Household Income Volatility in U.S. Farm Households

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*Abstract***.** Farm households are subject to several sources of income instability, including yield and production fluctuations, disasters such as droughts or disease, input and output price changes, and varying levels of off-farm income. This paper assesses the income variability of households operating family farms in the continental United States. We find that income volatility varies between farm household subgroups, such as farm size, commodity specialization, and geographic location and that volatility has decreased between 1998 and 2010. Regression analysis shows that households operating crop farms, larger farms, and more highly leveraged farms have higher levels of volatility. Finally, we decompose the sources of income variance and analyze the role of federal agricultural program payments in reducing volatility.

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Introduction

Farm income is highly variable, with earnings subject to wide fluctuations in yields and prices. Farmers may try to cope with farm income variation in many ways, including working off-farm, diversifying their farm enterprises, and altering their farm production practices. Because household income volatility influences what, how, and how much a farm produces, it can have important implications for rural household welfare, agricultural production, and environmental quality.

Farm households exhibit considerably higher levels of income than typical U.S. household (USDA 2015b).[1] For the nearly 1 million U.S. farmers who consider farming their primary occupation, variability from farm income can be a challenging part of running a farm business. Farm households also tend to have considerable current assets from their farm operation and non-farm holdings which may be used to smooth income, through sale or using a portion of the assets as collateral for a loan. Even for these farms, a sizable portion of annual income is derived from off-farm sources, including wage labor, earnings from other businesses, which can also be sources of farm household income variability.

Federal agricultural policies have long sought to shelter farmers from income fluctuations using price supports, direct income support, disaster assistance programs and crop yield and revenue insurance programs. The 2014 Farm Act ended fixed annual payments to producers based on historical production, and created new programs tied to annual or multi-year fluctuations in prices, yields, or revenues. The new programs include those that pay producers when prices fall below a reference price (Price Loss Coverage (PLC) and Agriculture Risk Coverage (ARC)), and crop insurance programs aimed at providing support for shallow revenue or yield losses (Supplemental Coverage Option (SCO) and Stacked Income Protection Plan (STAX)). Despite the new emphasis of Federal programs to reduce income risks to farmers, there exists little empirical information about U.S. farm household income volatility or the extent that Federal programs have mitigated income fluctuations.

[1] For instance, the median household income for a farm household in 2013 was $71,697 compared to $51,939 for all U.S. households.

This paper examines farm household income volatility across the United States from 1996 to 2013 using a large national panel dataset collected by the USDA. We look for secular trends in income variability across time and for differences between types of farms. We include three new analyses which contribute to the larger understanding of farm household volatility. First, we use regression analysis to uncover the determinants of an individual farm's volatility. Second, we decompose total household income into farm, non-farm and other components and trace which of these components contribute to the overall volatility. Lastly, we look at the effects of U.S. government programs of farm household income variability and welfare. We use a certainty equivalent measure to see how much a dollar of a particular program is worth to the farmer.

Literature Review

While little is known about the income volatility of farm households, a large body of economics research has examined the income volatility of individuals and households more generally – seeking to identify how volatility varies across income categories and over time. Early studies focused on decomposing the cross-sectional variance in individual earnings into permanent and transitory components and on identifying time trends using the Panel Study of Income Dynamics (PSID) (Gottschalk and Moffitt, 1994; Haider, 2001) or the Current Population Survey (CPS) (Cameron and Tracy, 1998). More recent studies have examined trends in non-farm income volatility using simpler measures of volatility, which are usually function of the percent change in income over the previous year (e.g., Congressional Budget Office, 2008; Dahl, DeLeire, and Schwabish, 2011; Dynan, Elmendorf, and Sichel 2012; Moffitt and Gottschalk, 2011; Shin and Solon 2011; Ziliak, Hardy, and Bollinger, 2011). Most of these studies find more income variability in the 1980s than in the 1970s and flat trends in variability during the 1980s and early 1990s – though these studies differ in their findings in more recent periods.

A more limited number of papers have explored the volatility of farm business income using small surveys of farmers in the United States, Canada or Europe. Most studies focusing on the variability of farm income have used a regression analysis to examine the determinants of variability. In an early study, Schurle and Tholstrup (1989) developed a model to estimate the relationships between enterprise mix and the variance of income. Using panel data on Kansas farms, they regress a measure of business risk on covariates, including enterprise mix, farm and operator characteristics, and government payments per dollar. Schurle and Tholstrup's measures of the mean and variance of returns on equity is used by Purdy et al (1997) who assess the returns to risk specialization in a panel of Kansas farms, finding that certain types of specialization can decrease volatility and that farms with both crop and livestock operations are less volatile. Mishra and Goodwin (1997) showed that increased farm income variability led farm households to work more off-farm, though households were less likely to do so if they received support through government farm programs. More recently, Poon and Weersink (2011) used a panel dataset of Canadian farmers and Enjolras et al. (2014) used a panel of French and Italian farm to estimate the determinants of the variation in farm income.

Studies of U.S. farm income variability that have used nationally representative data have relied on cross-sectional surveys, and have estimated income variation across farms at a single point in time. For example, Mishra and El-Osta (2001) used ERS ARMS data to investigate the sources of variability of total farm household income (farm and off-farm) in 1995 and 1999. For each year, they use a normalized variance decomposition to show how farm household income variation differs for farmers who participate in commodity programs compared to those who do not. Since commodity prices, policies and to some extent yields covary across time – sometimes resulting in "boom" and "bust" years – examining variation in income across farms at one point in time likely under-estimates individual farm income variation.

Data

For this analysis, we use matched data from individual years of the Agricultural Resource Management Survey (ARMS), an annual USDA survey carried out by the National Agricultural Statistics Service (NASS) and Economic Research Service (ERS) (USDA, 2015a). Although the

ARMS is not a panel survey, some farms are surveyed multiple times due either to random chance or their agricultural importance within their state.[2]

There are 38,317 farms which were surveyed more than once in annual ARMS surveys between 1996 and 2013. Of these, 29,488 were surveyed twice, with another 6,647 surveyed three times. Because most observations occurred only twice, the bulk of this analysis uses a "pairs" panel dataset, which compares two points in time. For farm households which were surveyed more than twice, we add one pair for each additional year of data.[3] After creating the "pairs" dataset, we drop observations where there the span between two years is greater than 5 years.[4] Observations were also dropped if the difference in operator age between two observations was more than 7 years (implying that a different household is operating the farm) or if the household had a negative net worth (to ensure consistency across different volatility measures).

For the regression analysis, we use all observations and construct volatility measures using the total number of available years for the particular observation. Because farms with higher number of observations tend to be larger and more variable (and may have other, unobservable characteristics), we control for the number of times a farm household is surveyed, as well as for the number of average number of years between observations.

Table 1 shows differences in median income and assets for each year between the panel and full ARMS samples. As compared with the full ARMS sample, the farm households which were surveyed more than once tend to operate larger farms and generate a higher value of production. On average, farms in the panel dataset received less income from off-farm activities, such as wage labor, and significantly more from their on-farm operations.

Measuring Farm Household Income Volatility

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[2] Although surveyors try not to select any one farm in two consecutive years, in practice this happens periodically because a particular farm is essential to understanding a given commodity in a particular state.
[3] For instance, if a household was surveyed in 1999, 2003 and 2005, we will have two observations in the "pairs" dataset, one including the years 1999 and 2003 and another which encompasses 2003 and 2005.
[4] We drop observations with a span length of more than 5 years because volatility increases significantly after this time and to keep the analysis closer to what has been done in the non-farm household literature.

One challenge working with farm household data is that in any year a significant proportion of households have negative farm or household income.[5] In the “pairs” panel dataset, roughly 30% of households realized negative farm income each year and 14% had negative income in both years. These values are similar to the average number of farms with negative income in the annual ARMS surveys: between 1996 and 2013, 36.5% of sampled farms had negative farm income and 11.0% had negative total household income.[6] Because of these negative values, it is not possible to use some standard measures of income change, such as the percent change or the arc percent change. Instead we develop alternative measures of volatility that allow for negative income values.

The first volatility measure is the absolute value of the arc percent change (AAPC). The arc percent change is a measure frequently used in the economics literature to assess changes in income because it has the advantage of being bounded at 0 and 200 (Dyan, Elmendorf and Sichel, 2012; Hardy and Ziliak, 2014). The AAPC provides a measure of the magnitude of income change and when compared to average income, is an indicator of income volatility. The AAPC in income between two years is defined:

$$AAPC_i = \left|100 * \frac{y_{it}-y_{it-1}}{\bar{y}_i}\right| \text{ where } \bar{y}_i = 0.5 * (y_{it} + y_{it-1}),$$

where y_{it} is the income earned by household i in year t and $\bar{y}_i$ is the average income over the two years. This measure successfully incorporates negative values. However, in cases where income is positive in one year and negative or zero in the other, the index will always equal 200, regardless of the magnitude the change.[7]

[5] There are many reasons for farm households to suffer negative income. For instance, during years of low crop yields or livestock loss; when output prices are low or input prices are high; or, when a farm is in the middle of a planned expansion.

[6] Off-farm income is usually positive – it is only negative if the household experienced a loss from running another farm or business, or capital losses from sales of assets or investments. These values are do not use probability weights and are therefore not nationally representative.

[7] A change from -$100 to $100 will appear the same as a change from -$100 to $1,000 even though the second is a larger increase.

A second measure of volatility is the absolute value of the coefficient of variation (ACV) of income across time:

$$ACV_i = \left|\frac{Std\ Dev(y_i)}{\bar{y}_i}\right|$$

Note that the standard deviation of income is calculated independently for each household. A problem can arise with this measure in cases where households realize a very small average income—for instance, if a large loss in one year offsets the other year's income. In these cases, the estimated *ACV* can be extremely large.[8] To address this, we use a related measure, *ACV10*, which includes only coefficients of variation below 10 in absolute value. This measure drops 2.9% of observations.

Asset-based Measures

We also use two measures of income volatility relative to assets. Assets provide a convenient base for comparing income changes because they are positive by definition. The first asset measure is the standard deviation of total (or farm) income divided by total (or farm) assets.

$$SD\_Assets_i = \frac{Std\ Dev(y_i)}{\bar{a}_i}$$

where $\bar{a}_i$ is the average assets over the number of periods the household is observed. The square of this measure, the variance of income divided by the square of the assets, is sometimes called "business risk" (Schurle and Tholstrup, 1989). Because it is right-skewed, we use the log of business risk in our analysis:

$$LN\_BRisk = \ln\left(\frac{Variance(y_i)}{\bar{a}^2}\right) = \ln\left(SD\_Assets_i{}^2\right).$$

[8] For instance, consider a small farm household which earns $20,000 one year and suffers a loss of $18,000 the next year. This corresponds with an average income of $1000 but a standard deviation of 26,870, The ACV is 26.9, which is an outlier.

Many analyses of farm finances use the rate of return on assets (ROA): pre-tax farm income divided by farm assets. This measures how effectively assets are being utilized for profit generation. The final measure, the absolute change in returns to assets (CRA), is similar but uses the two-year absolute difference in income rather than average income. This creates a measure which shows how volatile income is in relation to owned assets.

$$CRA_i = \left| 100 * \frac{y_{it} - y_{it-1}}{\bar{a}_i} \right|$$

When calculating the CRA for farm income we use farm assets in the denominator. Similarly, for total household income we use total household assets.

Aggregate Volatility Measures

Crop versus livestock farms

First we categorize farms based on whether most of their total value of production across each two-year period originated from either crops or livestock.[9] Table 2 shows the income, assets, and government payments for crop and livestock farms for all two-year observations within the panel dataset. Crop farms, which constitute 51.6% of all pairs within the dataset, tend to be larger, and receive more income and government payments. Crop farms received a median farm income of $72,322—double that of livestock farms—and they received $34,647 from non-farm income, only 10% more than livestock farms. Crop farms also had 10% more household assets than livestock farms, and similar amount of debt. Crop farms received about four times as many government payments as livestock farm—mostly in the form of commodity payments, such as direct payment, counter-cyclical payments and marketing loan benefits. As would be expected, crop farms also had higher participation in crop insurance programs, paying $17,158 in average premiums, compared to $2,478 for livestock farms.

[9] Information on the value of production across roughly 15 different commodities were present in the dataset. The median value of production for crop farms was $73,318 and for livestock farms was $195,666. 134 farms did not record any production value and are excluded from this part of the analysis. These excluded operations do fit the USDA definition of a farm and may have received income from, for instance, sales of stored inventory or conservation payments on non-producing lands.

Crop farms experienced higher levels of income volatility, according to most measures (table 3). Crop farms had greater average gains and losses. They also had a larger average absolute arc percentage change (AAPC) absolute coefficient of variation (ACV), change in return to assets (CRA) and business risk for both farm household and total household income.

One reason that livestock producers might have less income volatility is that many use production contracts. Production contracts are arrangements where farmers are paid a fee to feed and care for animals. Their fee usually does not depend on the market price of their product; hence they are not exposed to a significant source of farm income risk. Approximate 36.0% of livestock producers in the sample used production contracts, compared to only 5.9% of crop farmers. For crop farms, production contracts amounted to more than 10% of all production value for less than 4% of farms. Conversely, production contracts accounted for over 50% of the value of their production for 90% of livestock farms with a production contract.

Farm Type and Asset Class

In the United States, most farms are small-scale and most farm households obtain most of their income from off-farm sources. However, most agricultural output is produced on large scale operations with operators whose primary occupation is farming. The panel dataset oversamples the larger farms which produce most agricultural products. Hence, aggregate measures of income and volatility based on the panel data do not reflect the circumstances of most farm households. To examine how volatility varies with farm size we categorize crop and livestock farms based on their farm assets.

As expected, farms with more assets earned more farm income, and earned a greater share of their total household income from farm sources (table 4). Crop farms have higher levels of farm income in all asset classes, and similar levels of off-farm income. Crop and livestock farms have similar debt levels, although the largest livestock farms have more debt relative to similarly sized crop farms. Government payments and crop insurance participation increase across all asset categories.

The volatility measures are shown in table 5. The top rows show the income-only measures of AAPC and ACV. Several trends are present. First, income volatility for livestock farms is increasing as farm size increases for both farm and total household income. For farm household income, the AAPC rises from 124.6 to 139.2 while the ACV rises from 0.88 to 0.98. Total household income volatility increases more steeply, rising from 63.6 to 119.4.

For crop farms, farm income volatility is constant across asset categories. Using income based measures, larger farms do not experience more farm income fluctuations than smaller farms. However, total household income volatility increases as farm size increases. This is because at lower asset levels, farm income represents a relatively small share of total income. As farms grow larger, the portion of total household income coming from farm operations increases. Total income volatility converges to farm income volatility for the largest farms. For example, for crop farms, farm household income volatility (ACV) remains steady between 0.89 and 0.92 across asset categories, but total household income volatility rises monotonically from 0.55 to 0.84. For crop farms, the typical (median) level of total income derived from the farm similarly rises from 48% for farms with less than $750,000 of farm assets to 92% for firms with more than 3 million dollars of assets.

The asset based measures of volatility tell a somewhat different story. For livestock, and especially crop farms, asset based volatility measures decline with farm size. This likely reflects the increasing return to scale of larger operations. Large farms are able to produce more output and income per dollar of assets. As a result the absolute value of the change in income per dollar of assets is smaller for larger farms. Hence, while income becomes more volatile as farm size grows, business risk (return on assets) actually declines.

Changes over time

Examining the aggregate volatility measures over time provides an initial indication of trends in farm volatility. Figures 1a-f show three volatility measures plotted over the span of the dataset, for both total and farm household income. Because each observation is a single measure of income volatility between two points, we use the midpoint of those two years as the recorded date on the graphs.

The figures show that there has been a (noisy) decrease in household volatility. The absolute arc percentage change (AAPC), mean absolute coefficient of variation (ACV) and mean change in relation to assets (CRA) all show a declining trend from 1999 to 2010. While suggestive, these aggregate trends could be biased if the composition of the panel sample changes over time. For example, if there were more crop farms in the sample in later periods, we might observe an increase in volatility even if individual farm volatility did not change, or even decreased. In the next section we use a regression analyses to corroborate this volatility trend while controlling for changes in the characteristics of the farms in the sample.

Regression Analysis

In this section, we present regressions of various volatility measures on individual farm attributes while controlling for regional variation. The regressions allow us to identify which exogenous farm characteristics, such as size and location are associated with income volatility. By controlling for exogenous factors we are also able to identify time trends in the volatility measures.

For the regression we use the full panel dataset, rather than the "pairs" dataset used in the previous sections. The full panel includes all farms in the ARMS dataset which have appeared two or more times since 1996, a total of 38,317 farms and 88,269 observations. Each household appears between two and eight times in the dataset as shown in Appendix Table 1.
Because more than three-fourths of the observations are only observed twice, we generate one measure of volatility per household. Although this does not allow us to trace an individual household's volatility across time for households that were observed more than twice, it does generate a consistent metric for each farm household.

Table 6 shows summary statistics for all households in the full panel. We use three distinct measures of household income volatility, described above: the truncated absolute coefficient of variation (ACV10), and its log; the log of business risk (LN_BRISK); and, the standard deviation of income divided by assets (SD_ASSETS). The typical farm household appears twice in the dataset, roughly 4 years apart. It has average sales of $500,000 and household assets of $1.57 million. Most operators (84%) report farming as their primary occupation, and the mean and median farm age is 55. We include dummy variables for each of the production regions of USDA's Economic Research Service (ERS). The omitted category is the Heartland region, comprising Iowa, Illinois, Indiana, large parts of Missouri and Ohio and smaller parts of Kentucky, Minnesota, and the Dakotas. Volatility in this region is low, relative to the national average. We also include indicator variables for those households which own poultry, cattle, and corn farms producing an average of $10,000 in any one of those categories.

As compared with the full ARMS dataset, which is designed to be representative of the U.S. agricultural sector when survey weights are used, the panel dataset contains a skewed sample of farm households (See Appendix Table 2). These farm households own and operate larger farms and derive more of their total household income from farm operations and less (in both relative and absolute terms) from off-farm sources. As the yearly breakdown shows, the biggest discrepancy between the panel and complete datasets is in farm income and becomes most pronounced at the end of the dataset, from 2009-2013. The households in the panel dataset own more farm assets and similar amount of non-farm assets.

We use a standard ordinary least squares (OLS) regression model, regressing measures of volatility on farm characteristics using the following equation:

$$y_i = \alpha + \boldsymbol{X_1}'\boldsymbol{\beta} + \boldsymbol{X_2'}\boldsymbol{\gamma} + Year_t + Region_r + \epsilon_i$$

where y_i is the volatility measure, the vector $\boldsymbol{X_1}$ contains observational information, such as the number of times a farm appears in the dataset and the distance between observations, both of which contribute to higher observed volatility. $\boldsymbol{X_2}$ contains farm and operator characteristics. We use a time trend to measure change in volatility across the period from 1996-2013 and regional dummies to account for those characteristics. Finally, we use state-clustered standard errors, with groupings for each of the lower 48 states.

Table 7 shows the regression results. The first two columns regress income measures of volatility—the absolute value of the coefficient of variation and its log; the second two columns use asset-based measures, business risk and the standard deviation of income divided by mean assets. In each case, the time trend—expressed as the coefficient on the average year variable—is negative, indicating that, across all farm households, volatility decreased over this period by approximately 0.6% per year, according to the ACV10 metric.

Total household income volatility is lower if the principal operator has more education. This relationship is likely due to the greater importance of off-farm income in total income for better educated operators. While households in the lowest educational category earned roughly $42,000 per year from off-farm sources between 1996 and 2013, those in the highest earned $79,000 each year, on average. Those farms which are more highly leveraged and whose principal operator's primary occupation is farming have considerably higher levels of total household income volatility.

Decomposition of Income Variation

For farm households, total income is comprised of farm income (including payments from government programs) and non-farm income (wage income and non-wage income). To understand the extent to which of these components contributes to total income variation we decompose total income variation into four major components: farm income, agricultural payments, off farm wage income, and other income. Assuming each of these income components, y_{it}^{j}, is a random variable then the variance of household income is the sum of the 4x4 covariance matrix with elements $Cov(y_{it}^{j}, y_{it}^{k})$. That is:

$$Var(y_{it}) = \sum_{j=1}^{4} \sum_{k=1}^{4} Cov(y_{it}^{j}, y_{it}^{k}),$$

where each covariance term is computed for each observation as:

$$Cov(y_{it}^{j}, y_{it}^{k}) = \sum_{t=1}^{2} (y_{it}^{j} - \bar{y}^{j})(y_{it}^{k} - \bar{y}^{k}).$$

If income components, such as farm income and non-farm wage income, are negatively correlated, then the total variance will be lower than if these income sources were positively correlated.

For the case of four income components, the contribution of the j^{th} component to total income variability is sum of the elements of the j^{th} row of the 4x4 covariance matrix:

$$C\left(y_{it}^{j}\right) = \sum_{k=1}^{4} Cov\left(y_{it}^{j}, y_{it}^{k}\right)$$

The sum of the four variance components is the total variance: $Var\left(y_{it}\right) = \sum_{j=1}^{4} C\left(y_{it}^{j}\right)$. So the share of the j^{th} component in total variance is:

$$CS\left(y_{it}^{j}\right) = C\left(y_{it}^{j}\right) / Var\left(y_{it}\right).$$

Contribution of Income Components to Total Variance

Table 8 shows the covariance matrix for the four main income components divided by the total variance. Hence, the sum of each row (or column) shows the share of each income component in total variance, $CS\left(y_{it}^{j}\right)$. Results indicate that for the average farm in the sample, farm income contributes 77% of all income variation, non-farm wage income 10%, non-farm non-wage income 10%, and agricultural payments 3%.

As shown in the first row (or column) total income risk is substantially mitigated by the negative correlation between net farm income and the other three income sources. The variance of farm income alone is 107% of total income variance. However because farm income is negatively correlated with the other income sources, its total share of household income volatility is only 77%. The covariance of program payments with non-farm income sources are small and negative which slightly reduces total income risk. Similarly non-farm wage income is slightly negatively correlated with non-farm nonwage income.

Income component variance shares by farm type

Next we estimate the variance components shares for all farms and separately for primary crop and primary livestock producers by farm asset quartile (table 9). The table shows the sample means for each component, where extreme outliers have been dropped.[10] The results display several patterns about the contributions of farm income, agricultural payments, and wage and nonwage income to total variance.

For all farm types, farm income contributes the largest share of variation to total income and the share of farm income in total variation increases with farm asset class: from 60% to 90% for crop farms, and from 49% to 87% for livestock farms. In each asset category, farm income contributes a larger share to total variance for crop farms than it does for livestock farms. This is likely explained by the fact that crop income is more variable than livestock income, which makes farm income more variable for crop farms.

Conversely, the share of non-farm income (both wage and non-wage) in total variance decreases as farm assets increase for both crop and livestock farms. For the largest farms, non-farm income only contributes 9% of income risk compared to 41% for the smallest. This difference likely reflects the greater specialization of household labor in on-farm work for the larger operations.

Larger operations also derive relatively more income risk from nonwage income compared to wage income compared to smaller operations. Among the largest farms, wage income contributes 3% of risk compared to 6% for nonwage income. For the smallest farms, wage income contributes 25% of total risk compared to 17% for nonwage income. This pattern reflects the relative importance of nonwage income for larger-scale operations.

Agricultural payments contribute only about 3 percent of total income variation despite contributing about 17% to total income. Interestingly, the contribution of payments to risk

[10] For some farms, the total income variance (the denominator in (8)) is much smaller than the variance of individual income components (the numerator) causing the component variance share CS to be exceptionally large or small. Because these outliers have a disproportionate effect on the average component variance share, we delete observations with a component variance share larger than 300% or less than -300% of total income variance.

declines with farm asset size for crop farms, but increases with asset size for livestock farms. It is possible that the large crop farms receive relatively more payments from risk mitigating sources (e.g. countercyclical payments or disaster relief). Risk mitigating payments might be correlated with crop production rather than with livestock production – so the payments do not diminish total risk as effectively as livestock production increases. Overall, payment levels are much lower for livestock operations (table 4), which explains why payments have a lower contribution to income variation for livestock operations.

How do agricultural payments affect household income risk and welfare?

It is possible to observe how agricultural payments (e.g. commodity, conservation, or net crop insurance payments) affect income risk by estimating the mean and standard deviation (SD) of income with and without the payments. The SD provides an easily interpreted measure of income dispersion. If income varies randomly year to year and is normally distributed, then about 68% of the time realized income will fall within one SD of mean income, and about 95% of the time it will fall within 2 SDs of the mean. The coefficient of variation (CV), which is the SD divided by the mean, provides a unitless measure of variation relative to the mean. If the CV is large, then income varies widely relative to the mean, whereas if it is small then income usually falls within a narrow range around the mean.

While changes in the SD and CV provide insight into how payments affect income risk, these changes do not indicate whether a household is better off. Risk-averse individuals care about both their income level and income variation – they would be willing to trade some income for less risk. Neither the SD nor the CV captures this tradeoff - an increase or decrease in either measure does not indicate whether an individual is better off. For example, a program that doubles farm income would also double the SD of income and would clearly make a farmer better off. On the other hand, a program that left average income the same but raised it in good years and lowered it in bad years would also increase the SD of income, but would make a risk-averse farmer worse off. A similar problem can arise with the CV. An increase (decrease) the CV does not necessarily imply a decrease (increase) in welfare.

Estimating welfare impacts

One approach to rank risky alternatives (e.g. to compare income with and without government payments) is to compare the certainty equivalent (CE) for each alternative. The CE is the certain amount an individual would be just as happy receiving compared to the risky income source. Among risky alternatives, an agent will always prefer the one with the highest CE.

Estimating the CE requires making assumptions about how individuals' tradeoff risk versus return – that is, assumptions about individuals' utility functions. It is often convenient to assume that individuals display constant absolute risk aversion (CARA) – that is, risk aversion does not vary with wealth. The negative exponential is a CARA utility function:

$$U(y_i) = -\exp(-a_i y_i),$$

where a_i is the coefficient of absolute risk aversion[11] and y_i is income. With a negative exponential utility and with risky income having a normal distribution, it can be shown that the certainty equivalent is a function of the mean and the variance of the income distribution:

$$CE_i = \bar{y}_i - 0.5 * a_i Var(y_i),$$

It follows that the additional certain benefits from having an income with government payments (p) compared to an income with no payments (np) is:

$$CE_p - CE_{np} = \left(\bar{y}_p - \bar{y}_{np}\right) - 0.5 * a\left(Var\left(y_p\right) - Var\left(y_{np}\right)\right),$$

where the subscript *i* has been dropped for clarity. The additional benefit increases with the increase in expected returns (first term in parentheses) and decreases with the increase in

[11] The coefficient of absolute risk aversion is defined: $a_i = -\frac{u''(y_i)}{u'(y_i)}$

variance (second term). The extent to which it decreases with the variance depends on the risk aversion coefficient – it decreases more if a is larger – i.e. a farmer is more risk averse.

Comparing policies

The change in the CE resulting from a program is a measure of how much an individual would be willing to pay for the program payments. We can compare programs by comparing benefits per program dollar. For a given expenditure, programs that reduce income variation more will generate greater benefits (CE) per dollar. The average benefit per expected dollar of program *p* compared to no program (*np*) is:

$$\frac{CE_p - CE_{np}}{(\bar{y}_p - \bar{y}_{np})}.$$

We can compute the average benefit per expected dollar for each program for each household based on observed average income and income variance with and without the program and an assumed risk aversion coefficient. For the following analysis we use a "moderate" risk aversion value computed as: $a_i = 2/W_i$, where W_i is household net worth (Anderson and Dillon, 1992).[12]

For all farms and for crop farms and livestock farms separately, table 10 displays how the distribution of total household income and the CE changes with the addition of three types of government agricultural program payments: commodity payments, conservation payments, other payments. Commodity payments - which include total direct and counter-cyclical payments, such as Direct Counter-cyclical Payments (DCP), Average Crop Revenue Election (ACRE), Loan Deficiency Payments (LDPs), and Marketing Loan Gains (MLGs) - are by far the largest category of payments – averaging about $25,800 per farm. Conservation payments - from the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Conservation Reserve Enhancement Program (CREP), Environmental Quality Incentive Program (EQIP), and Conservation Security Payments (CSP), and other programs - is the smallest category, averaging

[12] By definition, $a = r/W$, where r is the relative risk aversion coefficients and W is household wealth (net worth). Based on a review of past studies, Anderson and Dillon (1992) proposed the following range of r: 0.0 = risk neutral; 0.5 = hardly risk averse; 1.0 = somewhat risk averse; 2.0 = moderately risk averse; 3.0 = very risk averse; and 4.0 = extremely risk averse.

only $3,100 per farm. The third category, "other payments" - which includes agricultural disaster assistance payments and market loss payments such as Milk Income Loss Contract (MILC) payments, tobacco buyout payments, and payments from all other Federal, State, or local programs - averages $7,800 per farm.

When payments from each category are added to base income separately, income with the payments has a lower CV than income with no payments. This suggests that all types of payments reduce income risk, as measured by the CV. However, the magnitude of the reduction in the CV does not tell us which program is more effective at reducing risk on a per dollar basis. The reduction in the CV is largely proportional to the size of each program – commodity payments are the largest source of payments and they reduce the CV the most, followed by "other" payments and then conservation payments.

To gain insight into benefits per dollar of program expenditures, we next estimate the CE per program dollar. Among the three categories of payments, "other payments" have the highest CE per dollar. This probably reflects the largely counter-cyclical nature of these disaster assistance payment and market loss payments. The CE per dollar for these payments is higher for livestock producers than it is for crop farmers (1.07 versus 1.03), likely reflecting the importance of disaster assistance and market loss payment programs to dairy operations and other livestock producers.

Crop insurance

Because of the way the ARMS questionnaire is designed, it is only possible to examine the risk-reducing benefits of net crop insurance payments (indemnity payments – premiums) for a subset of farms. ARMS asks farmers about their total crop and livestock insurance indemnity payments but only asks farmers about their crop insurance premiums – not their livestock insurance premiums. Hence, we can only accurately estimate net insurance payments (indemnities minus premiums) for farms with no livestock insurance. To account for this, we focus our analysis on the subsample of operations that are highly specialized in crop production (at least 90% of total sales are from crops).

For these highly specialized crop producers (table 11), net crop insurance payments are the second largest source of payments – about $8,900 per farm - just slightly larger than the "other payments". The CE per dollar of crop insurance payments is 1.29 – each dollar received from crop insurance is worth $1.29 to the farmer, on average. The benefits per dollar from crop insurance are substantially higher than the other programs because crop insurance is more effective at mitigating farm income risk.

For each type of program except crop insurance, a dollar of payments is worth about a dollar to the farmer. This implies that the payments are roughly equivalent in value to a fixed certain payment. However, the payments are worth much more per dollar than farm income. For all farms (column 1, table 10) the average CE per dollar of income is only 0.592 ($104,991/$177,426). In other words, a dollar of farm income is only worth about 60 cents to the farmer because the income is so highly variable.

Conclusion

This study used a newly created panel dataset drawn from the 1996 to 2013 Agricultural Resource Management Survey (ARMS) to examine how farm income varies over time. The panel dataset allows us to measure how income changed over time for individual farms, and thereby create several measures of temporal income variability.

Comparing the variability of farm and non-farm income for crop and livestock farms of different sizes showed that farm income is substantially more variable than non-farm income, and that crop farm income is more volatile than livestock farm income. While farm income risk does not vary substantially across farms of different sizes, total household income risk increases proportionately with farm size – especially for crop farms. Larger farms face greater total income volatility because farm income - which is riskier than non-farm income - comprises a greater share of the total income for large farms. While total household income risk is greater for larger farms, income risk relative to assets is actually smaller. In other words, while large farms face more variation in income relative to their average income, they face less variation relative to their assets. This could help explain why large farms generally do not experience a greater probability of farm business failure despite facing more variable income (Key and Roberts, 2006; 2007).

An examination of average income volatility over time suggests that farm and total income volatility have decreased between 1996 and 2013. This finding was confirmed using a regression analysis that controlled for farm, operator, and regional characteristics. It is possible that the increasing emphasis of Federal farm programs on risk mitigation, including the decade-long expansion of crop insurance programs, has reduced farm income variability and consequently total household income variability. Future work will explore the causes of this apparent trend volatility.

This study also examined the extent to which different components of household income (farm income, agricultural payments, non-farm wage income, and other non-farm income) have contributed to, or mitigated, income variation. We find that farm income contributes by far the largest share to total income variation – about 77% for all farms, and up to 90% and 87% for crop and livestock farms with at least $3.0 million of farm assets. We find that for the average farm, there is a negative correlation between net farm income and other sources of income which substantially reduces total income volatility (compared to a situation where the income sources are not correlated). This is strong evidence that the diversification of income sources is an effective strategy for reducing farm household income risk.

Finally we examined the effect of different types of government programs on income risk and welfare. We find that all types of agricultural payments (commodity, conservation, crop insurance, or other payments) reduce the coefficient of variation in income – a common measure of income risk. To compare the risk-reducing benefits of these programs, we estimated the certainty equivalent value of the payments per dollar. We find that an expected dollar of commodity, conservation, and other payments are worth about $1.03-$1.07. This indicates that all these programs reduce income risk and provide much higher benefits that an expected dollar of farm income, which we estimate to be worth only $0.60 (in certainty-equivalent terms). We estimate that expected net crop insurance payments (indemnity payments – premiums) provide the greatest value for farmers – worth $1.29 for the average specialized crop farmer.

References

Anderson, J., and J. Dillon. (1992). *Risk analysis in dryland farming systems*. United Nations Food and Agriculture Organization. Farm Systems Management Series No. 2. Rome. 117 p.

Bohrnstedt, G., and A. Goldberger. (1969) "On the Exact Covariance of Products of Random Variables." *Journal of the American Statistical Association*, 64(328): 1439–42.

Cameron, S. and J. Tracy. (1998). "Earnings Variability in the United States: An Examination Using Matched-CPS Data." Columbia University and Federal Reserve Bank of New York.

Congressional Budget Office. (2008). *Recent Trends in the Variability of Individual Earnings and Household*. Report available at: http://www.cbo.gov/publication/41714

Dahl, M., T. DeLeire, and J. Schwabish. (2011). "Estimates of Year-to-Year Volatility in Earnings and in Household Incomes from Administrative, Survey, and Matched Data." *Journal of Human Resources* 46(4): 750-774.

Dynan, K., D. Elmendorf, and D. Sichel. (2012). "The evolution of household income volatility." *The B.E. Journal of Economic Analysis and Policy*. 12(2): 1935-1682.

Enjolras, G., F. Capitanio, M. Aubert, F. Adinolfi. (2014). "Direct payments, crop insurance and the volatility of farm income. Some evidence in France and in Italy." *New medit: Mediterranean journal of economics, agriculture and environment* 13(1): 31-40.

Gottschalk, P. and R. Moffitt. (1994). "The Growth of Earnings Instability in the U.S. Labor Market." *Brookings Papers on Economic Activity* 2: 217-272.

Haider, S. (2001). "Earnings Instability and Earnings Inequality of Males in the United States, 1967-1991." *Journal of Labor Economics* 19: 799-836.

Hardy, B. and J. Ziliak (2014). "Decomposing Trends in Income Volatility: The "Wild Ride" at the Top and Bottom." *Economic Inquiry* 52(1): 459-476.

Key, N. and M.J. Roberts. (2007). "Do Government Payments Influence Farm Size and Survival?" *Journal of Agricultural and Resource Economics* 32(2): 330-348.

Key, N. and M.J. Roberts. (2006). "Government Payments and Farm Business Survival." *American Journal of Agricultural Economics* 88(2): 382-392.

Mishra, A. and H. El-Osta. (2001). "A temporal comparison of sources of variability in farm household income." *Agricultural Finance Review 61*(2): 181-198.

Mishra, A, and H.S. El-Osta. (2005). "Decomposition of Variability in Farm Household Assets and Debt." *Journal of Agribusiness* 23 (2): 163-182.

Mishra, A., and B. Goodwin. (1997). "Farm Income Variability and the Supply of Off-Farm Labor." *American Journal of Agricultural Economics* 79(8): 880-887.

Mishra, A., and C. Sandretto. (2002). "Stability of farm income and the role of nonfarm income in US agriculture." *Review of Agricultural Economics 24*(1): 208-221.

Moffitt, R., and P. Gottschalk. (2011). *Trends in the Transitory Variance of Male Earnings in the US, 1970-2004*. National Bureau of Economic Research. No. w16833.

Poon, K. and A. Weersink (2011) "Factors affecting variability in farm and off-farm income" *Agricultural Finance Review* 71(3): 379-397.

Purdy, B., M. Langemeier, and A. Featherstone. (1997). “Financial Performance, Risk, and Specialization.” *Journal of Agricultural and Applied Economics* 27(1): 149-161.

Schurle, B. and M. Tholstrup (1989). “Farm characteristics and business risk in production agriculture.” *North Central Journal of Agricultural Economics*11(2): 183-188

Shin, D., and G. Solon. (2011). "Trends in men's earnings volatility: What does the Panel Study of Income Dynamics show?" *Journal of Public Economics* 95(7): 973-982.

United States Department of Agriculture (USDA), Economic Research Service (ERS). (2015). “ARMS Farm Financial and Crop Production Practices.” Available online at http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx [accessed 5/11/2015]

United States Department of Agriculture (USDA), Economic Research Service (ERS). (2015). “Farm Household Well-being: Income and Wealth in Context.” Available online at http://www.ers.usda.gov/topics/farm-economy/farm-household-well-being/income-and-wealth-in-context.aspx [accessed 5/19/2015]

Ziliak, J., B. Hardy, and C. Bollinger. (2011). "Earnings Volatility in America: Evidence from Matched CPS." *Labour Economics* 18(6): 742-754.

Figure 1a – Mean Absolute Arc Percentage Change, Total Household Income

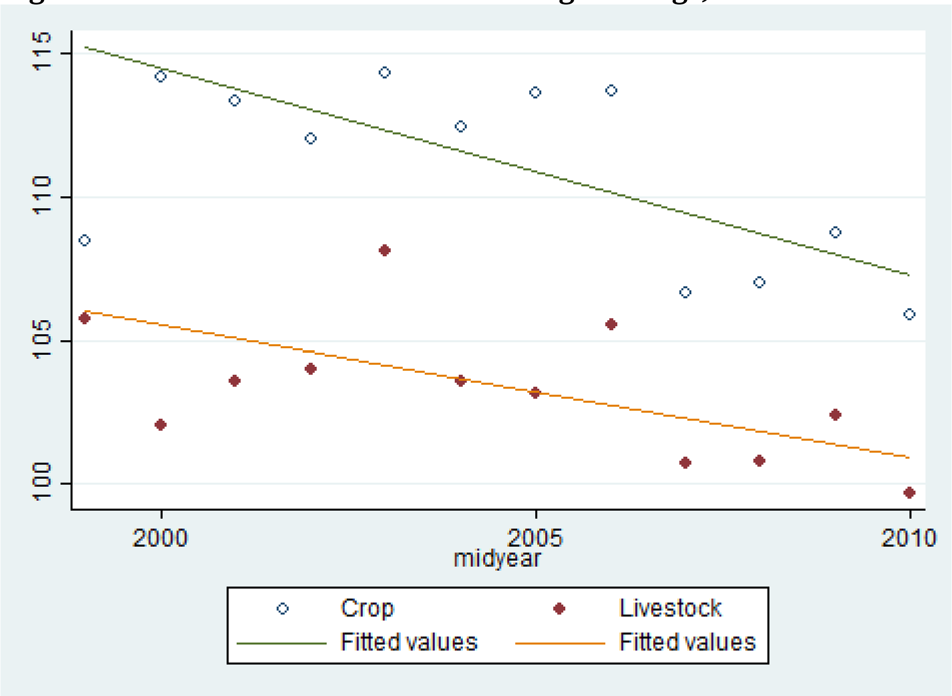

Figure 1b – Mean Absolute Arc Percentage Change, Total Farm Household Income

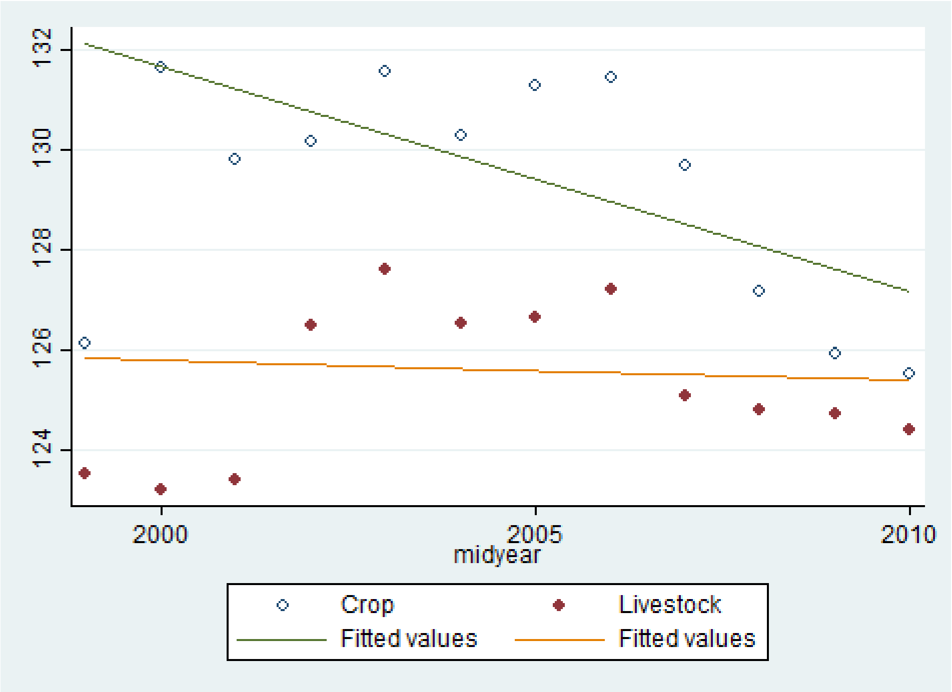

Figure 1c – Mean Absolute C.V. (cut-off at 10), Total Household Income

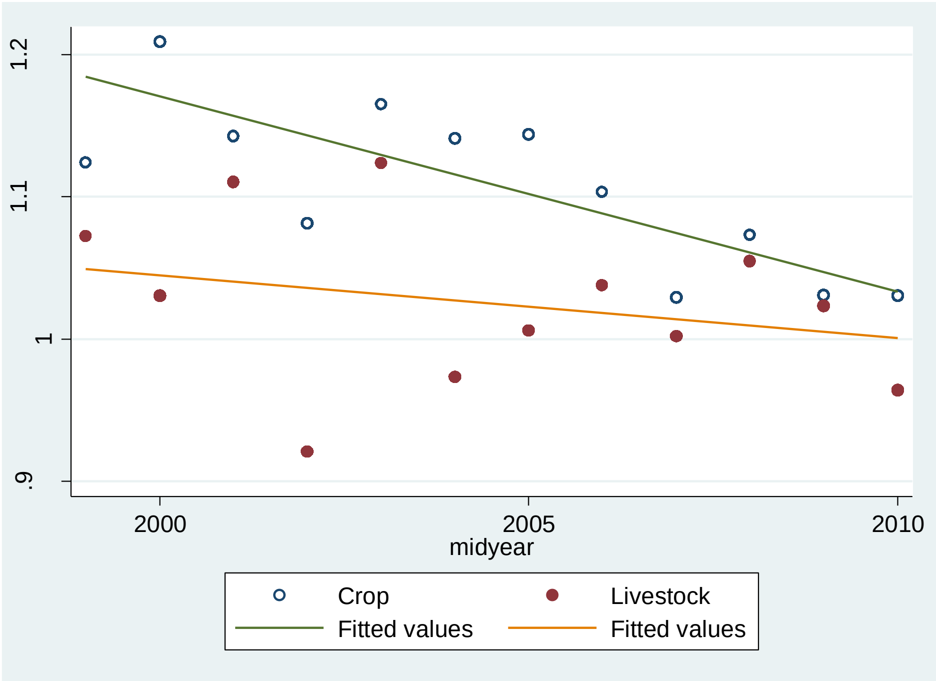

Figure 1d – Mean Absolute C.V. (cut-off at 10), Total Farm Household Income

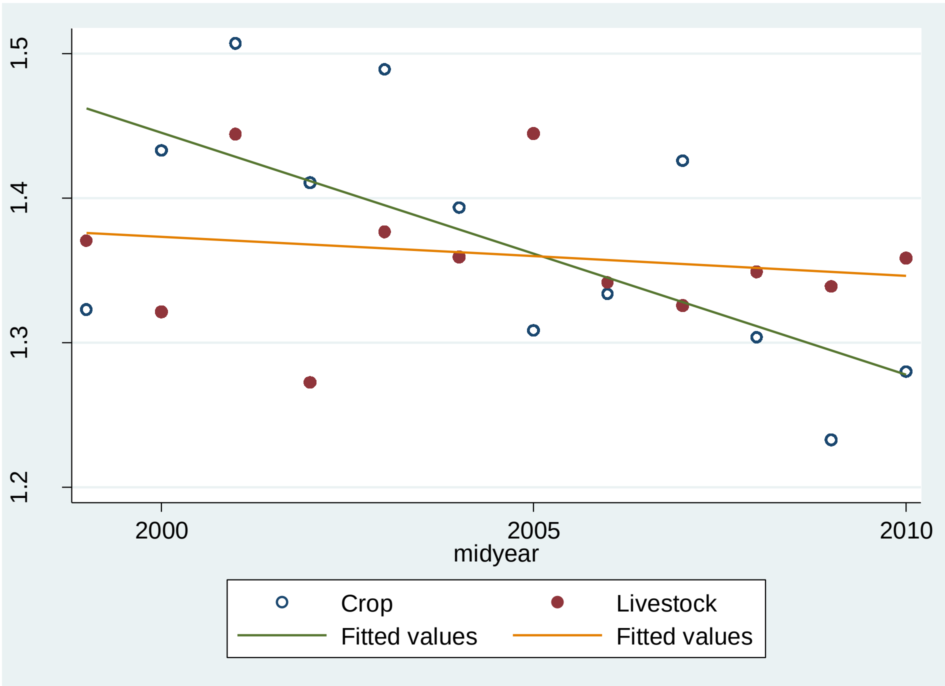

Figure 1e – Mean Absolute Value of CRA, Total Household Income / Assets

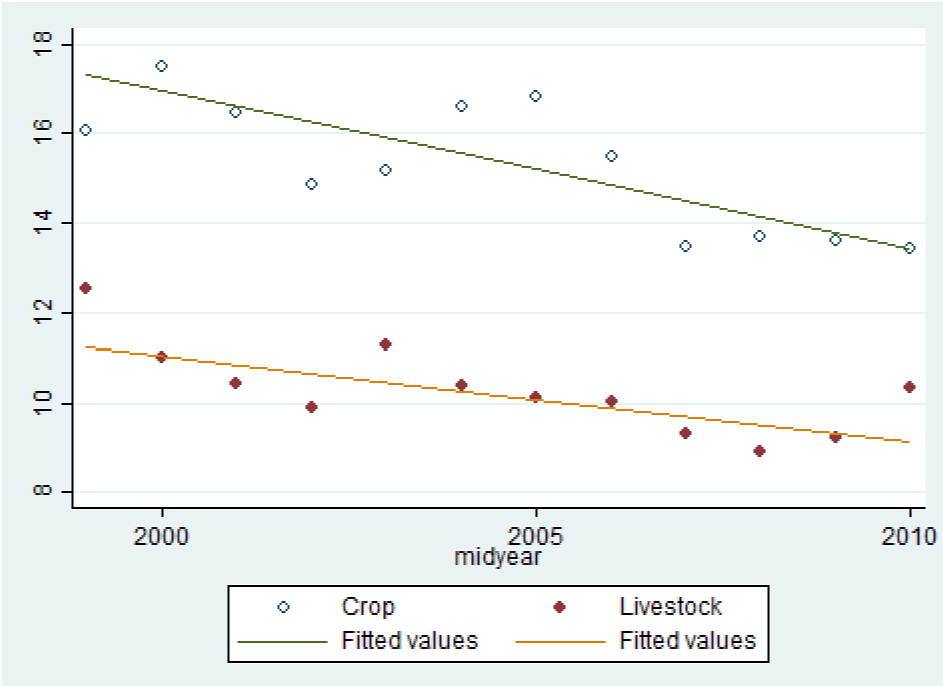

Figure 1f – Mean Absolute Value of CRA1A, Farm Household Income

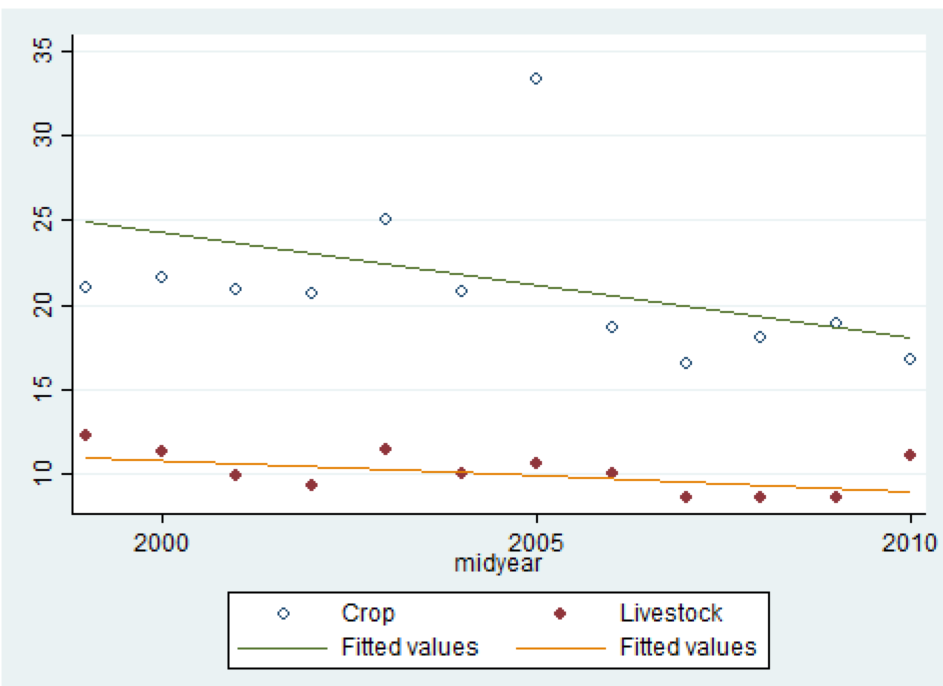

Table 1 – Panel vs. Full Dataset – Median Values

	Observations	Total Household Income	Off-farm Income	Farm Income	Farm Assets	Non-farm Assets
Panel Dataset	88,269	90,427	32,672	38,848	1,313,129	143,678
All Farms	279,291	72,805	40,473	9,467	865,195	133,929

Data Source: Agricultural Resource Management Survey (ARMS), 1996-2013

Table 2 -- Income, Assets and Government Payments for Crop and Livestock Farms

	Livestock Farms	Crop Farms
Farm Household Income (Median)	$36,297	$72,322
Off-farm Income (Median)	$31,847	$34,647
Total Household Income (Median)	$85,550	$125,176
Farm Household Income (Mean)	$112,959	$175,185
Total Household Income (Mean)	$169,482	$233,871
Household Asset (Median)	$1,729,134	$1,874,364
Household Debt (Median)	$201,932	$201,140
Gov. Payments (total) (Mean)	$17,964	$58,961
Commodity Payments (Mean)	$9,004	$45,597
Cons. Payments (Mean)	$2,145	$3,929
Crop Premiums (Mean)	$2,478	$17,158
Disaster Payments (Mean)	$2,733	$7,448

Data Source: Agricultural Resource Management Survey (ARMS), 1996-2013

Table 3 -- Volatility Measures for Crop and Livestock Farms

	Livestock Farms	Crop Farms
Total HHI Share Gain	48%	52%
Total Household Income Median Change	-$3,335	$8,001
Total Household Income Median Gain	$80,147	$142,874
Total Household Income Median Loss	-$78,255	-$133,150
AAPC Farm Household Income Median	131.9	136.9
AAPC Total Household Income Median	90.7	100.4
Farm Household Income Abs. CV	0.93	0.97
Total Household Income Abs. CV	0.64	0.71
Farm Household Income Abs. CV (<10)	0.87	0.91
Total Household Income Abs. CV (<10)	0.61	0.68
CRA (Assets) Farm Household Income	4.5	8.3
CRA (Assets) Total Household Income	5.0	7.7
Log Business Risk	-6.13	-6.99
Std. Dev. Total Household Income/ Assets	0.07	0.10

Data Source: Agricultural Resource Management Survey (ARMS), 1996-2013

Table 4 – Household Income and Government Payments by Type of Farm and Asset Class

	Livestock. Farm Assets: <$750K	Livestock. Farm Assets: $750K - $1.5M	Livestock. Farm Assets: 1.5M - 3M	Livestock. Farm Assets: >3M	Crops. Farm Assets: <$750K	Crops. Farm Assets: $750K - $1.5M	Crops. Farm Assets: 1.5M - 3M	Crops. Farm Assets: >3M
Farm HHI Median	$5,550	$29,784	$62,048	$117,418	$21,553	$58,112	$99,870	$207,015
Off-farm Income Median	$42,088	$31,208	$27,665	$27,603	$39,288	$34,408	$31,960	$34,024
Total HHI Median	$59,126	$73,576	$103,948	$180,723	$78,542	$109,751	$149,993	$265,648
HH Asst Median	$600,469	$1,254,425	$2,297,234	$5,202,371	$657,633	$1,333,948	$2,415,259	$5,115,684
HH Debt Median	$59,256	$170,487	$319,082	$780,876	$77,965	$161,204	$296,183	$571,074
Gov. Payments (total)	$4,325	$9,704	$20,099	$39,283	$36,405	$56,326	$65,979	$76,204
Commodity Payments	$1,971	$4,605	$10,862	$19,264	$29,358	$43,914	$50,768	$57,660
Cons. Payments	$593	$1,207	$2,262	$4,718	$2,015	$3,642	$4,141	$5,882
Crop Premiums	$358	$1,224	$2,973	$5,170	$6,177	$11,581	$16,549	$33,000
Disaster Payments	$852	$1,879	$3,745	$4,950	$4,227	$8,038	$10,092	$8,150

Data Source: Agricultural Resource Management Survey (ARMS), 1996-2013

Table 5 – Volatility Measures by Type of Farm and Asset Class

	Livestock. Farm Assets: <$750K	Livestock. Farm Assets: $750K - $1.5M	Livestock. Farm Assets: 1.5M - 3M	Livestock. Farm Assets: >3M	Crops. Farm Assets: <$750K	Crops. Farm Assets: $750K - $1.5M	Crops. Farm Assets: 1.5M - 3M	Crops. Farm Assets: >3M
AAPC Farm HHI Median	124.6	133.1	130.9	139.2	136.7	134.5	137.5	138.4
AAPC Total HHI Median	63.6	86.5	102.2	119.4	77.2	96.6	111.5	118.4
Farm HHI Abs. CV	0.88	0.94	0.93	0.98	0.97	0.95	0.97	0.98
Total HHI Abs. CV	0.45	0.61	0.72	0.84	0.55	0.68	0.79	0.84
Farm HHI Abs. CV (<10)	0.84	0.87	0.85	0.93	0.91	0.89	0.91	0.92
Total HHI Abs. CV (<10)	0.44	0.59	0.68	0.81	0.53	0.66	0.75	0.80
Asset-based Measures								
CRA (Assets) Farm HHI	4.76	4.61	4.35	4.40	10.77	8.83	8.43	6.22
CRA (Assets) Total HHI	6.40	4.87	4.41	4.45	9.45	7.96	7.81	5.88
Log Business Risk	-6.21	-6.77	-6.83	-6.73	-5.34	-5.75	-5.93	-6.16
Std. Dev. Total HHI / Assets	0.10	0.07	0.07	0.07	0.16	0.12	0.10	0.08
Gains and Losses								
Total HHI Share Gain	48%	48%	48%	49%	51%	52%	52%	55%
Total HHI Median Change	-$2,015	-$4,052	-$6,328	-$5,032	$2,312	$5,745	$8,857	$44,269
Total HHI Median Gain	$33,784	$60,608	$106,383	$257,378	$58,257	$110,292	$194,328	
Total HHI Median Loss	-$36,022	-$60,905	-$100,466	-$244,008	-$58,077	-$102,884	-$179,212	$339,295

Source: USDA Agricultural Resource Management Survey 1996-2013.

Table 6 – Variable Means and Distributions

Variable	N	mean	sd	min	p25	p50	p75	max
Absolute Value of C.V. of Total HHI	37239	1.10	1.36	0.00	0.33	0.70	1.27	10.00
Log of Business Risk	37042	-6.19	2.86	-27.60	-7.81	-6.02	-4.35	11.48
Std. Dev. Total HHI / Mean(Assets)	38316	0.10	0.20	0	0.02	0.05	0.11	8.94
Year (Avg.)	38317	2006.06	3.25	1996.5	2004	2006.5	2008.5	2012.5
Operator Age	38317	54.89	11.80	17	47	55	62	98
Operator Education	38317	2.71	0.94	1	2	3	3	5
Farm Occupation	38317	0.84	-	0	1	1	1	1
Farm Debt-to-Asset Ratio	38317	0.16	-	0	0.02	0.10	0.23	10.39
Household Assets	37052	2,638,202	4,685,479	0	825,340.6	1,565,456	2,948,398	-
Average Sales	38317	1,018,081	2,100,123	0	156,012	507,426.1	1,170,245	-
Span (Avg.)	38317	4.68	2.89	1	2.5	4	6	17
Number of Observations	38317	2.30	0.63	2	2	2	2	8
Poultry Farm (Value of Prod. > $10,000)	38317	0.12	-	0	0	0	0	1
Cattle Farm (Value of Prod. > $10,000)	38317	0.39	-	0	0	0	1	1
Corn Farm (Value of Prod. > $10,000)	38317	0.33	-	0	0	0	1	1
Heartland	38317	0.21	-	0	0	0	0	1
Northern Crescent	38317	0.11	-	0	0	0	0	1
Northern Great Plains	38317	0.04	-	0	0	0	0	1
Prairie Gateway	38317	0.11	-	0	0	0	0	1
Eastern Uplands	38317	0.08	-	0	0	0	0	1
Southern Seaboard	38317	0.16	-	0	0	0	0	1
Fruitful Rim	38317	0.19	-	0	0	0	0	1
Basin and Range	38317	0.04	-	0	0	0	0	1
Mississippi Portal	38317	0.06	-	0	0	0	0	1

Table 7 – regression results

VARIABLES	(1) Abs. CV Total HHI (<10)	(2) Ln(Abs. CV Tot. HHI)	(3) Ln(Business Risk)	(4) CV Tot HHI/Asst
Year (Avg.)	-0.00611***	-0.00583**	-0.0294***	-0.00505***
	(0.00222)	(0.00245)	(0.00493)	(0.000420)
Operator Age	0.000169	0.00114**	-0.0298***	-0.000785***
	(0.000626)	(0.000550)	(0.00147)	(0.000143)
Operator Education	-0.0365***	-0.0361***	-0.0755***	-0.00338**
	(0.00653)	(0.00655)	(0.0165)	(0.00132)
Occupation, Farmer (bin)	0.313***	0.379***	-0.0883**	-0.00192
	(0.0171)	(0.0220)	(0.0397)	(0.00302)
Farm Debt-to-Asset Ratio (Avg.)	0.534***	0.416***	1.035***	0.0925***
	(0.0646)	(0.0503)	(0.0919)	(0.0170)
Year Span (Avg.)	0.00727***	0.0139***	0.0133**	0.000750*
	(0.00237)	(0.00223)	(0.00545)	(0.000425)
Number of Indiv. Obs	0.166***	0.280***	0.550***	0.000398
	(0.0109)	(0.0117)	(0.0284)	(0.00161)
Sales $200K-600K	0.171***	0.222***	0.615***	0.0193***
	(0.0312)	(0.0318)	(0.0543)	(0.00295)
Sales $600K-1.25M	0.158***	0.234***	0.948***	0.0368***
	(0.0273)	(0.0233)	(0.0493)	(0.00419)
Sales > 1.25M	0.151***	0.254***	1.383***	0.0687***
	(0.0330)	(0.0266)	(0.0854)	(0.00540)
REGIONS				
Northern Crescent	0.0291	0.00611	-0.351***	-0.0122**
	(0.0261)	(0.0288)	(0.0868)	(0.00606)
Northern Great Plains	0.210***	0.168***	0.0471	-0.00154
	(0.0362)	(0.0248)	(0.125)	(0.00500)
Prairie Gateway	0.128**	0.135**	0.700***	0.0331***
	(0.0576)	(0.0511)	(0.176)	(0.0115)
Eastern Uplands	0.0863***	0.0939**	0.208**	0.0202**
	(0.0303)	(0.0367)	(0.0998)	(0.00909)
Southern Seaboard	0.117***	0.110***	0.335***	0.0237***
	(0.0273)	(0.0248)	(0.0912)	(0.00579)
Fruitful Rim	0.211***	0.201***	0.364***	0.0265***
	(0.0485)	(0.0438)	(0.125)	(0.00840)
Basin and Range	0.142***	0.130***	-0.0543	0.00681
	(0.0466)	(0.0399)	(0.143)	(0.00932)
Mississippi Portal	0.196***	0.167***	1.089***	0.0869***
	(0.0303)	(0.0373)	(0.114)	(0.0101)
Household Assets	1.07e-08***	9.89e-09***		
	(2.70e-09)	(2.17e-09)		
Poultry (bin)	-0.116***	-0.155***	-1.150***	-0.0617***
	(0.0423)	(0.0322)	(0.115)	(0.00700)
Cattle (bin)	0.0670***	0.0450**	-0.652***	-0.0313***
	(0.0232)	(0.0203)	(0.0528)	(0.00334)
Corn (bin)	0.0690***	0.0737***	0.0493	-0.00341

	(0.0208)	(0.0188)	(0.0604)	(0.00387)
Constant	12.41***	9.831*	52.61***	10.25***
	(4.444)	(4.919)	(9.901)	(0.843)
Observations	36,013	36,013	37,042	38,316
R-squared	0.042	0.080	0.126	0.065
Region FEs	Yes	Yes	Yes	Yes

State-clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8. Covariance of income components divided by total income variance: all farms

Income components	Net farm income	Agricultural program payments	Non-farm wage income	Other non-farm income	Total
Net farm income	1.069	-0.124	-0.088	-0.090	
Agricultural program payments	-0.124	0.175	-0.012	-0.009	
Non-farm wage income	-0.088	-0.012	0.230	-0.025	
Other non-farm income	-0.090	-0.009	-0.025	0.223	
Component shares	0.767	0.030	0.105	0.098	1.000

Source: Author's Calculation based on the Agricultural Resource Management Survey (ARMS)

Table 9. Share of income components in total income variation

	Income components			
	Net farm income	Agricultural program payments	Non-farm wage income	Non-farm non-wage income
All farms	0.767	0.030	0.105	0.098
All farms				
Farm assets: < $750K	0.547	0.039	0.247	0.167
Farm assets: $750K – $1.5M	0.774	0.031	0.100	0.096
Farm assets: $1.5M – $3.0M	0.848	0.026	0.054	0.073
Farm assets: > $3.0M	0.884	0.026	0.027	0.063
Crop farms				
Farm assets: < $750K	0.605	0.060	0.195	0.141
Farm assets: $750K – $1.5M	0.801	0.046	0.077	0.076
Farm assets: $1.5M – $3.0M	0.878	0.028	0.042	0.052
Farm assets: > $3.0M	0.899	0.025	0.025	0.051
Livestock farms				
Farm assets: < $750K	0.489	0.017	0.300	0.193
Farm assets: $750K – $1.5M	0.749	0.016	0.121	0.114
Farm assets: $1.5M – $3.0M	0.817	0.022	0.066	0.095
Farm assets: > $3.0M	0.867	0.028	0.030	0.076

Source: Author's Calculation based on the Agricultural Resource Management Survey (ARMS)

Table 10. Income variability and certainty equivalent values with and without program payments

	Total household income plus …			
	No payments	Commodity payments	Conservation payments	Other payments
All farms (N= 30176)				
Mean	177,426	203,053	180,557	184,866
SD	208,234	208,005	208,183	207,502
CV	1.165	1.026	1.145	1.114
CE	104,991	130,772	108,134	112,768
Change in CE	0	25,781	3,143	7,777
Program payment	0	25,628	3,131	7,440
$\Delta CE/$ payment	-	1.001	1.006	1.049
Crop (N=15454)				
Mean	196,993	239,278	200,989	205,704
SD	243,924	243,415	243,914	243,500
CV	1.238	1.017	1.214	1.184
CE	110,245	152,887	114,233	119,198
Change in CE	0	42,642	3,987	8,953
Program payment	0	42,285	3,996	8,711
$\Delta CE/$ payment	-	1.008	0.998	1.028
Livestock (N= 14722)				
Mean	156,885	165,027	159,108	162,992
SD	170,769	170,835	170,675	169,715
CV	1.088	1.035	1.073	1.041
CE	99,475	107,557	101,732	106,018
Change in CE	0	8,082	2,257	6,543
Program payment	0	8,142	2,223	6,106
$\Delta CE/$ payment	-	0.993	1.015	1.072

Source: Author's Calculation based on the Agricultural Resource Management Survey (ARMS)

Table 11. Income variability and certainty equivalent values with and without program payments and net crop insurance payments: Highly specialized crop farms

	Total household income plus …				
	No payments	Commodity payments	Conservation payments	Other payments	Net Crop insurance payments
Highly specialized crop farms (N= 4628)					
Mean	230,380	282,142	235,034	239,098	237,186
SD	299,279	298,710	299,405	299,638	295,828
CV	1.299	1.059	1.274	1.253	1.247
CE	117,428	170,428	122,178	126,221	126,314
Change in CE	0	53,001	4,751	8,793	8,886
Program payment	0	51,762	4,654	8,718	6,806
$\Delta CE/$ payment	-	1.023	1.020	0.975	1.291

Source: Author’s Calculation based on the Agricultural Resource Management Survey (ARMS)

Notes: Highly specialized crop farms receive at least 90 percent of sales from crops. Sample includes only observations for which crop insurance premiums and indemnity payments were non-missing in both periods.

Appendix Table 1: Household observation frequency in the Panel Dataset

Number of Observations	Frequency	Percent	Cumulative Percent
2	29,488	76.96	76.96
3	6,647	17.35	94.31
4	1,705	4.45	98.76
5	396	1.03	99.79
6	66	0.17	99.96
7	13	0.03	99.99
8	2	0.01	100
Total	38,317	100	-

Appendix Table 2a: Selected variables from the Panel and Full datasets

	Panel Dataset							Full Dataset						
		Income			Assets				Income			Assets		
Year	N	Total	Off-farm	Farm	Farm	Non-farm	Crop (%)	N	Total	Off-farm	Farm	Farm	Non-farm	Crop (%)
1996	1,455	127,253	35,660	91,593	1,296,737	123,186	55	6,985	116,968	57,628	59,340	1,290,897	158,940	53
1997	2,867	111,383	37,035	74,348	1,180,451	-	63	11,159	121,948	55,233	66,716	1,188,049	-	60
1998	2,163	125,417	39,388	86,029	1,431,896	145,103	56	7,991	127,896	60,662	67,234	1,343,588	169,314	53
1999	2,795	129,056	40,487	88,569	1,419,521	213,987	50	9,778	126,662	62,267	64,395	1,316,622	263,763	48
2000	3,336	99,719	41,630	58,089	1,488,718	142,581	50	9,863	110,629	58,249	52,380	1,399,189	169,105	48
2001	2,439	144,640	43,394	101,246	1,838,659	145,900	52	7,343	135,904	58,318	77,586	1,615,235	166,753	49
2002	3,868	111,491	47,090	64,401	1,493,240	168,534	52	11,926	114,018	65,321	48,698	1,333,171	192,694	50
2003	6,002	140,462	47,847	92,615	1,474,068	237,926	54	17,782	137,476	62,323	75,154	1,421,878	267,069	51
2004	6,090	163,905	48,908	114,997	1,688,414	262,428	50	19,468	152,985	69,450	83,536	1,459,386	292,711	47
2005	7,121	193,753	47,801	145,951	2,104,499	277,772	43	21,564	162,100	63,669	98,431	1,665,469	285,002	42
2006	7,338	158,168	58,251	99,918	2,095,327	297,856	51	20,351	148,976	72,899	76,077	1,784,044	305,485	48
2007	5,945	217,145	54,689	162,456	2,506,499	343,350	58	17,465	176,872	66,013	110,859	2,022,115	328,613	53
2008	6,727	187,593	55,085	132,508	2,486,676	292,740	54	20,469	150,130	65,268	84,862	1,927,139	273,324	49
2009	6,370	146,795	54,510	92,285	2,432,865	274,600	53	19,877	118,097	63,369	54,729	1,748,661	274,511	49
2010	6,300	177,416	52,180	125,236	2,526,780	293,321	49	20,661	138,276	63,595	74,681	1,754,890	279,122	44
2011	6,366	214,651	51,547	163,104	2,781,097	309,707	51	19,441	157,152	60,647	96,505	2,029,347	289,098	48
2012	5,937	295,837	69,482	226,355	3,160,615	631,925	62	20,561	198,643	77,024	121,619	2,153,328	567,217	55
2013	5,150	283,748	69,682	214,065	2,842,510	686,527	61	16,607	196,198	77,820	118,378	1,927,089	582,624	53
Total	88,269	179,277	52,196	127,080	2,166,185	311,831	53	279,291	148,955	65,625	83,329	1,700,272	307,903	49

Source: USDA Agricultural Resource Management Survey (ARMS)

Appendix Table 2b: Percent difference between Panel and Full Dataset

Percent difference between Panel and Full Dataset[13]						
	Income			Assets		
Year	Total	Off-farm	Farm	Farm	Non-farm	Crop (%)
1996	8.8%	-38.1%	54.4%	0.5%	-22.5%	3.8%
1997	-8.7%	-32.9%	11.4%	-0.6%		5.0%
1998	-1.9%	-35.1%	28.0%	6.6%	-14.3%	5.7%
1999	1.9%	-35.0%	37.5%	7.8%	-18.9%	4.2%
2000	-9.9%	-28.5%	10.9%	6.4%	-15.7%	4.2%
2001	6.4%	-25.6%	30.5%	13.8%	-12.5%	6.1%
2002	-2.2%	-27.9%	32.2%	12.0%	-12.5%	4.0%
2003	2.2%	-23.2%	23.2%	3.7%	-10.9%	5.9%
2004	7.1%	-29.6%	37.7%	15.7%	-10.3%	6.4%
2005	19.5%	-24.9%	48.3%	26.4%	-2.5%	2.4%
2006	6.2%	-20.1%	31.3%	17.4%	-2.5%	6.3%
2007	22.8%	-17.2%	46.5%	24.0%	4.5%	9.4%
2008	25.0%	-15.6%	56.1%	29.0%	7.1%	10.2%
2009	24.3%	-14.0%	68.6%	39.1%	0.0%	8.2%
2010	28.3%	-17.9%	67.7%	44.0%	5.1%	11.4%
2011	36.6%	-15.0%	69.0%	37.0%	7.1%	6.3%
2012	48.9%	-9.8%	86.1%	46.8%	11.4%	12.7%
2013	44.6%	-10.5%	80.8%	47.5%	17.8%	15.1%
Total	20.4%	-20.5%	52.5%	27.4%	1.3%	8.2%

Source: USDA Agricultural Resource Management Survey (ARMS)

[13] Percent difference = (Panel dataset average – Full dataset average) / (Full dataset average)