HEDGING WITH OFF-FARM INCOME: IMPLICATIONS FOR PRODUCTION AND INVESTMENT DECISIONS ACROSS FARM SIZES

by

Steven C. Blank

Steven C. Blank is an extension economist in the Agricultural and Resource Economics Department, University of California, Davis, and a member of the Giannini Research Foundation. The author thanks Ken Erickson, Richard Nehring and Charlie Hallahan for their assistance with the data analysis.

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ABSTRACT

This study uses portfolio theory to evaluate the effects of off-farm income on the labor allocation and production decisions of American farmers. It finds that hedging with off-farm income makes markets more risky, although the effects decrease for larger farm sizes. Farmers respond to increases in off-farm income opportunities by producing more-risky crops, but they produce using a smaller percentage of available household labor. Empirically, off-farm income is significant in raising the wealth of only mid-sized farms. It appears that hedging with off-farm income effectively reduces farm households' risk exposure level, but it creates a need for new agricultural policies.

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Off-farm income (OFI) represents a high and increasing percentage of average farm operator household income in the United States (Mishra *et al.*). As shown in Table 1, OFI accounted for about 95% of total farm household income in 2002 whereas it represented only 88% in 1998. This trend has been in place for decades (OFI represented about half of farmers' income in 1964, Mishra *et al.*), but has been more noticeable since the 1980s because real farm income has been trending downward since the 1970s. A long-used explanation for the increase in OFI of farm households is that rural economies have developed, thus making off-farm employment more available to farm families. Certainly, *availability* is a necessary condition, but it is not sufficient to explain why some farmers pursue OFI and others do not. A second explanation has been proposed recently: that off-farm income represents a vehicle with which farm households can hedge against the variability in farm income. This view implies that risk (expressed as farm income variability) and farmers' risk attitudes are the factors driving the decision of whether or not to hedge with OFI. A third explanation sometimes suggested is that farmers pursue OFI to replace lost income from farming operations, thus implying that farmers focus on profit levels, possibly in a safety-first context, when making decisions about OFI. However, what has been overlooked in previous research on this topic is the effects of farm size on the decision to hedge with OFI.

Farm size must be considered to provide a more-complete understanding of the decision-making process of farm households that are allocating some of their labor to off-farm employment. Both the absolute *level* and *variability* of farm incomes are expected to increase with the size of farm. That means different production and investment decisions may be made by producers who are identical in all respects except for the size of their farming operations.

The proposition of OFI as a hedging tool is consistent with the behavior of all types of American farmers. However, a strategy of risk management through labor allocations among on- and off-farm opportunities has wide-ranging implications for agricultural production and investment decisions.

The objective of this study is to evaluate the effects of off-farm income on the labor-allocation and cropping decisions of households across farm sizes in a hedging context. Portfolio theory is well suited to this effort because it facilitates describing farmers as investors facing the decision of how to allocate their labor (and other) assets so as to maximize utility (Robison and Barry). Thus, a simple portfolio model is developed that identifies the optimal hedging position for farm households. Then, the effects of off-farm income opportunities are evaluated across farm sizes using the theoretical model. Finally, regression analysis is used to test hypotheses about the effects of farm size, a variable neglected in the literature.

BACKGROUND

Returns from agriculture have been declining for a century (Schultz; Tweeten; Antle; Mishra and Sandretto). This creates a major source of default risk to farmers and provides an incentive to seek risk-reducing strategies. Unfortunately, the few business tools available for use in managing risks facing farmers (e.g., futures, options, crop insurance) all fail in some regard (Blank, Carter and McDonald). Conversely, the economic literature has shown that OFI can help with both parts of the problem: declining mean income and increasing income variability. For example, Mishra and Sandretto documented that real net farm income has been declining over the past 50 years, and that income variability has not diminished since the 1930s, on either an aggregate or per-farm basis. They also showed that OFI has contributed to significantly raising the level of farm household incomes, relative to non-farm households, since the 1970s, and in reducing the variability of farm household incomes in recent years.

Much work has been done in evaluating the sources of farm income risk and its implications for farm household labor allocations (e.g., Findeis and Reddy). Mishra and El-Osta (2001) evaluated the sources of variability in farm household income and found that farming is the primary source of variability in total income for farms participating in federal commodity programs, while the major source of income variability for nonparticipating households is income from off-farm sources. This indicates that the performance of the markets for a farm's outputs plays a strong role in labor allocation decisions. Empirical results confirm that, as expected, variability in farm income and off-farm income have a positive and negative effect, respectively, on off-farm hours worked by farm operators (Mishra and Holthausen).

Numerous studies have developed empirical estimates of the value of farm operators' time (e.g., El-Osta and Ahearn, Blank 1999). When accounting for the opportunity cost of the farm owner-operator's time, Blank (1999) showed that average net returns to farmers are negative for all regions of the United States. That indicates there are strong incentives to shift labor resources off the farm. This may partially explain the results of Goetz and Debertin who found counteracting effects from off-farm employment opportunities on the probability that a county would have a net loss in farm numbers. They concluded that off-farm employment could, in different local circumstances, lead to net farm losses or a stabilization in farm numbers within a county. This is consistent with other results. For example, Corsi and Findeis found evidence of labor state persistence for Pennsylvania farmers and spouses, thus indicating stability in labor allocations. Ahearn and El-Osta found off-farm work to be (1) a permanent way of life rather than a temporary situation, and (2) a way to supplement household income. Also, El-Osta, Bernat and Ahearn found regional differences in off-farm employment. This result is likely due to both differences in economic development across regions and differences in the profitability of the commodities produced in various locations (Ngarambe, Goetz and Debertin). In total, these previous results lead to a hypothesis that farmers *want* to remain in agriculture and will do so if they can earn sufficient income from all sources to meet their financial obligations and, possibly, increase household wealth.

Although this paper focuses on American farms, the results of international studies of OFI are consistent with domestic studies, implying that there is a consistent decision process for farmers in developed countries. In Canada, farming families depend upon employment in rural communities for family members who want to use their time more profitably (Jean). This is due to the declining profitability of agriculture. Using census data from Israel, Kimhi and Lee found that a one-hour increase in farm labor supply causes a one-hour decrease in off-farm labor supply for men but not for women. Also, Kimhi concluded that part-time farming is a stable situation in Israel, not just a step on the way out of agriculture. However, off-farm employment levels vary over the life cycle and with levels of wealth (Ahituv and Kimhi).

Income variability in agriculture has long been identified as a major source of risk in farm-level analyses (Held). Hedging, as described by Peck and others, is a process with a goal of reducing income variability. It involves combining two or more sources of income that have low or negative levels of correlation in their variability over time so as to reduce the net level of variation in total household income. One such strategy is to combine nonfarm investments with farm production operations (e.g., Betubiza and Leatham). Andersson, Ramamurtie and Ramaswami provide a detailed theoretical model of this process and note the importance of household wealth in decision-making.

When implementing a hedging strategy, a key factor is determining the "hedge ratio," or relative allocations in the two investments (Kawaller and Koch). Since Kahl explained the process for determining the "optimal hedge ratio," much empirical research has applied it in various situations (e.g., Briys and Pieptea).

Viceira showed one relationship between income variability and labor allocations in the nonfarm sector, noting that the analytical process involves choosing an optimal "portfolio." He showed that, for nonfarm households, employment status (i.e., income and its stability) affects the level and composition of investments in risky assets. In this paper, it is argued that the level and composition of a farmer's investment in producing risky agricultural enterprises (expressed as income and its variability) affect the household's off-farm income (i.e., employment) status. The decision process follows portfolio theory.

A PORTFOLIO MODEL OF OFF-FARM INCOME EFFECTS

Crop market opportunities available to farmers vary over time and space. It is possible that a farmer's financial obligations and/or risk preference may not be satisfied by any of the returns currently expected from producing specific crops. In this case the farmer may consider "selling" some of the household's labor in some local market, rather than allocating it all to farming operations. The off-farm sales price of farm labor (i.e., the wage rate) was shown by El-Osta and Ahearn to depend on the current labor supply in the local market, local demand for particular skills, and the level of skills possessed by the individual job seeker (i.e., the human capital). Thus, the decision of whether to allocate some household labor to off-farm employment involves a comparison of the expected income from farming operations and the cost of foregoing off-farm opportunities.

A person deciding whether to produce crop and/or livestock enterprises in a particular market must first identify the opportunities available in that market. Those opportunities can be plotted on an expected return-variance (EV) graph to facilitate analysis.[1] This is done for a hypothetical market in Figure 1. The curved line labeled "EV" represents the opportunity set available to farmers within some geographic market. Each point on the EV is an enterprise or portfolio of enterprises that is efficient in terms of its return/risk relationship. The location and shape of the EV is determined by the data used to calculate expected returns for all portfolios.

If no off-farm employment is available, for whatever reason, farmers can invest household labor only in the production of crops and/or livestock. Each person would choose to produce the portfolio represented by the point on the EV that is tangent to one of his or her

[1] Although expected utility maximization is the objective of decision making in portfolio theory, graphical EV analysis is used here because it simplifies the presentation of relevant economic concepts. Also, Freund shows that shifting from mathematical expressions in EV analysis to expected utility analysis is made easy by focusing on the certainty equivalent of expected returns. However, much literature argues that two-moment decision models are consistent with expected utility maximization only if the choice set or the agent's preferences are restricted (Levy; Levy and Markowitz). Yet, Meyer notes that common restrictions, such as quadratic utility or normality assumptions, are not required for EV and utility maximization to be consistent. He showed that the location and scale condition, which fits many economic models (like the one here), is sufficient to ensure an EV ranking of elements in a choice set is consistent with an expected utility maximization ranking of random variables.

indifference curves. This leads to different enterprise portfolios being produced by farmers with different risk attitudes.

If off-farm income is available, the opportunity set available to farmers is altered. In this study, a risk-free return (R_f) to labor is defined as the highest amount of money a farmer could earn from working off-farm. That amount is the product of the hourly wage rate offered and the number of hours that can be worked (usually assumed to be "full-time," but could be less). Such a risk-free return is available only if an active labor market exists for the skills a farmer possesses. Working only off-farm is analogous to investing entirely in a risk-free asset, which has a return of R_f, and is plotted as a point on the vertical axis of an EV graph.

When off-farm income is available, and under the assumption of efficient markets, the separation theorem indicates that all farmers who have the same returns expectations (represented by a single EV curve) and OFI opportunities will produce the same crops, although the composition of their selected portfolios will still vary with their risk attitudes (Johnson). Using the risk-free return, a single optimal risky portfolio and a farmer's opportunity line (OL) can be identified. The OL represents the opportunity set available to farmers in a market (given some returns expectations). It is plotted as a straight line that passes through the point representing the risk-free return and is tangent to the EV. The OL dominates the EV at all points except where the two frontiers are tangent. The point of tangency represents the market's "optimal" portfolio, which has expected returns of $E(R_m)$. The particular portfolio selected by each farmer is found at the point of tangency between this linear OL and an indifference curve for that person. The selected portfolio in this case is a mix of the market portfolio of enterprises produced with the portion of labor allocated on-farm, and the risk free asset amount earned as OFI, and has total expected returns of $E(R_i)$.

For example, in Figure 1 the OL existing for farmers when OFI opportunities have the value R_{f1} is the line labeled "1", which is tangent to the EV at point *A*. If a farmer's indifference curve is tangent to line 1 at point *A*, all of that household's labor should be "invested" in producing the crops comprising the optimal portfolio represented by that point. If the indifference curve is tangent at some point to the left of *A*, the household will invest some labor in producing portfolio *A* (the specific combination of crops in the optimal portfolio) and will invest the remaining labor in the risk-free asset by working off the farm. Points on the OL to the right of *A* require an investment in portfolio *A* involving all of a household's labor and some additional hired labor. Thus, all labor used for crop production by farmers sharing the expectations represented by the EV will be used to produce the same portfolio of enterprises in the same relative proportions. The only difference in composition of selected portfolios between farmers will be the relative proportions of available labor each chooses to use on- or off-farm (and the resulting difference in total agricultural output due to different input levels). This result comes from the separation theorem that suggests that the selection of the crop mix does not depend upon the decision maker's risk preferences, since it is constant along the OL. Instead, the amount of labor allocated on- or off-farm is the variable affected by risk preferences (see Johnson; Turvey *et al.* for further explanation of the separation theorem). This is consistent with Viceira's results for labor allocations made in the nonfarm sector.

A farmer's profit function for holding his or her selected portfolio over some future period can be specified as

$$E(R_i) = E(GR_m)X_m + R_fX_f - K \quad (1)$$

where R_i is net profit (returns) from selected enterprise portfolio *i*, E is the farmer's expectations operator, GR_m is gross returns from the market's optimal enterprise portfolio, R_f is the risk-free return from off-farm employment, X_m is the proportion (or total number of units) of labor used to produce the market portfolio, X_f is the proportion (or total number of units) of labor sold (or hired if negative) off the farm, and *K* is the total fixed costs incurred in owning a farm (including mortgage, property taxes, insurance, investments in improvements, etc.), expressed in per acre (or total dollar) terms. If X_m and X_f are expressed in terms of proportions (hours), they must sum to one (the total hours available). The variance of returns for a portfolio held by a farmer is

(2) $$\sigma^2_i = X_m^2[\sigma^2_m]$$

where σ^2_i and σ^2_m are the variance in expected returns of the selected and optimal portfolios, respectively. The variance of the profit model is the variance of expected returns to the optimal portfolio component only because all other factors are known with certainty and, therefore, have zero variance.

In portfolio theory, utility maximization is assumed to be the objective. Therefore, the focus of decision making is the certainty equivalent of $E(R_i)$, which Freund and others have shown is

(3) $$E(U_i) = E(R_i) - (\gamma/2)(\sigma^2_i)$$

where *U* is utility and γ is a risk-aversion parameter (equaling the slope of the indifference curve at the tangency point) which is positive for risk-averse hedgers.[2] The first-order conditions for equation 3 give the utility-maximizing portfolio composition,

(4) $$X_m = \frac{E(GR_m) - R_f}{\gamma\sigma^2_m}$$

subject to the constraint $X_m \geq 0$, and remembering that the proportion of labor sold or hired (X_f in equation 1) is 100%-X_m. Thus, equation 4 is analogous to the "optimal hedge ratio" for a household allocating its labor to farm and off-farm activities.

EFFECTS OF OFF-FARM INCOME LEVELS

Comparing OFI opportunities to expected production returns leads to implications concerning the decision whether or not to produce and, if so, what crop/livestock enterprises to produce. In general, if the situation facing some farmers is $E(R_m) < R_f$, those households would want to work "full-time" off-farm (but may choose to continue farming as a "leisure" activity, Blank 2002). On the other hand, if $E(R_m) > R_f$, some rational farmers may work full-time on-farm because higher returns are expected from production of efficient agricultural enterprise portfolios. However, most American farmers now allocate some household labor to both farm and off-farm employment activities.

Different cropping possibilities across time and spatial markets generate different levels

[2] Equation 3 is based on negative exponential utility and normality, although similar specifications can be derived using quadratic utility or other assumptions.

of expected income that, in turn, help explain labor allocation differences between dates and locations. For farmers, returns from agricultural production are the alternative to working off the farm and earning the risk-free return. The higher the value of agricultural returns, the more incentive there is for farmers to produce crops rather than to work for others. The reverse is also true. Therefore, it is often necessary to specify a new OL to represent changing market opportunities available to farmers over time and locations.

In this section, the effects of OFI levels on farmers' production and investment decisions are discussed. It is hypothesized that OFI affects cropping decisions both directly and indirectly through other factors, as described in the following subsections.

Direct Effects of Off-Farm Income Changes

The first question to be addressed is, "what direct effects do changes in off-farm income levels have on farmers' cropping decisions?" To begin it is assumed that a farmer has the OFI opportunities reflected by R_{f1}, making line 1 the relevant OL in Figure 1. The indifference curve I_1 reflects the farmer's risk attitude. Since I_1 is tangent to line 1 at point 1, the farmer would select portfolio 1. Portfolio 1 requires that the farmer use all household labor and some additional hired labor for production of the crops in portfolio *A* (the optimal portfolio). Thus, X_m in equation 4 is greater than one (or 100%) in this case.

If OFI opportunities increase to R_{f2}, cropping decisions of the farmer change significantly. Line 2 in Figure 1 becomes the relevant OL and it is tangent to the EV at point *B*. The farmer's utility is increased, as indicated by the move from indifference curve I_1 to I_2. The farmer's new selected portfolio is at point 2. Portfolio 2 requires that the farmer use only part of household labor for production of the crops in portfolio *B* (the new optimal portfolio), with the remaining labor being allocated off-farm ($1 > X_m > 0$). The composition of portfolio *B* is clearly more risky than that of portfolio *A*. As plotted, the difference between portfolios 1 and 2 is a slight reduction in expected returns and a large reduction in risk levels, resulting in an increase in the certainty equivalent (plotted at the intersection of the relevant indifference curve and the vertical axis). Hence, farmers respond to increases in off-farm income levels by producing more-risky crops, but they produce using lower labor inputs (and probably fewer acres).

If available OFI levels increase further to R_{f3}, the farmer's cropping decisions change again. Line 3 in Figure 1 becomes the relevant OL and it is tangent to the EV at point *C*. The farmer's utility is increased further, as indicated by the move from indifference curve I_2 to I_3. The new selected portfolio is at point 3. Portfolio 3 requires that the farmer allocate all household labor off-farm ($X_m = 0$). The composition of the new optimal portfolio, *C*, is more risky than that of portfolio *B* and, considering the farmer's risk preferences, *C* is too risky to produce given current OFI opportunities (thus line 3 is dashed). As plotted, the difference between selected portfolios 2 and 3 is a relatively slight increase in expected returns and a total reduction in risk levels, resulting in another increase in the farmer's certainty equivalent.

In sum, higher OFI opportunities lead to the production of more-risky crops and a "hedge ratio" involving more household labor being allocated off-farm. This can be seen by substituting higher values for R_f in equation 4.

Finally, it is noted that farmers have some control over their OFI opportunities. A person's investments in their own human capital can raise their potential salary in off-farm markets. Much literature has documented that higher education and/or training can improve a person's skills, making him or her more valuable to potential employers. As explained above, higher OFI opportunities create incentives for farmers to produce higher returning crops. Thus, a farmer's personal investments can lead directly and indirectly to higher returns from farming.

Effects of Risk Attitudes

The previous sub-section assumed one set of risk preferences for a farmer; this sub-section outlines how the cropping decision might differ for producers who were more or less risk averse. In particular, the issues addressed here are what effect a decision maker's risk attitudes may have on risk efficiency and labor allocations over the life cycle.

Being more or less risk averse would change a farmer's indifference curve and, hence, his or her choice of portfolios, but it would not change the risk efficiency of his/her selected portfolios. Farmers are always able to select a portfolio on the linear OL involving some efficient combination of the optimal portfolio and off-farm income (if off-farm employment is available). As is evident from equation 4, a more (less) risk-averse farmer would allocate a higher (lower) proportion of household labor off-farm than described earlier. Increasing values of γ reduce the proportion of labor used in production, thereby raising the amount allocated off-farm. Of course, the reverse is also true.

Risk attitudes change over the life cycle, with people usually becoming much more risk-averse as they approach retirement (Viceira). This is due to the reduced time a person has to recover from financial losses as they age. Such an increase in risk aversion means γ in equation 4 grows larger, indicating that the slope of a person's indifference curve at the point of tangency with the EV is steeper with age. In Figure 1 it is easily seen that increasingly steep indifference curves will be tangent to the EV at points moving closer to the vertical axis. This means as a person approaches retirement he/she will allocate more labor off-farm, if possible. This is consistent with the fact that off-farm income as a percentage of household income is highest among farms the USDA's topology labels as "retirement" and other "residential farms" (USDA). For example, "rural residence farms" account for about 63% of all farms in the United States and had an average net cash farm income of -$1,800 per farm over the 1996-2000 period. This means OFI represents over 100% of total household income for this group. Not surprisingly, in 2003 80% of the 851,000 farmers in this group worked full-time off-farm (USDA).

In summary, the positive relationship between risk aversion and off-farm allocations of farm household labor has some implications for the structure of American agriculture. First, the increasing availability of off-farm employment has enabled many highly risk-averse farmers to at least partially remain in agriculture whereas they would have chosen to exit the industry if they faced a choice between full-time farming and full-time off-farm. Off-farm employment opportunities make part-time farming labor allocations possible for risk-averse people who would not be comfortable with the risk-return tradeoff offered by farming only. Second, with an aging farm labor force, the increasing risk aversion of farmers approaching retirement age will cause an increasing percentage of farm labor to be allocated off-farm, *ceteris paribus*. Finally, both of the implications noted above can, in the aggregate, lead farmers to be less responsive to markets for the commodities produced. It is expected that as the percentage of farm household income derived from farming operations declines, farmers may become less likely to make major changes to their operations (e.g., shift from producing one enterprise to another).

Effects of Farm Size

The two other variables on the right side of equation 4, GR_m and σ^2_m, are both functions of farm size. A farmer's gross revenues from producing the optimal enterprise portfolio obviously are expected to increase when that portfolio is produced on more acres. The variance of those returns is also expected to increase as farm size increases. It is easily seen that higher values of GR_m in equation 4 result in more labor being allocated on-farm while higher values for σ^2_m encourage more labor to be allocated off-farm. Thus, in the simplest case, larger farm sizes can have either more or less household labor allocated off-farm, compared to decisions made by the same person when operating a smaller farm.

However, the simple case ignores economies of scale. One of the incentives for farmers to expand the size of their operations is the increased production and management efficiencies that lower production costs per unit, thus increasing profit margins. In other words, it is expected that economies of scale improve the return-risk tradeoff facing operators of increasingly larger farms. That means the value of X_m in equation 4 is expected to grow as farm size grows. This theoretical result is consistent with observed behavior of American farmers: a smaller portion of household labor is allocated off-farm by farms of increasingly larger size (Lee and Blank; Yee, Ahearn and Huffman).

This is illustrated graphically in Figure 2. There are three EV curves in the figure to represent three farms of different sizes, EV_1 being the smallest and EV_3 being the largest. The three curves are drawn so as to illustrate the two ideas mentioned above. First, the fact that returns and risk are positively correlated is shown by the position of each successive EV, from 1 to 3, being drawn above and to the right of previous curves. Second, the efficiency gains from larger sized farms is shown by having larger farms able to earn higher returns at the same levels of risk as available to smaller farms. In other words, a vertical line from the x-axis that intersects two or three of the EVs identifies portfolios (at the points of intersection with each of the EVs) that have identical levels of risk exposure, but have higher returns for larger farms. The effects of farm size on farm labor allocations are illustrated with three OLs drawn from a single off-farm income opportunity, R_1, tangent to the EVs to identify the optimal portfolio for each farm size at the points labeled *A*, *B* and *C*. This shows how a single farmer would react if he or she were operating farms of different sizes. For example, given the OFI opportunity R_1, and assuming the farmer's indifference curve is tangent to OL_1 at point *A*, all household labor would be allocated on-farm to produce the enterprises in portfolio *A*. If that same farmer was operating the farms represented by EV_2 or EV_3, he or she would allocate increasing amounts of (hired) labor to producing portfolios *B* or *C*, respectively.[3] The amount of labor hired would be indicated by the point of tangency between OL_2 or OL_3 and one of that person's indifference curves (not shown in the figure).

Figure 2 also illustrates that increases in OFI opportunities cause farmers to produce more-risky crops (as shown in Figure 1), but the scale of changes in production risk exposure and a farmer's reaction to it vary across farm sizes. For example, a change in OFI opportunities from R_1 to R_2 shifts the optimal portfolio from points *A*, *B* and *C* to points *A**, *B** and *C**, respectively. It is clear in Figure 2 that the new optimal portfolios are each more risky than the original portfolios, but the *amount* of increase in production risk exposure between the pairs of points (measured by the horizontal distance between the points, e.g., between *A* and *A**) is smaller with larger farm sizes. As a result, the points of tangency between the new opportunity lines (1*, 2* and 3*) and the farmer's indifference curves indicate much different hedge ratios

[3] Note that enterprise portfolios *A*, *B* and *C* are plotted to illustrate that increasing farm sizes have different return-risk tradeoffs. Moving from *A* to *B* is clearly an improvement because portfolio *B* offers both higher total returns and a lower level of risk. Conversely, moving from *B* to *C* is less obvious: portfolio *C* offers higher total returns but a higher level of risk. In this case, portfolio *C* is more efficient because it has a better return-risk tradeoff ratio than *B*.

across the farm sizes. If it is assumed that the tangency point for OL 1* is at R_2 on the vertical axis, all labor would be allocated off-farm by the farmer. That same person, however, would not allocate all labor off-farm if he or she was operating the farm represented by OL 2*. Finally, even less labor would go off-farm if the person was operating the largest farm.

EMPIRICAL ANALYSIS

A number of the hypotheses raised in the discussion above were tested empirically with farm household survey data. Specifically, the significance of OFI to household wealth was assessed across farm sizes. Wealth was the focus because studies have shown that wealth affects farmers' financial decision making and degree of risk aversion (e.g., Ahituv and Kimhi; Andersson, Ramamurtie and Ramaswami). Also tested was the contribution of human capital investments to raising farm profitability.

To begin, off-farm income is expected to be important to a farm household because it is a source of wealth (Koenigstein and Lins). Wealth changes (measured by changes in a farmer's total equity) during a period of time ending at *t* consist of farm income (*FInc*) plus off-farm income (*OFInc*) plus capital gains (ΔK) minus consumption (C), or

(5) $$\Delta W_t = FInc_t + OFInc_t + \Delta K_t - C_t.$$

The components on the right-hand side of equation 5 are themselves functions of other factors. For example, the capital variable (*K*) is a function of many other factors. It can be expressed as the sum of the market values for all assets (farm real estate, nonreal estate, and non-farm assets) held by a person at time *t*. Thus, equation 5 can be estimated over time for farms of different sizes to determine whether OFI does, in fact, play a significant role.

Next, the expected profit (i.e., farm income) for farm *i* at time *t*, was specified as

(6) $$E(FInc_{it}) = E[R_{it} - PC_{it} - OK_{it} + (m_i)g(cr_{it})G - \Delta(cr_{it})]$$

where *R*, *PC* and *OK* are defined as the revenue, production costs and ownership costs, respectively. E(•) is the expected value of (•). The expected values of R, PC and OK are the observed values from the previous period. The managerial expertise of firm *i* is denoted m_i. The probability of firm *i* improving its productivity in period *t* is $(m_i)g(cr_{it})$, where cr_{it} is defined as the firm's cumulative investment in human capital and productive resources through time *t* and is some function (g) of profits earned in all prior periods. The potential increase in profits earned by an innovation that improves productivity is *G*. Therefore, estimating equation 6 across farm sizes enables a test of whether human capital investments raise farm profits, and whether economies of scale (expressed as productivity) exist in agricultural production.

These two equations were estimated using farm-level data from the USDA's Agricultural Resource Management Survey (ARMS). A unique pseudo-panel dataset was constructed from the ARMS data, pooling data for 1996-2002 over three regions: the Lake States, the Corn Belt, and the Southeast. These regions were selected to represent production sectors dominated by different commodities: dairy, corn, and specialty crops, respectively. Then the equations were estimated using a two-way fixed effects approach (Baltagi, Chapter 3).

For empirical studies using such panel data, the temporal pattern of a given farm's production behavior must be established. In the absence of genuine panel data, repeated cross-sections of data across farm typologies may be used to construct pseudo panel data (see Deaton; Heshmati and Kumbhakar; and Verbeek and Nijman). A pseudo panel was created here by grouping individual observations into homogeneous cohorts, distinguished according to time-invariant characteristics such as fixed assets, geographic location, or land quality. The empirical analysis was then based on the cohort means rather than the individual farm-level observations.

The farm-level data were assigned to cohorts, based on the USDA's farm typology groups (Hoppe and MacDonald). Then, three farm sizes were identified using the typologies. Farm size 1 includes "limited resource," "retirement," and "residential" farms. These farms all have total sales of less than $250,000 per year and the operators are either "retired" or have another major occupation. Hence, these are often referred to as "hobby farms" and are expected to be less responsive to agricultural markets than are farms that provide the primary source of income for a household. Farm size 2 includes typologies "farm/lower sales" and "farm/higher sales." Their total annual sales are also less than $250,000, but farming is the operator's primary occupation, thus these operators are expected to be highly responsive to market opportunities. Farm size 3 covers the typologies "large family farms" and "very large farms" that have annual sales of $250,000 and more.

There were 13 sales level cohorts per state and 14 states, resulting in a total of 182 cross-sectional entities per year, totaling 1,274 for the seven years covered by the surveys. These entities are referred to as "firms." In general, the cohorts averaged close to 30 survey observations each, but cohorts with no observations occurred in a couple states. Thus, the equations were estimated using unbalanced panels.

The problem when using time series and cross-sectional data to estimate a relationship is to specify a model that will adequately allow for differences in behavior over cross-sectional units as well as for differences in behavior over time for a given cross-sectional unit (Judge *et al.*). Fixed effects regression is a method of controlling for omitted variables in panel data when the omitted variables vary across "firms" but do not change over time. The combined time and state fixed effects regression model estimated here for equations 5 and 6 eliminates omitted variables bias arising both from unobserved variables that are constant over time and from unobserved variables that are constant across states. Estimation of reduced forms of the equations was by ordinary least squares since these equations constitute a recursive system (Hsiao; Greene, p. 659).

Change in Wealth Estimation Results

Equation 5 was estimated with variables representing capital gains coming from both farm and non-farm capital, although most farm household wealth is held in the form of farmland. Both capital components were highly significant when examining changes in farm wealth across farm sizes (Table 2). Income generally was not significant, therefore wealth comes from capital, not income, for all farm sizes. This result is important in understanding farm household decision-making. In particular, it partially explains why small farms that lose money each year on their production stay in agriculture: if their capital gains exceed their operating losses, the farm is increasing the wealth of its owners.

Non-farm income was significant for mid-size farms only. This may be because off-farm income is more stable over time than is farm income for small-sized firms, and off-farm income may be a small part of large farms' total wealth, thus the lack of statistical significance in explaining changes in wealth for farm sizes 1 and 3 (Mishra *et al.*, p. 26). The negative sign on OFI for size 2 farms leads to the surprising conclusion that time spent working off-farm apparently does not compensate for the lost capital gains that might have been earned on farm capital had the labor been allocated toward improving crop revenues per acre.

Finally, the absolute and relative sizes of the coefficients for changes in farm capital and changes in non-farm capital across farm sizes have policy implications. Those coefficients are the marginal returns available to households at each farm size. For farm size 1, the coefficient for farm capital is larger that the coefficient for non-farm capital, indicating there is relatively more incentive for those households to invest in farm assets. Unfortunately, those people are either retired or have limited resources, thus it is unlikely that they will make significantly more farm investments. For farm size 2 the coefficients are nearly equal. However, the coefficients for farm size 3 show a much greater incentive to invest in non-farm assets due to agriculture's rapidly diminishing marginal returns. Therefore, America's largest and possibly most efficient farms are better served in current markets by shifting resources out of agriculture.

Farm Profits Estimation Results

Equation 6 was estimated with variables included to represent economies of scale and managerial skills (Table 3). Economies of scale are reflected in the *Productivity* variable. The fact that its coefficient decreased in absolute size as farm size increased, and that the variable was significant for farm sizes 1 and 2, but not for farm size 3, shows that economies of scale are captured by larger farms, but it implies that scale economies are exhausted at some large size.

The variable *HumanCapitalEd*, which represents the productivity and investment components of human capital, was significant for only size 2 farms. This result, combined with the result for productivity noted above, is important because it shows that farm size affects personal investment decisions. It may also indicate that there is a substitution effect between economies of scale and managerial skills. To begin, investments in human capital have insignificant effects on production profits of farm size 1 operations because the retired and/or limited resource farmers do not have the desire or assets needed to apply their improved skills so as to capture available productivity improvements. For farm size 2 operations, managers have the desire and opportunity to become more productive, thus human capital investments offer significant rewards for these producers. On the other hand, farm size 3 operators receive no significant increase in profits from human capital investments because the economies of scale already captured apparently leave little room for productivity improvements.[4]

SUMMARY AND CONCLUSIONS

This study uses portfolio theory to evaluate the effects of off-farm income levels on farmers' production and investment decisions. An "optimal hedge ratio" of farm household labor allocated on- and off-farm is derived from a simple model of hedging with off-farm income. It is found that off-farm income opportunities have direct and indirect effects on cropping decisions and farm household wealth.

Risk attitudes do not affect the composition of the "optimal portfolio" of agricultural enterprises, but risk aversion is positively related to the proportion of household labor allocated

[4] It is not tested here, but this result raises the hypothesis that human capital investments of farm size 3 operators may benefit the firm by reducing the volatility (i.e., risk) of farm profits, even though those investments do not appear to raise the average level of profits. In other words, investments in improved decision-making skills, such as knowledge of how to hedge against income risk, may be justified for large scale farms if those investments reduce the firm's risk exposure, even if they do not raise average profit totals.

off-farm. This means the trend of increasing average age of farm operators is partly responsible for the trend of increasing levels of off-farm income because people become more risk averse as they approach retirement age.

Farm size is shown to have significant effects on production and investment decisions through the improved return-risk tradeoff coming from economies of scale. As a result, large farm operators are expected to pursue fewer OFI opportunities than are small farm operators.

Taken together, the results from the simple model presented here have some significant implications for both American agriculture and policy. To begin, hedging with OFI makes markets more risky in that the composition of enterprise portfolios produced by individuals with off-farm income is more risky. In other words, total output of "risky" crops increases with OFI. Second, hedging with OFI enables many risk-averse farmers to remain in agriculture longer than they would without OFI. Third, as OFI increases as a proportion of total household income, it facilitates hysteresis in that farmers become less likely to diversify or to use other risk-reducing strategies (Mishra and El-Osta 2002). This, in turn, makes markets less responsive[5] and agricultural policies aimed at market operations less effective.

The empirical results provide evidence that farm size affects both farm wealth and production profits. Changes in farm and non-farm capital have differential impacts on farm wealth by farm size. In general, the fact that changes in non-farm capital have larger impacts than do changes in farm capital for larger farms implies that there are economic incentives for those farms to shift resources out of agriculture. On the other hand, smaller farms have opportunities to raise production profits by capturing existing potential productivity improvements, while economies of scale appear to have been captured by larger farms. Finally, the off-farm opportunities of small farm operators can be improved through human capital investments that, in turn, can raise operating profits by enabling the production of higher-value crops (through a move to a higher indifference curve of the farmer).

In summary, hedging with off-farm income is effective in reducing farm households' level of risk exposure, but the increase in its use makes clear there is a need for new agricultural policies. When a majority of farmers voluntarily stay in agriculture despite low or negative profits, policies based on profit-maximizing behavior by all farmers are obviously inappropriate. New policies must adopt the wealth- and utility-maximizing perspectives of today's American farmers. For example, policies intending to stimulate investments in small "hobby" farms will be ineffective for the nation. However, policies that direct resources to mid-sized farms and their human capital may generate the best production and investment results for American agriculture.

[5] The lack of responsiveness to markets by farm size 1 operators is apparent in the insignificance of the *CashFlow* variable in equation 6 (Table 3).

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Figure 1. Farm Labor Allocation and Production Decisions

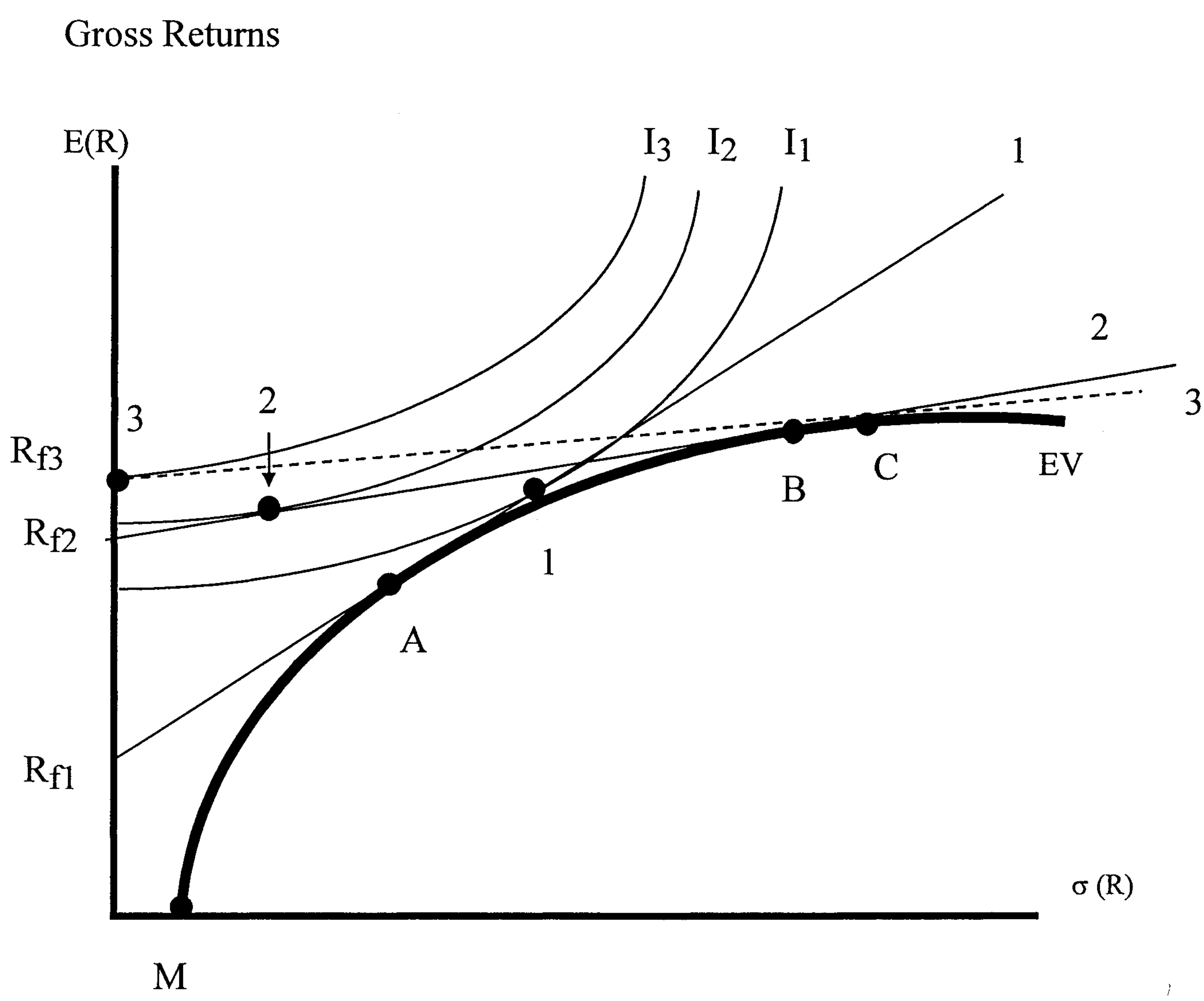

Figure 2. Off-Farm Income and Farm Size Effects

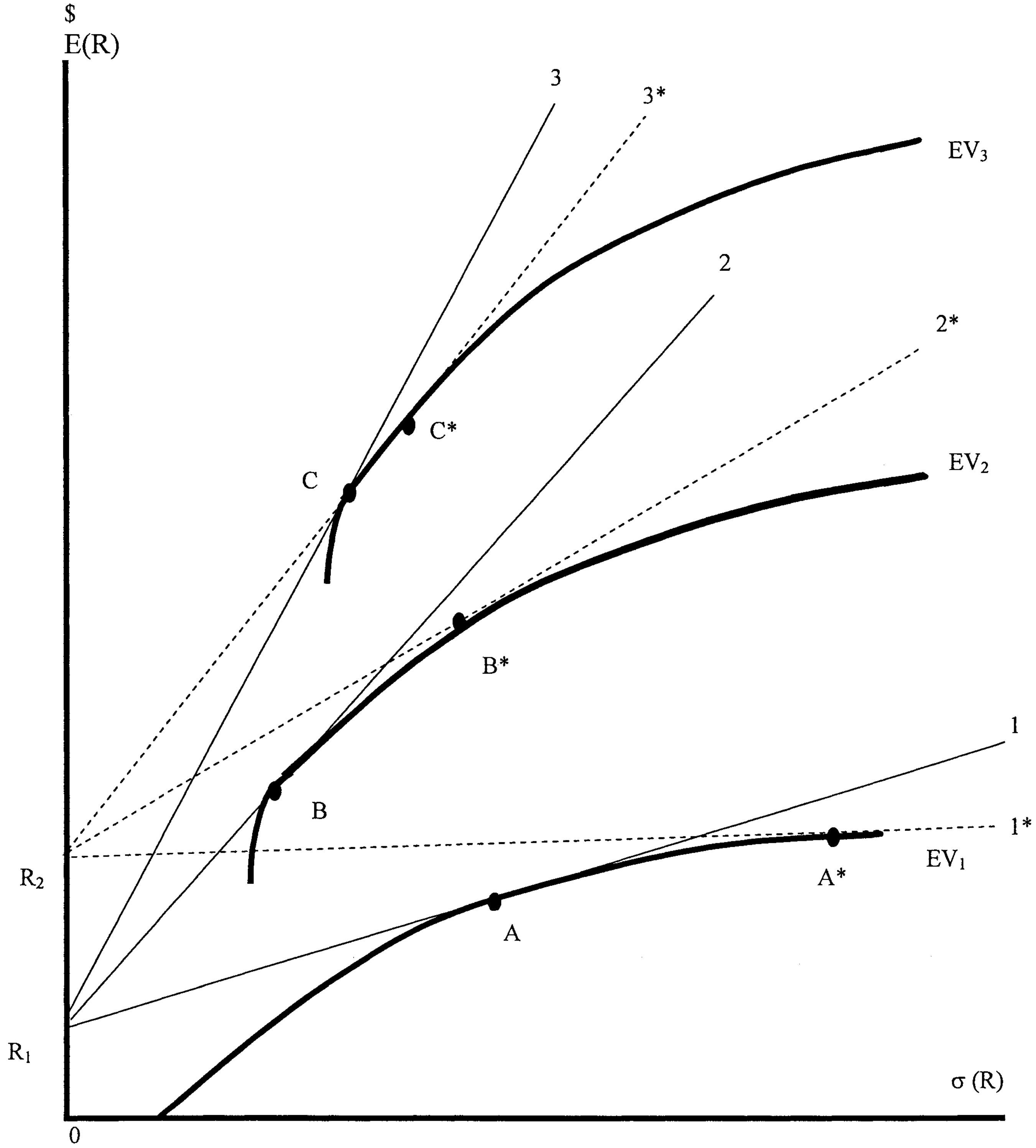

Table 1. U.S. Farm Income, 1998-2003

	1998	1999	2000	2001	2002	2003
			$ billion			
Total cash receipts	195.8	187.6	192.1	200.1	195.1	211.6
Net farm income	42.9	46.8	47.9	50.6	37.3	59.2
Direct government payments	12.4	21.5	22.9	20.7	11.0	15.9
Adjusted production income*	30.5	25.3	25.0	29.9	26.3	43.3
			$ per farm operator household			
Net cash farm income	14,357	13,194	11,175	14,311	11,331	14,569
Earnings from farming	7,106	6,359	2,598	5,539	3,473	7,640
Off-farm earnings	52,628	57,988	59,349	58,578	62,285	60,865
Average farm household income**	59,734	64,347	61,947	64,117	65,757	68,506

Source: USDA (and earlier issues)
* This is calculated as net farm income minus direct government payments.
** This is the sum of "earnings from farming" and "off-farm earnings."

Table 2. Change in Wealth Estimation Results by Farm Size (1996-2002)

	Farm Size 1		*Farm Size 2*		*Farm Size 3*	
Variable	**Estimate**	**t statistic**	**Estimate**	**t statistic**	**Estimate**	**t statistic**
FarmInc	0.1662	0.48	0.3110	1.63	0.0005	0.00
NonFarmInc	-0.1638	-1.47	-0.4293	-1.88*	-1.6816	-0.88
ChngFarmCap	0.9908	118.62***	0.9374	69.83***	0.2568	21.68***
ChngNFarmCap	0.8597	30.58***	0.9439	18.94***	0.6524	2.22**
Consumption	0.2698	0.93	-1.0688	-1.96**	2.3527	0.92
Fixed Effects						
Year	***		***		NS	

***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 confidence levels. NS denotes "not significant."

Farm Size 1 corresponds to limited resource, retirement, and residential farms. Farm Size 2 corresponds to farm/lower sales and farm/higher sales. Farm Size 3 is large family farms and very large farms.

Table 3. Profits Equation Estimation Results by Farm Size (1996-2002)

	Farm Size 1		*Farm Size 2*		*Farm Size 3*	
Variable	**Estimate**	**t statistic**	**Estimate**	**t statistic**	**Estimate**	**t statistic**
CashFlow	0.0129	0.51	0.0771	3.48**	0.0054	5.82***
TotalExpenses	-0.0663	-2.32**	-0.0237	-3.25**	-0.0038	-3.69**
Depreciation	-0.0600	-1.15	-0.1678	-9.35***	-0.0485	-5.11***
Productivity	1.7527	2.23**	0.7212	2.09**	0.0456	0.24
HumanCapitalEd	1.5789	1.37	6.8049	3.49**	0.0022	0.05
Fixed Effects						
Firm	*		***		**	
Year	*		*		NS	

***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 confidence levels. NS denotes "not significant."

Farm Size 1 corresponds to limited resource, retirement, and residential farms. Farm Size 2 corresponds to farm/lower sales and farm/higher sales. Farm Size 3 is large family farms and very large farms.