Thus it is crucial that the functional form of the utility function be consistent with the behavior displayed by a large group of farm operators.

Drawing implications from the regression estimates of this study is constrained by data limitations. Yet, using two different definitions of "risk free" assets, regression estimates suggest that farm operators display decreasing absolute risk aversion. However, the linear, quadratic, and exponential utility functions imply constant or increasing absolute risk aversion. Consequently, models which have utility functions with these functional forms do not appear to be consistent with the observed behavior of farm operators in this study. For example, the quadratic and exponential utility functions which underly the use of quadratic programming models may be inconsistent with the observed behavior of farm operators in this sample.

Using the traditional approach of defining financial assets as risk free, regression estimates suggest that a utility function with decreasing absolute risk aversion and constant relative risk aversion is consistent with

TABLE 4. Regression Estimates of Absolute and Relative Risk Aversion Characteristics of Farm Operators by Farm Type, Land and Financial Assets Defined as Risk Free.[a]

Type of Farm/ Risk Aversion	Constant	Regression Coefficients for Explanatory Variables: Net Worth	Leverage Ratio	Gross Sales	Age of Operator	Form of Business Organization	Percent of Land Rented	Off-Farm Income	Sample Size	R^2
Absolute Risk Aversion										
Grain	106,878	.17*	15,963*	.35*	−294	−44,874*	23,827**	−.73**	881	.65
Tobacco	−21,614	.26*	4,717	.91*	−555*	−49,283*	−19,861*	.64*	190	.97
Cotton	61,299	.21*	14,057	.54*	−1299	28,634	6,683	−2.27*	57	.83
Poultry	12,237	.49*	−7,207	.03*	−357	8,971	53,618	−1.15**	82	.93
Dairy	16,207	.39*	63,184*	.44*	−221	−8,992	25,297	−.30	377	.91
Cattle & Calves	31,410	.22*	114,861*	.74*	−368	−9,053	3,011	.16	882	.86
Hogs & Sheep	97,869	.15*	18,271**	.77*	−526*	−43,842*	7,897	−.51**	322	.82
Relative Risk Aversion										
Grain	.41	$-.65^{(-7)*}$	$.21^{(-1)*}$	$.12^{(-7)}$	$-.21^{(-2)*}$	$.32^{(-2)}$	.35*	$-.33^{(-6)}$	881	.51
Tobacco	.66	$-.32^{(-6)*}$	$-.46^{(-1)}$	$.69^{(-6)*}$	$-.45^{(-2)*}$	$-.38^{(-1)}$	.20*	$.55^{(-6)}$	190	.50
Cotton	.51	$-.21^{(-6)*}$	.25*	$.44^{(-6)*}$	$-.25^{(-2)}$	$-.62^{(-2)}$	.02	$.13^{(-5)}$	57	.31
Poultry	.58	$-.24^{(-7)}$	$-.73^{(-1)}$	$.21^{(-7)*}$	$-.30^{(-2)*}$	$-.16^{(-1)}$	.17*	$.37^{(-6)}$	82	.25
Dairy	.51	$-.12^{(-6)*}$	$.46^{(-1)*}$	$.24^{(-6)*}$	$-.16^{(-2)*}$	$-.77^{(-2)}$	.32*	$.25^{(-6)}$	377	.50
Cattle & Calves	.58	$-.44^{(-7)*}$	$.64^{(-1)*}$	$.13^{(-6)*}$	$-.36^{(-2)*}$	$-.21^{(-1)}$	.10*	$-.72^{(-6)*}$	882	.25
Hogs and Sheep	.51	$-.16^{(-6)*}$	$.38^{(-1)}$	$.22^{(-6)*}$	$-.17^{(-2)*}$	$-.36^{(-1)}$	.32*	$-.14^{(-5)*}$	322	.54

[a]Significance levels are denoted by * = significant at the 1 percent level, ** = significant at the 5 percent level.

the observed behavior for many farm operators. Both the semi-log and log linear utility functions have these attributes. Other types of farm operators, however, display decreasing absolute and increasing relative risk aversion. The important point is that in modeling the behavior of farm operators, there may be significant differences in relative risk aversion characteristics by type of farm which need to be accommodated. In addition, researchers must be cognizant of the impact of age, type of farm, form of business structure, and other characteristics which affect the holding of risky assets versus risk free assets.

When taking into account real purchasing power, no assets can be considered risk free. Rather the riskiness of assets can be viewed as a continuum from low risk to high risk. Farm operators frequently view land as a hedge against inflation. In this sense they are treating land as a low risk asset. Regression estimates with land and financial assets defined as "risk free" suggest that farm operators display decreasing absolute and increasing relative risk aversion. For all of the utility functions examined in Table 1, only the generalized utility function with λ less than one has this set of properties.

The results presented here also indicate that the direct observtion approach to measuring risk attitudes may be useful when applied to portfolio data of farm operators. Of course this study was limited in that only one year's data were available. Ideally, a set of data describing the financial actions of a large number of farm operators over time would be most useful for such analyses.

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