Off-farm Income and Risky Investments:
What Happens to Farm and Nonfarm Assets?

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Introduction

Can off-farm income help small farms to survive by providing a means of diversifying their farm household portfolios[1]? The farm household structure is a complex set of inter-relationships between and among a variety of internal and external factors involving consumption, investment, and income-earning activities. The importance of the farm as an activity included in the household portfolio will vary among households (Morehart et al. 2004; Mishra et al., 2002).

Andersson et al. use a household portfolio model to explain the farm household investor's response to an increase in off-farm income. The risk-averse farm investor holds a portfolio of assets (farm and nonfarm), and may also work off-farm. We use the USDA's Agricultural Resource Management Survey (ARMS) data and a unique pseudo-panel dataset to examine the effect of off-farm income on the composition of risky farm household portfolios, by region and by farm size and typology. In the absence of genuine panel data, repeated cross-sections of data across farm typologies may be used to construct pseudo-panel data (Deaton, Verbeek and Nijman). A pseudo-panel is created by grouping individual observations such as farm and nonfarm assets, geographic location, or farm household wealth. The empirical analysis is then based on the cohort means rather than the individual farm-level observations.

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[1] Henceforth "farm" refers to any place from which $1000 or more of agricultural products were produced and sold. "Farm household portfolio" includes the farm and nonfarm assets of the household (*ATOT*, USDA-ARMS).

The adjustment processes of the agricultural sector are well studied. However, not all aspects of the structural change are well understood. For example, farm households today receive a substantial part of their income from nonfarm sources such as wage and salary jobs, nonfarm businesses and services. In the U.S., for example, income from off-farm sources accounted for 90% of the total income for farm households in 1999 (USDA-ERS, Mishra et al, 2002). Other studies documenting the importance of off-farm income are Fuller (1991), Huffman (1991) and Weiss (1999). The picture remains the same if part-time farm households are defined on the basis of time spent in farming. In a study of off-farm employment in Austria, Weiss (1997) estimates that on more than 50% of farms, the husband and wife work less than 50% of their working time on the farm.

These findings may seem surprising since it is generally presumed that full-time farm operations are more efficient than part-time farms. Full-time operations have the advantage of scale efficient technology and lower costs of credit. This led Cochrane to comment, "…most [part-time farms] are going to bite the dust…cannibalized by their larger, aggressive, innovative neighbours" (Cochrane, 1987). However, there is little evidence that this is happening. Instead, studies indicate that mid-sized farms are squeezed out as the size structure of farms settles to a bi-modal distribution where farms are either large full-time operations or small part-time activities (Weiss, 1999).

In general, off-farm work has provided a mechanism for maintaining income parity with other categories in the society (Gardner, 1992). Gardner (2005) also notes that the integration of farm and nonfarm labor markets has slowed the overall rate of decline in the number of farms. Now many people are commuting to nonfarm jobs while they remain living on the farm. Furthermore, according to Gardner, small farms are flourishing to an extent that no one guessed 20 or 30 years ago. Presumably, off-farm income has contributed to reducing the riskiness of the income stream facing the farm household. However, if part-time farms are less economically efficient then lower rates of returns on total assets should lead to their exit. Previous studies have examined investment behaviour of farm households but have not taken into account the riskiness of nonfarm assets as well as the riskiness of off-farm income (Ahituv et al., 2002) and Serra et al. (2004). Serra et al. find that off-farm income increases the share of non-farm investments while Ashituv et al. only consider farm assets without explicitly considering off-farm income.

To what extent does off-farm income affect the investment behaviour of the farm household farm/non-farm assets, given that both asset categories are risky? Furthermore, what are the effects on investment behaviour if the magnitude and riskiness of off-farm income are taken into account?

Objectives

The objective of this paper is to examine what determines the structure of farm household portfolios. To do this we apply the results derived from a theoretical model developed by Andersson et al. (2003). The qualitative results obtained from the model are tested econometrically in order to assess the impact on investment behaviour. Tests are performed for the shares/total investment in non-farm assets as well as in farm assets owned by the farm household. Furthermore, the model allows us to assess the risk-adjusted value to the farm household of the future income stream of off-farm income.

Household portfolios serve several important objectives. First, they help finance retirement. Second, savings can act as household buffer stocks in both upturns and downturns of the economy. Third, households can spread their portfolio risk over their lifetime consumption patterns through portfolio diversification and re-balancing of asset holdings.

Two other factors have important implications for household portfolios. First, the presence of liquidity constraints on consumption smoothing must be considered. This suggests that the cost of credit (interest rate) could affect investment shares. Second, the greater risks borne by households are not insurable portfolio risks but uninsurable risks affecting their human capital. This suggests that households bearing a larger risk on their human capital would choose to invest less in risky assets.

Model

Consider a farm household where the spouse is employed in a part-time job. Suppose, for some reason, off-farm earnings rise. How does this affect the household's choice of investments? Would it ever lead to an increase in farm investment?

To examine when this might be true, we consider a portfolio choice model with labor income. The household receives a stochastic stream of labor income and can invest in a risk-free asset or a risky portfolio consisting of a farm asset and a nonfarm asset. The correlation structure between the three risky sources of income (farm asset, nonfarm asset, and labor income) is unrestricted except for the assumption that the three traded assets span labor income. This means that there exists a combination of the traded assets that has the same risk characteristics as off-farm income.

Andersson et al. (2003) use a dynamic choice model rather than a static one because it enables them to consider wealth effects of changes in the level of labor income. Optimal investments can be decomposed into a *tangency portfolio* and a *hedge portfolio*. The tangency portfolio is the point of tangency of the borrowing-lending line with the mean-variance frontier and the hedge portfolio allocation is entirely due to the riskiness of off-farm income. The hedge portfolio's return provides maximum negative correlation with the change in off-farm income (Ingersoll, 1987, p. 282).

Andersson et al. (2003) demonstrate that the total investments in risky assets, under the spanning assumption, is given by

$$\mathbf{1}'W\boldsymbol{\Omega}^{*} = (1/A(W+bV))\mathbf{1}'\mathbf{t} - (1+b)\mathbf{1}'\boldsymbol{\Sigma}^{-1}\boldsymbol{\Phi}_{qv}V \qquad (1)$$

where $A(.)$ is the risk aversion of the indirect utility function, W wealth, b a risk adjusted discount rate, $\boldsymbol{\Sigma}$ a covariance matrix of returns on risky assets, $\boldsymbol{\Phi}_{qv}$ is a vector of covariances between the growth rate of off-farm income and the returns on the risky assets.

Differentiating with respect to V *(off-farm income)*,

$$\partial(\mathbf{1}'W\boldsymbol{\Omega}^{*})/\partial V = -(A'/A^{2})b\mathbf{1}'\mathbf{t} - (1+b)\mathbf{1}'\boldsymbol{\Sigma}^{-1}\boldsymbol{\Phi}_{qv} \qquad (2)$$

If risk aversion is decreasing in wealth, the first term is positive and higher off-farm income increases wealth, reduces risk aversion and thus leads to an increase in investments in risky assets. The second term represents a portfolio rebalancing effect. As V increases, the farm household alters the hedge portfolio to reduce the risk associated with higher income. It is apparent that these portfolio adjustments in general depend on the relative magnitude of correlations and standard deviations and their signs.

Consider now the effect of off-farm income on the composition of the risky portfolio consisting of the farm and nonfarm asset. It is hard to unambiguously predict the qualitative direction of the adjustments. One option is to examine the demand for individual assets such as the farm asset. The impact of off-farm income on the demand for farm assets is given by

$$\partial(W\omega_f^*)/\partial V = -(A'/A^2)bt_f - (1/s_f)(1+b)(K_{fv} - K_{fp}K_{pv})\sigma \qquad (3)$$

where t_f is the first element of the vector ***t*****,** defined as the traditional tangency portfolio.

The first term is the *wealth effect* and leads to an increase in investment. The intuition provided by (3) is that if K_{fv} is low, farm assets serve as a hedge to off-farm income and therefore an increase in off-farm income is associated with an increase in the investments in farm assets. The second term is the *portfolio re-balancing effect*. Andersson (2003) notes that farm households would want to hold different proportions of the risky assets depending on the correlation of their off-farm income earnings with the returns on the risky assets (farm and nonfarm assets). He further shows that as off-farm income increases, a farm household reduces the portfolio weight of the riskier asset (p. 483). Hence, it is possible that even though the farm asset has a higher CV than the financial asset, an increase in income increases the allocation to the farm asset if the correlation of off-farm income with farm returns is much less than the correlation of off-farm income and returns from nonfarm assets. Therefore, an increase in off-farm income on the farm investments depends on the net impacts of both the wealth and re-balancing effects. We now describe the empirical strategy for estimating the farm household portfolio investment shares model.

A number of studies suggest that adding high-risk financial assets with expected higher returns can reduce the overall risk associated with farm investments (Young and Barry, 1987; Irwin et al., 1988; Moss et al., 1987; Crisostomo and Featherstone, 1990; Weldon, 1988. Penson (1972) argued that investment in financial assets is an attractive means of diversification for many farmers.

Procedure

The investment equation given by (1) is estimated for nonfarm and farm assets using ordinary least squares (OLS). Estimation is conducted in shareform following Hochguertel (2002), where the independent variable is farm assets divided by total assets (farm and nonfarm). We initially planned to use a censored two-limit Tobit estimator following Hochguertel (2002) but found that the two-limit Tobit did not converge because ARMS pseudo-panel dataset did not yield enough observations at 0 or 1. OLS (unlike the two-limit Tobit) does not predict any negative shares and only a few predicted shares were slightly greater than 1. We also ran regressions using the change in farm assets/change in farm assets plus change in nonfarm assets as an alternative to estimation in shareform using robust regression methods. These regressions were not subject to the restriction that predicted shares be between 0 and 1.

We use farm-level data from the USDA's Agricultural Resource Management Survey (ARMS). We construct a pseudo-panel dataset from pooled ARMS data for 1996-2002 over three regions: the Lake States, the Corn Belt, and the Southeast. These regions were selected to represent, respectively, production sectors dominated by wheat, corn, and specialty crops. The pseudo-panel data set contains 13 cohorts per state in each year. Cohorts are aggregations of individual farms of similar size and characteristics and are tracked in each state. Explanatory variables are household and socioeconomic characteristics, level of wealth, nonfarm income, and other farm characteristics. The data enable us to measure off-farm income, and ex post returns to various asset categories such as farm and nonfarm assets.

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, we used repeated cross-sections of data across farm typologies to construct a pseudo panel dataset. We grouped the individual observations into homogeneous cohorts, distinguished according to time-invariant characteristics such as fixed assets, geographic location, or land quality. The empirical analysis is then based on the cohort means rather than the individual farm-level observations.

We assigned the farm-level data to cohorts, based on the ERS farm typology (TYP) groups (Hoppe and MacDonald). The typologies and cohorts are summarized in table 1. The data in TYP1-3 (limited resource, retirement, and residential) are relatively limited compared to the traditional farm data. Therefore, they were further grouped into three cohorts by level of agricultural sales. Three cohorts each were similarly defined for TYP4 and 6, and two each were designated for TYP5 and TYP7&8. A cohort group is formed for each state in the sample. Thus, there are 13 cohorts per state and 14 states, resulting in a total of 182 cross-sectional entities per year. We will refer to these entities as "firms," where "firm" is the farm household. In general, the cohorts averaged close to 30 observations and form a balanced panel in the Lake States and Corn Belt. Cohorts with no observations occurred in the Southeast. Thus, we estimated the equations using unbalanced panels.

The pseudo panel data we use are the weighted mean values of the variables to be analyzed, by cohort, state, and year. For example, for the Corn Belt states we have 65 observations per year, for our 5-state sample. To present our results below, we group these cohorts into (i) residential farms (RES, COH1-3); (ii) small family farms (SM, COH4-6); (iii) larger family farms (LG, COH7-10); and (d) very large family and non-family farms (VLG, COH11-13).

Following Alessie, Hochguertel, and van Soest (2002) we analyze the shares of farm financial portfolios invested in risky assets (farm and nonfarm) by the farm operator household-owners of these assets. Hsiao(2003) notes that the presence of unobserved heterogeneity is the most typical concern in empirical work using panel data.

Our aim is to study how nonfarm income affects the shares of farm and nonfarm assets of farm operator households. We may or may not observe the value of the desired level (or share) of risky assets w_{it}^{*} for each household *i* at time *t*, but we know whether farm households hold farm and nonfarm assets and want to study the ownership (or participation) probabilities Pr(w_{it}=1) where

w_{it}= 1 if w_{it}^{*}> 0 or w_{it} = 0 if $w_{it}^{*} \leq$ if short sales are not permitted.

If we assume that ownership is independent over time, then ownership probabilities can be studied using standard cross-section discrete models. That is, current ownership is not affected by past ownership. However, there are two major reasons why ownership may not be independent over time.

1. Heterogeneity. Farm households are characterized by unobservable variables that affect their risk aversion and their information set and, hence, their attitudes toward investment in risky assets (Miniaci and Weber, 2002 and Mishra et al., 2002).
2. True state dependence. Some theoretical models suggest that due to transaction costs and cumulated experience, current ownership depends on past ownership (Miniaci and Weber, 2002).

Different assumptions regarding the presence and nature of heterogeneity and state dependence will affect the specification of the model, its statistical properties, and computational burden.

The problem when using time series and cross-sectional data is to specify a model that will adequately allow for differences in behaviour over time as well as for a given cross-sectional unit. Fixed effects regression is a method of controlling for omitted variables in panel data when the omitted variables vary across subjects and/or over time. (We refer to "firm" and/or "cohort" as "subject effects", where "firm" is the farm household). We assume that unobservable individual heterogeneity is relevant but that time varying effects such as expectation errors are serially independent and that there is no true state dependence (Miniaci and Weber, pp. 148-150). We considered relaxing the assumption of serial independence and estimating a random effects model in which we assume that unobservable heterogeneity is relevant but that the μ_{it}, the time-varying effects such as individual income innovations or expectation errors may be correlated. However, we ran the Hausman test for fixed versus random effects and rejected the random effects specification.

We include both location and time effects to test if some omitted variables are constant over time but vary across regions, while other variables are constant across states but vary over time. This is done by including both $n - 1$ subject dummy variables and $T - 1$ time dummy variables in the regression, plus an intercept. We estimate a two-way fixed effects model (4). We pool cohort means with the individual observations collapsed into the cohort means.

The combined time and firm fixed effects regression model is

$$\textit{Cohort and Time fixed effects: } InvShare_{it} = \alpha_0 + \alpha_i + \gamma_t + \beta' X_{it} + \varepsilon_{it} \qquad \textbf{(4)}$$

where *InvShare* is the share of farm assets as a share of total assets, and X_{it} is a vector of explanatory variables including principal operator age (*Age*), education (*Education*), farm income (*FarmIncome*), nonfarm income (*NonfarmIncome*), wealth (*Wealth*), and the average interest rate on farm debt outstanding (*CostCapital),* and *Wages & Salaries* (later dropped from the model). The model has an overall constant term as well as a group or cohort effect for each cohort and a time effect for each time period. The cohort effect could also reflect time invariant risk aversion across cohorts (Miniaci and Weber, p 149). The combined time and subject fixed effects regression model accounts for omitted variables that vary over time and/or across subjects. F-tests indicate that the time and cohort fixed effects are highly significant.

The estimates from the equations shed some light on the puzzle to what extent and how off-farm income contributes to or mitigates structural change in agriculture. Furthermore, the accessible data provides an estimate of *b* (in (1)) that enables us to assess the present value of off-farm income for various farm categories.

Farm share of investment = f (*Age*, *Education*, *Wealth*, *FarmIncome*, *NonfarmIncome*, *CostCapital*, *FarmType*, *RateReturnEquity*)

with a “Year” and “Cohort” dummy for the two-way fixed effects model). See tables 2, 3, and 4.

We estimate the investment share equation (5) by region (table 2) and with all regions combined (table 3). Tables 4 and 5 give the definitions and summary statistics for variables used in the regressions. Because the Andersson (2003) and the Hochguertel

(2002) formulations demonstrate that the effects of an increase in off-farm income on the investment shares vary by region and by farm size (typology), we include dummy and interaction variables to account for this heterogeneity. See tables 6 and 7.

In developing the investment shares model, we asked two basic questions. First, how do off-farm earnings affect the household's choice of investments (farm and nonfarm)? Second, would an increase in off-farm earnings ever lead to an increase in farm investment?

Age is hypothesized to have a positive impact on off-farm investment (Mishra and Morehart, 2001) and (Young and Barry, 1987). *Age,* a proxy for constraints on borrowing, may disproportionately affect the young because they have few assets. *Education* is expected to have a positive effect on off-farm investment because producers with a higher level of education are more likely to study complex investment markets (Mishra and Morehart). *Wealth* (which includes both farm and nonfarm wealth) is expected to have a positive impact on off-farm investment. It is assumed that a household/producer with greater equity would have more resources to invest off-farm in financial assets (Mishra and Morehart). Farm households that report off-farm income are expected to have a higher proportion of off-farm assets. This is because many off-farm jobs have incentive savings options such as 401K plans that may be funded in part or entirely by the employer. Therefore, we expect a positive relationship between off-farm income and off-farm investment. We expect a positive relationship between the *RateReturnEquity* and off-farm investment, but perhaps less strong than the relationship between wealth and off-farm investment. This is because risk-averse farm household investors would likely capitalize only a portion of these expected returns into farm and non-farm assets (wealth). Finally, we expect a negative relationship between *CostCapital* (the average interest rate on farm debt) and investment in farm assets simply because higher borrowing costs, ceteris paribus, would lead to lower levels of overall investment in land, farm machinery, and other farm assets. However, the overall impact of an increase in *CostCapital* would depend on how the shift in the borrowing-lending line with the mean-variance frontier affects the tangency portfolio and how the riskiness of off-farm income affects the hedge portfolio. Therefore, we have no priors for how *CostCapital* will affect investment shares in farm versus nonfarm assets.

Empirical Results

We ran the two-way fixed effects model (4) with firm and year fixed effects. This is a true fixed effects (FE) model (as in Wooldridge, 2002, p. 268, eq. 10.49). We ran the regressions with all data merged across all regions (Lake States, Corn Belt, Northern Plains, and Southeast) and separately by region. We also ran the two-way fixed model (4) with dummy variables for farm size (typology) and with interaction terms (*FarmSize* and *NonfarmIncome* and *Region* and *NonfarmIncome*). We found that the two-way fixed effects model with both "year" and "firm" dummy variables better accounted for the heterogeneity across cohorts and over time than did the one-way fixed effects model, which only includes a "year" dummy variable to account for "fixed effects".

Two-way fixed effects: By Region and All Regions) – Without Allowance for Outliers and Without Farm Size or Region Interaction Variables – With Year and Cohort Fixed Effects

Table 2 shows regression results for the investment share equation by region, without allowance for outliers and without any farm size or region interaction variables, but with year and cohort fixed effects. *Age* was significant in the Corn Belt and Northern Plains (0.05 level), and *Education* in the Lake States and Corn Belt (0.05). *Wealth* was significant in the Corn Belt (0.01) and in the Northern Plains (0.05). *FarmIncome* was significant in the Lake States only (0.05). *NonfarmIncome* was significant at the 0.01 confidence level in the Lake States and Southeast, and at the 0.05 level in the Corn Belt. *FarmType* was significant in two regions (Lake States and Northern Plains, 0.05). *CostCapital* had the sign predicted by economic theory (negative) but also was not significant in all regions except for the Lake States, where it was highly significant (0.01). This may be due to relatively greater share of capital-intensive farm operations (e.g., dairy operations) in the Lake States. *RateReturnEquity* was only significant (0.10) in the Lake States. *Wages &Salaries* was not significant in any region and thus was therefore dropped from subsequent regressions. Year and cohort fixed effects were highly significant in all four regions, indicating that other farm-related variables also possibly affecting investment shares (such as farm size) are omitted.

Table 3 shows regression results for the investment share equation for all regions. Overall, *Education* was significant (0.05) and *NonfarmIncome* highly significant (0.01) and had the expected negative sign. The negative sign indicates that the investment share of farm assets would fall relative to total assets (farm and nonfarm) as off-farm income increases. However, farm assets could still increase absolutely, but the negative sign suggests that, at the margin, investments in farm assets would rise by less than investments in nonfarm assets.

Year and cohort fixed effects were highly significant in all four regions, again indicating that other farm-related variables affecting investment shares are omitted.

We ran a diagnostic test for multicollinearity using SAS@ PROC REG to examine the variance inflation factor, or VIF. Variance inflation is a consequence of multicollinearity. We found little evidence of multicollinearity.

Two-way fixed effects: By Region and All Regions) – With Allowance for Outliers (Robust regression) and With Farm Size and Region Interaction Variables

Because we found that there were many outliers (Greene, 2003, pp. 60-61) in the input data, we ran SAS@'s Least Trimmed Squares (LTS) method, a robust regression method to adjust both those in the y-direction and also leverage points (in the x-direction). The SAS@ procedure we used (PROC MIXED), a maximum likelihood estimator, is not equivalent to the 'true' FE estimator (Lambert, 2005; Wooldridge, 2002) as the asymptotic variances differ from those of the FE estimator.) However, SAS@ PROC ROBUST estimates the 'true' FE variances. We included an interaction variable, *NonfarmIncome*FarmSize2* (Greene, 2003, pp.123-124) where *FarmSize2* includes all farms in Cohorts 7-13 (large farms). We found that this improved the model's performance by increasing the significance of the parameter estimates and raising the model's R-squared.

Table 6 shows regression results for the investment share equation for all regions using Robust Regression (Least Trimmed Squares). This procedure allows for outliers and also adds interaction variables (*FarmSize* and *Nonfarm Income*, and *Regio*n and *NonfarmIncome*), but without year and cohort fixed effects. The interaction terms allow for the joint effects of farm size/region and *NonfarmIncome* on *investment shares* in farm and nonfarm assets.

Age was significant at the 10% level. *Education, Wealth, FarmIncome, NonfarmIncome, FarmType, CostCapital,* and *RateReturnEquity* were not significant. However, using FarmSize=2(cohorts 7 – 13, 'large farms') revealed that there is a statistically significant difference in the effect on nonfarm income on "share change" for small farms (cohorts 1–6) and large farms (cohorts 7-13) (table 6).

Table 7 shows regression results for the investment share equation for all regions again using Robust Regression (Least Trimmed Squares). This time we added Region and Nonfarm Income interaction variables to allow for the joint effects of region and *NonfarmIncome* on *investment shares*.

None of the independent variables was statistically significant. However, using Region=6(Southeast) revealed that although there is no statistically significant different in the effect of nonfarm income on investment shares between the Lake States, Corn Belt, and the Southeast, there is a statistically significant difference in the effect of nonfarm income on "share change" in the Northern Plains and the Southeast.

Summary and Conclusions

This study represents an initial effort at testing the theoretical relationships regarding the effect of nonfarm income on investments in farm and nonfarm assets. We used OLS and pseudo-panel data from the USDA's ARMS survey to examine how off-farm income affects the shares of farm/non-farm assets given that both asset categories are risky. (Furthermore, what are the effects on investment behaviour if the magnitude and riskiness of off-farm income are taken into account?).

These results generally agree with other studies that have used farm-level data to empirically assess the impacts of off-farm income on farm and nonfarm investments. Our econometric estimation using OLS with pseudo-panel data suggests that, as expected and consistent with economic theory, off-farm income affects the investor's portfolio allocation between farm and nonfarm assets. We suggest several implications of these results.

First, the impacts of changes in off-farm income on investment in farm versus nonfarm assets vary widely by farm type, farm size, location, and by other factors. Across these four regions, *Age* and *NonfarmIncome* were the most significant factors affecting the farm-nonfarm investments shares. We also found, as expected, the farm heterogeneity affects investment shares. Since the two-way fixed effects estimation shows that other farm-related variables possibly affecting investment shares are very significant, we introduced dummy variables and interaction variables to help account for these affects.

We found that both region and farm size (large vs. small farms) significantly affect investment shares.

Second, changes in shares of funds invested in farm versus nonfarm capital affects the distribution of wealth by farm type, farm size, and location (Blank et al., 2004). In general, the fact that changes in nonfarm capital have larger impacts than do changes in farm capital across all regions implies that there are economic incentives to shift resources out of agriculture. To the extent that additional off-farm income leads risk-averse farm household investors to hold relatively larger shares of nonfarm versus farm assets, there are economic incentives to shift resources out of agriculture. However, Blank et al. note that this may not happen because there appear to be incentives for small-scale farms to increase their capital levels (Blank et al., p. 1306).

There are several others paths we plan to pursue. First, we will further examine the correlations of off-farm income with farm and nonfarm income since this affects the investor's portfolio allocation through their impacts on K_{fv}. We believe that K_{fv} may vary across regions (e.g., Eastern vs. Western Corn Belt) reflecting differing risk preferences, commodity mixes, and other factors contributing to firm heterogeneity. Second, we will more specifically account for the riskiness of nonfarm assets as well as for the riskiness of off-farm income. Ahituv et al. (2002) and Serra et al. (2004) found that these factors can significantly affect investment shares in farm and nonfarm assets. Third, we will consider alternative model formulations, including one that more directly relates operator capital expenditures to the subsequent investment shares allocation between farm and nonfarm assets. Fourth, we will later develop a dynamic model that will better reflect ‘state dependence’ since investment decisions are linked intertemporally.

In subsequent analysis we will pool the ARMS data at the farm-level (rather than using pooled cohort data) and then estimate the equations using a censored two-limit Tobit. Using farm-level data rather than averaged means (pseudo-panel data) will yield sufficient investment shares in the 0 to 1 range so that the two-limit Tobit will converge. We will also use a richer dataset with risks and returns on nonfarm assets varying by state and over time, more regions, and a longer time frame. We will parameterize the model as in (4.3) and (4.5), including a dynamic model with more complete allowance for firm heterogeneity and state dependency (following Hochguertel et al. in Chapters 4 and 9 of *Household Portfolios*).

The effect of additional nonfarm income on the farm operator’s investment behaviour under risk depends on a number of factors, including risk preferences, level of diversification of farm production (Mishra and Goodwin; McNamara and Weiss), and on a variety of other factors. We will leave these issues for future research.

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Table 1. The Farm Typology Groups and Cohort Definitions

Typology	*USDA definition*	*Sales ($)*
TYP1	Limited resource	<100,000 (assets <150,000, income < 20,000)
TYP2	Retirement	<250,000
TYP3	Residential (other major occupation)	<250,000
TYP4	Farm/lower sales	<100,000
TYP5	Farm/higher sales	<250,000
TYP6	Large family farms	250,000-499,999
TYP7	Very large farms	500,000+

Cohort	*Typology*	*Gross Value of Sales*
COH1	TYP1-3	<2,499
COH2	TYP1-3	2,500-29,999
COH3	TYP1-3	>30,000
COH4	TYP4	<10,000
COH5	TYP4	10,000-29,999
COH6	TYP4	30,000-99,999
COH7	TYP5	100,000-174,999
COH8	TYP5	175,000-249,999
COH9	TYP6	250,000-329,999
COH10	TYP6	330-000-409,999
COH11	TYP6	>500,000
COH12	TYP7	<1000,000
COH13	TYP7	>1000,000

Table 2. Regression Results for Investment Share Equation by Region:
Lake States, Corn Belt, and Southeast (1996-2002) - (two-way fixed effects)

	Investment Share equation							
	Lake States		*Corn Belt*		*Northern Plains*		*Southeast*	
Variable	**Estimate**	**t value**	**Estimate**	**t value**	**Estimate**	**t value**	**Estimate**	**t value**
Age	-0.0010	-0.85	0.001513	1.96*	0.004022	2.31**	-0.00143	-1.39
Education	-0.05021	-3.11***	-0.02741	-2.71***	-0.00002	-0.00	-0.01244	-1.11
Wealth	-0.00001	-0.76	-0.00004	-2.73***	-0.00008	-2.29**	9.511E-6	-1.11
NonfarmIncome	-0.00142	-3.25***	-0.00038	-2.00**	-0.00036	-0.73	-0.00105	-3.42***
FarmIncome	0.000148	2.00**	-0.00010	-1.47	0.000176	1.32	-0.00004	-0.44
FarmType 1=crop, 2=livestock	0.0674	2.35**	0.01810	0.90	0.09499	2.57**	-0.01164	-0.48
CostCapital And an inn in June and the	-0.00096	-4.35***	0.000133	0.84	-0.00015	-0.23	-0.00004	-0.38
RateReturnEquity	-0.00282	-1.82*	-9.62E-6	-0.01	-0.00257	-1.17	0.000357	0.35
Wages & Salaries[1]	0.00919	1.51	-0.00005	-0.17	-0.00090	-1.24	0.000667	1.26
Fixed Effects								
Year:		***		***		***		***
Cohort:		***		***		***		***

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

[1] Since *Wages & Salaries* is included in *NonfarmIncome* and was NS, *NonfarmIncome* was not included in tables 4 and 5.

Source: USDA, Agricultural Resource Management Survey.

Table 3. Regression Results for Investment Share Equation: ***All Regions (1996-2002) –*** ***(two-way fixed effects)***		
Investment Share equation		
All Regions		
Variable	**Estimate**	**t value**
Age	0.000168	0.32
Education	-0.02019	-3.10***
Wealth	-3.01E-6	-0.51
NonfarmIncome	-0.00073	-4.92***
FarmIncome	-7.30E-6	-0.19
FarmType 1=crop, 2=livestock	0.02911	2.30*
CostCapital	-0.00008	-1.02
RateReturnEquity	-0.00038	-0.71
Wages & Salaries[1]	0.000160	0.70
Fixed Effects		
Year:		***
Cohort:		***

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

[1] Since *Wages & Salaries* is included in *NonfarmIncome* and was NS, *NonfarmIncome* was not included in tables 4 and 5.

Source: USDA, Agricultural Resource Management Survey.

Table 4. Definitions and Summary Statistics of Variables Used in Regressions: By Regions, Small and Large Farms.

		Small farms[1]	Large farms[2]	Small farms	Large farms	Small farms	Large farms	Small farms	Large farms
Variable	Description	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
		Lake States: MI, MN, WI		*Corn Belt:* IL, IN, IA, MO, OH		*Northern Plains:* KS, NE (excluding ND and SD)		*Southeast:* AL, FL, GA, SC	
Independent variable									
Actual_Share	Actual share of farm assets as share of total (farm + nonfarm)	0.7987	0.9187	0.7945	0.9232	0.7728	0.9303	0.7857	0.9051
Operator/Household Characteristics:									
Age		55.06	48.35	55.76	49.50	56.12	50.79	57.66	51.24
Education		2.36	2.71	2.34	2.68	2.59	2.85	2.56	2.70
HH_NETW	Farm household's net worth (includes both farm and nonfarm net worth, $000s)	424.72	980.91	419.84	918.79	385.38	877.67	602.55	1014.00
Farm Characteristics:									
FarmIncome	Farm income ($000s)	4.40	127.82	6.32	91.51	3.91	100.31	4.24	72.46
NonFarmIncome	Nonfarm income ($000s)	46.87	24.68	47.43	34.00	48.23	27.92	55.46	30.61
CostCapital	Average interest rate on farm business debt outstanding (percent)	10.37	11.21	13.65	9.97	13.09	9.57	11.17	19.11
FarmType	1=crop; 2=livestock	1.43	1.54	1.45	3.05	1.43	1.39	1.61	1.40
RateReturnEquity	Rate of return on farm equity	-4.46	2.48	-3.34	3.05	-4.95	1.56	-2.88	1.53

[1] Small farms are defined as farms in cohorts 1-6 (farm typologies 1 through 4).

[2] Large farms are defined as farms in cohorts 7-13 (farm typologies 5 through 7).

Source: USDA, Agricultural Resource Management Survey.

Table 5. Definitions and Summary Statistics of Variables Used in Regressions: All Regions, Means and Standard Deviations

Variable	Description	Mean	Std. Dev.
		All Regions: Lake States, Corn Belt, Northern Plains, Southeast	
Actual_Share	Actual share of farm assets as share of total (farm + nonfarm)	0.86	0.12
Age	Age of principal operator	52.83	6.85
Education	Education of principal operator	2.59	0.48
HH_NETW	Farm household's net worth (includes both farm and nonfarm net worth, $000s)	729.09	622.04
FarmIncome	Farm income ($000s)	53.49	131.23
NonFarmIncome	Nonfarm income ($000s)	39.19	29.85
CostCapital	Average interest rate on farm business debt outstanding (percent)	12.48	32.37
FarmType	1=crop; 2=livestock	1.44	0.28
RateReturnEquity	Rate of return on farm equity	-0.47	7.83

Source: USDA, Agricultural Resource Management Survey.

Table 6. Robust Regression (Least Trimmed Squares) Results for Investment Share Equation and Interaction of FarmSize and NonfarmIncome[1]:

All Regions (1996-2002) – using FarmSize=2(cohorts 7-13, large farms) as the reference category

Investment Share equation – Using "share_change"[1]		
All Regions		
Variable	**Estimate**	**Chi-Square**
Age	-0.0042	4.51*
Education	0.0074	0.07
Wealth	0.0000	3.26
NonfarmIncome[2]	0.0007	1.35
FarmIncome	0.0000	0.04
FarmType 1=crop, 2=livestock	-0.0745	2.72
CostCapital	-0.0001	0.02
RateReturnEquity	-0.0010	0.20
NonfarmIncome_FarmSize1[3]	-0.0033	32.29

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

[1] *FarmSize=2* (cohorts 7-13) is the reference category for the interaction of *FarmSize* and *NonfarmIncome*.

[2] Coefficient for LargeFarms (cohorts 7-13).

[3] Coefficient for small farms = 0.0007 – 0.0033 = -0.0026. The Chi-Square statistics for *NonfarmIncome_FarmSize1* (the interaction of *FarmSize* and *NonfarmIncome*) suggests that there is a statistically significant difference in the effect of *NonfarmIncome* on "share change" for small (cohorts 1-6) and large farms (cohorts 7-13).

Source: USDA, Agricultural Resource Management Survey.

Table 7. Robust Regression (Least Trimmed Squares) Results for Investment Share Equation and Interaction of Region and NonfarmIncome[1]:

All Regions (1996-2002) – using Southeast (RegCode=6) as reference category

Investment Share equation – Using "share_change"[1]

All Regions[2]

Variable	**Estimate**	**Chi-Square**
Age	-0.0068	10.74
Education	0.0199	0.44
Wealth	0.0001	9.82
NonfarmIncome[3]	-0.0017	7.58
FarmIncome	0.0001	
FarmType 1=crop, 2=livestock	-0.1068	4.79
CostCapital	-0.0001	0.05
RateReturnEquity	-0.0006	0.06
NonfarmIncome_Region2[4]	-0.0003	0.10
NonfarmIncome_Region3	-0.0007	1.29
NonfarmIncome_Region4[5]	-0.0022	5.55**

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

[1] "Share_Change" (from previous year) = (change in farm assets)/(change in farm assets + change in nonfarm assets)

[2] Region2 = Lake States, Region3 = Corn Belt, Region 4=Northern Plains, and Region6=Southeast. Region6 (Southeast) is the reference category for the interaction of Region and NonfarmIncome.

[3] Coefficient for Region6 (Southeast).

[4] Coefficient for Region2 (Lake States) is (-0.0017) - (-0.0003); no significant change from Region6 (Southeast).

[5] Only Region4 (Northern Plains) is statistically different from Region6 (Southeast).

Source: USDA, Agricultural Resource Management Survey.