Do Wealth Gains from Land Appreciation Cause Farmers to Expand Acreage or Buy Land?

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Recent increases in farm real estate values in the U.S. have increased farm equity in the form of unrealized capital gains. Exploiting periods of high and low appreciation that caused different increases in wealth for farmers owning different shares of their farmland, we examine if U.S. grain farmers expanded their acres harvested or acres owned in response to an increase in their land wealth. We find that land wealth had little effect on farm size. However, for farms of a similar size, owning 10 percentage points more land increased the growth rate of land owned by 2 percentage points. Because older farmers own a larger share of the land in the farm, an increase in the rate of land appreciation slows the rate at which younger farmers acquire land relative to older farmers.

Key words: farmland appreciation, wealth, land ownership, farm size

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In recent years, high crop prices and record farm incomes, combined with low interest rates and urban development pressure, have caused dramatic increases in farmland values. From 2004 to 2012 nominal cropland values in the United States doubled (USDA-NASS 2006, 2012). With real estate accounting for 85 percent of farm sector assets, the higher land values have meant substantial increases in wealth for some farmers (USDA-ERS 2012). The capital gains from land appreciation may have increased access to credit by making more collateral available for loans, enabling some farmers to expand production or purchase more land. Rapid appreciation may therefore contribute to the ongoing consolidation of crop agriculture (MacDonald, Korb, and Hoppe 2013). By lowering borrowing costs for established farmers and encouraging them to buy land, rising land prices may also work against state and federal beginning-farmer bond programs designed to help beginning farmers buy land. We explore the implications of land appreciation by estimating the extent that farmers experiencing larger wealth gains from recent farmland appreciation harvested more acres or bought more land compared to farmers with smaller wealth gains.

Increases in land wealth could influence land use and ownership decisions by lowering the cost of borrowing. Writing in the wake of the large increase in farmland values in the 1970s, Plaxico and Kletke (1979) and Lowenberg-DeBoer and Boehlje (1986) argued that capital gains from farmland appreciation increase a farmer's collateral, which allows him to borrow more or borrow at a lower rate. Improved borrowing terms, in turn, could allow farmers to expand. However, as we demonstrate using a simple theoretical model, land appreciation does not necessarily induce farmers to expand acreage, even if it lowers borrowing costs. Land appreciation is driven by higher crop prices and profits, which provide an incentive to expand, but higher land values and rental rates also make it more costly to expand on the extensive margin. While the effect of land values on farm size is ambiguous, our model predicts that higher land prices encourage farmers to buy land because the increase in equity lowers borrowing costs, decreasing the cost of accessing land through purchase relative to renting.

This is the first study that we are aware to estimate farm-level responses to land wealth appreciation, although some have explored how changes in wealth caused by real estate markets affect non-farm household borrowing, consumption, and entry into self-employment (Hurst and Lusardi 2004; Campbell and Cocco 2007; Bostic, Gabriel, and Painter 2009; Disney and Gathergood 2009; Mian and Sufi, 2009; Fairlie and Krashinsky 2012). To identify an exogenous change in wealth, these studies exploit variation in real estate prices across space. A problem with this approach is that such variation is likely correlated with unobserved changes in the local economy affecting household decisions. Campbell and Cocco (2007) take a more promising approach and interact changes in regional housing prices with a variable indicating whether the household owns or rents its home (since only owners experience wealth increases from higher prices).

To empirically identify farm-level responses to farmland appreciation we exploit, as did Campbell and Cocco (2007), differences in how real estate appreciation affects owners and renters. More specifically, we use variation in the share of land operated by the farm that is owned by the farm. In addition, we exploit two periods with markedly different appreciation rates. From 1997 to 2002 the average value of farm real estate increased by 20 percent in real terms; in the following period, 2002 to 2007, it appreciated by 44 percent (figure 1). As prices increased, farmers who owned a greater share of their farmland had a larger wealth gain than those with similar farms but who rented more of their land. Linking farms surveyed in the 1997, 2002, and 2007 Censuses of Agriculture allows us to observe farm-level changes in farm size and land ownership for crop farms across the U.S. Identification of the effect of appreciation comes from farms who own a greater share of their land expanding faster (or buying more land) from 2002 to 2007 than from 1997 to 2002 compared with farms owning a smaller share.

The empirical approach has several strengths. Because most crop farmers rent some of the land that they farm, we can exploit variation in ownership shares among farms renting some land. This eliminates bias that could arise if farmers who own all the land they operate are different from renters in unobservable ways. Second, observing the same farm in three different years allows us to control for the possibility that farmers who own a greater share of land tend to expand more quickly (or more slowly) than those with a smaller share.

The third and perhaps most important strength is that the approach uses variation in farmland appreciation across time instead of across space, which is likely correlated with local conditions affecting farm decisions. Farmers have the greatest incentive to expand in areas best suited to grow the crops with the largest price increases. But, these are also the areas where farmland values will appreciate the most, inducing a spurious correlation across space in real estate appreciation, farmer wealth, and changes in acres harvested or owned. Instead of relying on spatial variation, we rely on an unexpected increase in land appreciation across time caused in part by the 2005 ethanol mandate and the resulting higher global crop prices (real corn prices increased by more than 40 percent from 2002 to 2007).[1]

We find that increases in land wealth had a negligible effect on farm size as measured by acres harvested. In contrast, we find that farmers with larger increases in wealth bought more land than they otherwise would have. Owning 10 percentages points more of the land in the farm was associated with 2 percentage points faster growth in land owned. This effect does not appear

[1] An even larger increase in corn prices occurred following the 2007 Energy Independence and Security Act, which strengthened the renewable fuel standard created by the 2005 Energy Policy Act.

when we replicate the analysis for an earlier period when land appreciated at a constant rate, which is evidence that our results are not spurious. Because older farmers own a larger share of the land in the farm, the findings imply that greater land appreciation slows the rate at which younger farmers acquire land compared to older farmers. And because smaller farms own a larger share, greater appreciation works against the consolidation of land ownership among larger farms.

Farm Response to Wealth Gains from Land Appreciation

Plaxico and Kletke (1979) argued that an unrealized capital gain from land appreciation can serve as equity when applying for a loan, thereby reducing the risk to the lender that the borrower defaults. Building on this assumption, Lowenberg-DeBoer and Boehlje (1986) supposed that the cost of borrowing to purchase land decreases with the farm's debt-to-equity ratio. Lowenberg-DeBoer and Boehlje used a modified Vicker's model (Vickers, 1968) where the farmer seeks to maximize the present value of future income (less the equity used to generate it) and the salvage value of the farm's assets. Farmland appreciation encourages expansion in acreage because farmers treat some of the capital gains as current income, which raises profits in the current period and increases the profit-maximizing farm size.

A limitation of the Lowenberg-DeBoer and Boehlje model is that the value of land consumed as an input to production (e.g, from the depreciation of fences) enters the objective function, but the cost of acquiring land, either through renting or purchase, does not. This hides the increase in land values that makes buying or renting land more expensive. And for those who rent land, payments for land increase even if rented acres do not expand. Although simpler in several aspects, we posit a model that explicitly incorporates land prices and rental rates and transparently provides two key results.

The first result is that if borrowing costs depend on wealth, then the more a farmer benefits from an increase in land values, the more he will shift towards owning land instead of renting it. This is because greater wealth lowers the cost of acquiring land through borrowing but not the cost of renting land. The second result is that an increase in land values has an ambiguous effect on farm size that depends on whether the land rental price increases relatively more than the crop price.

Consider a farmer who purchased land in the past and now must choose how much land to rent and buy. The farmer has a debt D and acres l_o from past land purchases, which are exogenous to the farmer's current period optimization problem:

(1) $$\max_{l_r, l_b} \pi = p_c f(L) - p_r l_r - p_b ra\left(\frac{p_b l_b + D}{p_b l_o - D}\right) l_b,$$

where p_c is the crop price, p_r is the rental price of land, and p_b is the purchase price of land. The total amount of land farmed is equal to the amount rented, plus purchased, plus already owned: $L = l_r + l_b + l_o$. The term $p_b ra\left(\frac{p_b l_b + D}{p_b l_o - D}\right)$ is the annual cost of purchasing an acre of land. Because of capital market imperfections, assume that the cost of purchasing land increases linearly with the debt-to-wealth ratio, where the debt includes past debt from land purchases D (which does not depend on current prices) plus debt incurred from purchasing $p_b l_b$ worth of land in the current period. Wealth in the current period is defined as the current value of land already owned ($p_b l_o$) minus the outstanding debt. The factor a is positive and determines the rate at which the debt-to-wealth ratio increases the cost of borrowing.

The cost of buying an acre of land specified in (1) assumes that the farmer makes no down payment on the land purchase and only pays interest on the debt. A more complicated model could relax these assumptions, but the simpler specification more clearly illustrates the relationships of interest.

The first order conditions for a farmer who owns and rents some land are:

(2a) $$p_c f'(L) - p_r = 0$$

(2b) $$p_c f'(L) - p_b ra\left(\frac{p_b l_b + D}{p_b l_o - D}\right) - p_b ra\left(\frac{p_b}{p_b l_o - D}\right) l_b = 0.$$

Assuming that the land purchase price is the discounted stream of the expected rental price ($p_b = \frac{p_r}{R}$) and that the discount rate is greater than the risk-free market interest rate ($R > r$), we can solve for the optimal quantity of land to buy in the current period:

(3) $$l_b^* = \frac{1}{2p_b}\left[\frac{R}{ra}(p_b l_o - D) - D\right].$$

From (3) we see that the optimal land purchase decreases in past debt D and in a. To evaluate how land prices affect land purchases, we take the derivative of (3) with respect to the land price:

(4) $$\frac{\partial l_b^*}{\partial p_b} = \frac{D}{2p_b^2}\left[\frac{R}{ra} + 1\right] > 0.$$

Hence, land price appreciation induces the farmer to buy more land.

More relevant for our empirical analysis is whether farmers who own more land, and are therefore positioned to benefit the most from higher land prices, buy more land than other farmers. At first glance, it appears that the effect of land prices on purchases does not depend on land owned. However, the debt D incurred by purchasing land in the past can be written as the product of the weighted average price at which the acres were purchased ($\bar{p}l_o$). Differentiating (4) with respect to land owned shows that in response to higher prices farmers owning more land would indeed buy more land than farmers owning less:

$$(5) \qquad \frac{\partial^2 l_b^*}{\partial p_b \partial l_o} = \frac{\bar{p}}{2p_b^2}\left[\frac{R}{ra} + 1\right] > 0.$$

The purchase of land does not necessarily imply that the total land in the farm, $L = l_o + l_b + l_r$, will increase. Consider a crop price increase from p_c^1 to p_c^2, with a corresponding increase in the land rental price. For the majority of farmers who own some land and rent the rest, more land is rented until its marginal value product equals the rental cost, a condition that holds before and after the crop price increase. Combining the two conditions corresponding to the periods of higher and lower prices and rearranging gives:

$$(6) \qquad \frac{f_2^{'}}{f_1^{'}} = \frac{p_r^2/p_r^1}{p_c^2/p_c^1}.$$

The farm becomes larger if the proportional increase in the rental price (p_r^2/p_r^1) is smaller than the proportional increase in the crop price (p_c^2/p_c^1). When this is the case, $\frac{f_2^{'}}{f_1^{'}}$ will be less than one (assuming f is concave), meaning that more land is employed in production in the higher price period. But if f is constant returns to scale and the supply of land is fixed, then the rental price increases in the same proportion as the crop price and there is no change in farm size.

Most importantly, as long as the farmer rents in some land, the marginal cost of expanding on the extensive margin – the rental price of land – is independent of the wealth gain. If on the other hand the cheapest way to expand is through buying land, wealth gains affect the farm's optimal size if borrowing costs depend on wealth.

Empirical Approach

With farm-level panel data, one could use a first-differenced model to estimate the effects of land wealth on acres harvested (or acres owned):

(7) $$\Delta\, Acres_{it} = \psi + \lambda(\Delta\, Wealth_{it}) + \varepsilon_{it}.$$

An advantage with this approach is that it controls for a time-invariant farm fixed effect. To approximate changes in wealth from land appreciation one could exploit variation in rates of appreciation across space using regional change in the per acre price of land ($\Delta\, p_{r(i)t}$).

(8) $$\Delta\, Acres_{it} = \psi + \lambda\left(Acres\ owned_{it-1} * \ \Delta\, p_{r(i)t}\right) + \varepsilon_{it}.$$

Regional land prices have the advantage over farm-level prices in that an individual farmer's decisions can affect farm-level prices but not regional prices. For example, farm-level changes in average per-acre cropland prices might reflect endogenous responses by farmers such as improvements to the land (e.g. fences, irrigation systems) or changes in the quality-composition of the land on the farm (e.g. a greater share of cropland, which raises average price).

A problem with (8), however, is that land rental prices and land purchase prices have a direct effect on farm size (acres harvested) apart from any indirect effect that they might have through wealth. Even if borrowing costs were independent of wealth, the change in price per acre would be correlated with changes in acres harvested. This is shown by the familiar first-order condition in (2a) where the crop price and the land rental price determine the optimal farm size. A similar problem emerges if acres owned is the dependent variable.[2]

Including the change in the regional per-acre land price as a separate variable in the model does not resolve the problem because the interaction between acres owned and regional land appreciation will still be endogenous. To illustrate this, suppose that the regional change in land price can be written as the sum of a systematic change common to all regions and a region-specific idiosyncratic change: $\Delta p_{r(i)t} = \Delta \bar{p}_t + \mu_r$. Re-writing (8) gives

(9) $$\Delta Acres_{it} = \psi + \lambda\big(Acres\ owned_{it-1} * (\Delta \bar{p}_t + \mu_r)\big) + \varepsilon_{it}.$$

Idiosyncratic changes in land prices might be caused by difference in urban development pressures or land quality. Proximity to urban areas would result in higher appreciation, but would also likely affect farmers' decisions to buy or sell land. Similarly, regions with soil that is better suited to grow the crops whose prices increased the most in the 2000s would have seen greater price appreciation, but farmers in these areas would also have had a greater incentives to expand

[2] If borrowing costs are independent of wealth, then the first order condition in (2b) simplifies to $p_c f'(L) = p_b r$. In an interior solution (owning and renting some land) the farmer is indifferent between owning versus renting land. If some farmers prefer to own land, the simplified version of (2b) indicates that for them land values will determine the optimal farm size and consequently the optimal amount of land owned.

farm size. As long as the idiosyncratic spatial variation in land appreciation (μ_r) is correlated with farm decisions, it will bias parameter estimates by inducing a spurious correlation between the estimated change in wealth (calculated as in (8)) and the dependent variable.

In contrast, the systematic shift in land prices ($\Delta \bar{p}_t$) common to all farms is exogenous to farm-level decisions. It can be exploited with data on changes over a normal appreciation period and over a high appreciation period. By observing a farm in three different censuses (1997, 2002, 2007), we can create two panels, one corresponding to a period of normal price appreciation (1997-2002) and another corresponding to high appreciation (2002-2007). Holding initial farm size constant, the variation in capital gains depends on the share of the land in the farm that is owned by the farm (*Share owned*).

More formally, let the relationship between the change in acres and the share of land owned in the "normal" appreciation period (period 1) be modeled as:

(10a) $\Delta\, Acres_{i1} = \alpha_1 + \delta_1 Share\ owned_{i1} + Acres\ operated + \varepsilon_{i1},$

where δ_1 captures any correlation between *Share owned* and $\Delta\, Acres$ under normal conditions and *Acres operated* is the initial acres operated at the beginning of the period (1997). In the period of high appreciation, capital gains from land wealth results in the "normal" effect δ_1 on acres plus the effect from unexpectedly higher appreciation (δ_2):

(10b) $\Delta\, Acres_{i2} = \alpha_2 + (\delta_1 + \delta_2) Share\ owned_{i2} + Acres\ operated + \varepsilon_{i2}.$

Using the dummy variable $P2_t$ to indicate the second period (high appreciation), equations (10a) and (10b) can be pooled to give

$$(11) \quad \Delta\, Acres_{it} = \alpha_1 + (\alpha_2 - \alpha_1)P2_t + \delta_1 Share\ owned_{i1} + \delta_2(Share\ owned_{i02} \cdot P2_t) + \\ + Acres\ operated + \varepsilon_{it}$$

where $t = 1{,}2$. The dummy variable $P2_t$ captures all time varying factors affecting farmers similarly. As long as other temporal shocks are uncorrelated with the share owned, the coefficient on the interaction $Share\ owned_{i2} \cdot P2_t$ captures the effect of the wealth increase alone. Furthermore, we can allow temporal shocks to vary across states and control for other farm characteristics that might affect growth and be correlated with the share owned, which leads us to the main equation we estimate:

$$(12) \quad \Delta\, Acres_{it} = \alpha_1 + (\alpha_2 - \alpha_1)P2_t + \delta_1 Share\ owned_{i97} + \delta_2(Share\ owned_{i02} \cdot P2_t) \\ + \delta_3(Share\ owned_{i97}{}^2) + \boldsymbol{X_{i97}\beta_1} + (\boldsymbol{X_{i97}} \cdot P2_{it})\boldsymbol{\beta_2} + \gamma_{s(it)} + \varepsilon_{it},$$

where the dependent variable is the log difference in acres harvested or acres owned over one of the two periods (1997-2002 or 2002-2007) and $\boldsymbol{X_{i97}}$ is a vector of independent variables in the initial year. Because the dependent variable is a log difference, δ_2 gives the approximate percentage point increase in the dependent variable for a one percentage point increase in the share owned.

Because of a potentially nonlinear relationship between a farm's initial share owned and its expansion of acres harvested or owned, we include a quadratic term for the initial share owned. We assume that the coefficient on the quadratic term is the same in both periods but allow the linear term to change by interacting it with the second period dummy variable. Allowing the linear term to change is consistent with the linear relationship between wealth gains from land appreciation and the share owned when farm size is held constant. Owning one percentage point more of the land in a 100 acre farm corresponds to owning one more acre. If the price of land increased by $500 over the period, each percentage point increase in the share owned corresponds to $500 more in wealth.

The control vector $\boldsymbol{X_{97}}$ includes the log of the total land in the farm (i.e., acres operated, which equals acres owned plus rented), the log of the value of production per acre harvested, and a linear and quadratic term for the age of the farm's principal operator. The 1997 values are used for all of the control variables, but we interact the period dummy variable with them to allow their coefficients to be different in the second period. We also include a time-varying state effect $\eta_{s(it)}$ to control for time-specific state shocks such as the interaction between changing commodity prices and a state's suitability for growing the crops favored by the changes.

The setup in (9) fits a standard difference-in-difference framework with two periods and a continuous treatment variable (*Share owned*). The interpretation on the coefficient of *Share owned* is the same as if it were a binary variable: the effect of going from owning none of the land in the farm (*Share owned* equals zero) to owning all of the land (*Share owned* equals one). One concern of difference-in-difference models is that members of one group may migrate to another group, changing the group composition and affecting estimates of the interaction effect between time periods and groups (Angrist and Pischke 2009). Higher ability farmers with more profitable farms may have purchased land between 1997 and 2002, increasing the share of land that they own. In a binary treatment approach the purchase would move the farm from the control group (low share owned) to the treatment group (high share owned). We instrument for the share of land owned in 2002 with the share of land owned in 1997. An auxiliary first-stage regression of the share owned in 2002 on the share owned in 1997 (and its square, the previously mentioned covariates, and state dummy variables) shows that the instrument is sufficiently strong: the F-statistics on the restriction that the coefficient is zero is 447, well above the typical threshold of 10.

Possible Bias from Sample Attrition

The model (12) is only estimated for continuing farms, which may differ from farms that exited over the 15 year period of analysis. Estimates made only with continuing operations may therefore suffer from selection bias due to sample attrition. There are no obvious instrumental variables that affect farm survival but not farm size change (or land ownership change), which would allow us to control for attrition based on unobservable characteristics. Instead, we address potential selection bias based on observable characteristics by incorporating the survival propensities estimated in a probit model. Specifically, we weight the model in (12) by the inverse of the probability of survival estimated with probit model:

$$\text{(10)} \qquad \Pr(\text{Survival}_{it} = 1) = \Phi(\theta_1 P2_t + \theta_2 Share\ owned_{i,97} + \theta_3 (Share\ owned_{i,97} \cdot P2_t) + \theta_4 (Share\ owned_{i,97}{}^2) + \boldsymbol{X_{i97}}\lambda_1 + (\boldsymbol{X_{i97}} \cdot P2_t)\lambda_2 + \eta_{s(it)}).$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function. Weighting by the inverse of the probability of survival reduces the weight of farms that are more likely to survive compared to those whose observable characteristics make them less likely to survive. It therefore aids in identifying population parameters, as shown theoretically by Wooldridge (2002, 2007) and applied in panel data settings by Giles (2006) and Thirumurthy, Zivin, and Goldstein (2007).

Census of Agriculture Panel Data

The National Agricultural Statistics Service attempts to collect data on all farms and their operators every five years through the Census of Agriculture (hereafter "the Census").[3] We use each principal operator's unique identification number to link farms across Census years. We start by narrowing the sample to sole proprietorship farms observed in the three most recent Censuses: 1997, 2002, and 2007. We then focus on grain farms (where at least half of the value of production came from grains) and that owned and rented some land (share owned ranging from 0.01 to 0.99). The share of land owned is the land owned by the farm divided by acres operated (the sum of acres owned and acres rented from others). We further exclude the few farms that rented out land.

Lastly, we focus on farms in states where cropland values appreciated more from 2002 to 2007 than from 1997 to 2002 according to the June Area Survey conducted by the USDA-NASS. The June Area Survey is an annual nationally representative survey of cropland. It is the only national survey collecting data on cropland values over our study period. State-level estimates of cropland values show that there were only seven states where cropland values did not appreciate more from 2002 to 2007 than from 1997 to 2002: Colorado, Michigan, New Mexico, North Carolina, Utah, Wisconsin, and Wyoming.

[3]The Census attempts to reach all agricultural operations that produce, or would normally produce and sell, $1,000 or more of agricultural products per year. Data are primarily collected through the mail, with supplemental reporting on the internet and non-response follow-ups by telephone and personal enumeration. The final response rate was 85.2 percent for the 2007 Censusand 88.0 percent for the 2002 Census.

Focusing on states where appreciation increased, the average state saw real cropland values appreciate by 14 percent from 1997 to 2002 and by 39 percent from 2002 to 2007. State-specific data on cropland values at the Crop Reporting District level, which is available in a few agriculturally important states, suggest that the increase in appreciation occurred broadly within states. Survey results in Iowa, Indiana, and Nebraska show that average real cropland values appreciated more from 2002 to 2007 than from 1997 to 2002 in each crop reporting district in each state.[4]

There are 38,343 farms that meet our sample criteria (table 1). In 1997 the average sample farmer was 48 years old and operated 851 acres, of which 38 percent was owned by the farm. Harvested acres accounted for more than three-quarters of the total land in the average farm. The median farm was smaller, operating 622 acres, and owned a slightly lower share of the land (33 percent).

Land Appreciation and Changes in Wealth

Our empirical approach rests on comparing over time similar sized farms owning different shares of the land in the farm. To illustrate the relationship between the share of land owned and wealth gains from land appreciation, we multiply the acres owned by the farm in 1997 by the average cropland value for the state. Using the state average cropland appreciation rate we then calculate the value of the 1997 land holdings in 2002 and 2007 in real terms. Finally, in dollar terms we calculate each farm's increase in land wealth from 2002 to 2007 relative to the increase from 1997 to 2002.

[4] Data are from Iowa is from the Iowa State University Farmland Value Survey: http://www.extension.iastate.edu/agdm/wholefarm/html/c2-70.html ; for Indiana ,data are from the Purdue Agricultural Economics Report: http://www.agecon.purdue.edu/extension/pubs/paer/2010/august/dobbins.asp. For Nebraska they are from the Nebraska Farm Real Estate Report: http://agecon.unl.edu/realestate.html.

Figure 2 shows the average estimated wealth increase for farm's grouped by the share of the land owned in 1997. Farms with a larger share owned tended to have higher estimated wealth increases from 2002-2007 relative to the increase in 1997 to 2002. For example, those owning between 40 and 49 percent of the land had an estimated wealth increase of about $180,000, which was $27,000 more than for farms owning between 20 and 29 percent of the land. And because acres owned increases with farm size while the share of land owned decreases, these suggestive statistics understate the strength of the relationship between share owned and wealth gains.

The raw data also illustrate a link between land wealth and changes in acres harvested and acres owned (table 2). We break farms into three categories based on the share of land owned: less than 25 percent; 25 to 50 percent; and more than 50 percent. For each group we calculate the mean change from 1997 to 2002 and from 2002 to 2007 for the log of acres harvested and acres owned and for the estimated wealth increase from land appreciation described in the previous paragraph. The difference in the mean change for the two periods can be interpreted as the group's departure from its prior trend.

On average, farms expanded harvested acres in the 1997-2002 period and then contracted over the 2002-2007 period. In contrast, farms of all share classes increased their acres owned in both periods. Not surprisingly, the second period produced larger wealth increases from land appreciation. The average estimated increase in wealth from appreciation was $31,271 in the first period and $189,190 in the second period.

The descriptive statistics in table 2 suggest that the share of land owned is weakly correlated with changing trends in acres harvested. Farms owning less than 25 percent of their land had growth in acres harvested 0.06 log points less in the second period relative to the first;

those owning more than 50 percent of their land saw a similar decline in growth. When looking at trends in land owned, however, farms owning less than 25 percent of their land had growth decline by 0.25 log points compared to a decline of just 0.02 log points for farms owning more than 50 percent of the land in the farm.

The comparisons illustrate the spirit of our empirical approach to isolate the wealth effect of greater land appreciation. They also show that during the period of higher appreciation farms owning more of the land in the farm better sustained their trend of expanding acres owned compared with farms owning less of the land in the farm.

Empirical Model Results

First we estimate the probit survival model (10) to address potential bias from sample attrition. The results also shed light on the effects of land wealth on farm survival. Wealth could change the likelihood of surviving by changing borrowing costs, or by altering the farmer's retirement decision. For the survival model, we include all farms that met the initial sample criteria in 1997, regardless of whether they were observed in the 2002 or 2007 Census of Agriculture. We estimate the model using the pooled sample, dropping farms once they exit.

If wealth gains from farmland appreciation affect survival, we would expect the relationship between *Share owned* to be different in the second period since farms with a greater share owned would have had the largest wealth gains. The survival results (table 3) indicate that farmers owning a larger share of the land in the farm were more likely to survive from 1997 to 2002 than farms owning a smaller share. But as evidenced by the small and statistically insignificant coefficient on $Share\ owned \cdot P2$, the same pattern continued in the second period even though farmland appreciated at a much higher rate.

The remaining coefficient estimates tell an intuitive story. Larger farms and farms with a greater value of production per acre were also more likely to survive. The results also imply that the age of the farm operator has a negative effect on the probability of survival after age 43 (calculated using the unrounded coefficient estimates). Given that the sample average age of continuing farmers was 48, it is unsurprising that all farms were more likely to continue through the first period than through the second period.

Wealth, Farm Size, and Land Ownership

We find weak evidence that the increase in farmland appreciation in 2002-2007 led to small increases in acres harvested (table 4). The estimate of the coefficient on $Share\ owned \cdot P2$ implies that owning 10 percentage points more of the land in the farm was associated with 0.56 percentage points more in growth in the second period relative to the first period. In addition to the small size of the coefficient, it is statistically insignificant at the 1 percent level, which is an appropriate level given the large number of observations (76,686). The coefficients on the age variables fit the descriptive statistics discussed earlier. Farmers tend to expand their acres harvested more slowly as they age. Thus, there is a negative relationship between age and growth in acres harvested over the range of sample values for age. This could be explained by farms' having an optimal farm size and many older farmers achieving this size.

In contrast to the findings for acres harvested, there is strong evidence that farmers experiencing larger wealth gains from appreciation bought more land than they otherwise would have. The coefficient on $Share\ owned \cdot P2$ implies that owning 10 percentage points more of the land in the farm was associated with 2.2 percentage point higher growth in acres owned in the period of high appreciation compared to the period of low appreciation.

For acres owned, the coefficients on the other variables reveal patterns similar to those found for acres harvested. Larger farms accumulate land at a slower rate, which may be because they are closer to their optimal amount of land owned. It may also reflect the apparent preference of larger farms for growing through renting rather than owning. Presumably, buying land ties up capital that could otherwise be used to rent and farm more acres. We also see that farmers accumulate land as they age but at a decreasing rate, causing a negative correlation between age and growth in acres owned and a positive relationship between age squared and growth.

The results for acres owned and harvested control for possible selection bias due to sample attrition using the observable variables included in the survival model. There remains the possibility for bias if unobservable variables that affect both survival and farm growth are not correlated with the observed variables. The bias will be most problematic if the unobservable variables affecting survival are correlated with the share owned. The survival results suggest that they are not correlated. The relationship between the share owned and survival was the same in the low and high appreciation periods. If the share owned were correlated with unobservable variables related to survival in the high appreciation period they likely would have caused the relationship between share owned and survival to change across periods.

A Falsification Test

Our model allows farmers who rent most of their land to have different growth rates (in acres harvested or owned) than those who rent less. The core assumption for identification of the wealth effect is that the relationship between share owned and changes in acres harvested and owned observed in the first period (1997-2002) would persist in the second period (2002-2007) had an unexpected increase in cropland values not occurred. Census of Agriculture data from the 1992-2002 period conveniently allow us to see if the assumption holds in a prior period.

As figure 1 illustrates, farm real estate appreciated at similar rates over the 1992-1997 and 1997-2002 periods. If we re-estimate the model using these periods and find that the coefficient of interest (δ_2) is small and statistically indistinguishable from zero, it will give us confidence that when applied to the later period the empirical approach captures the effect of wealth gains from land appreciation and not confounding factors correlated with the share owned. Linking farms in the 1992, 1997, and 2002 Censuses and applying the same criteria used to create the 1997-2007 sample gives a sample of 38,345 farms.

We apply the probit model of survival to the earlier panel to produce survival propensities, which we use in the same manner as in the 1997-2007 panel when estimating equation (12) (results not shown). Using the 1992-2002 sample and looking at acres harvested, we find a coefficient on $Share\,owned \cdot P2$ similar to the one found for the 1997-2007 panel (table 4). Thus, it is unlikely that the weak effect found for the 1997-2007 panel reflects responses to wealth gains from land appreciation.

In contrast, the falsification findings for acres owned supports interpreting the previously estimated effect as a response to greater wealth. Using the 1992-2002 panel, the coefficient on $Share\,owned \cdot P2$ is economically small and statistically insignificant even at the 10 percent level. The difference in coefficient estimates from the two panels (1992-2002 and 1997-2007) is striking. The estimate from the 1992-2002 sample is close to zero, at -0.011 (s.e. 0.032); the one from the 1997-2007 sample is 0.227 yet with an even smaller standard error (0.030).

Implications for Land Ownership

The results imply that land appreciation slows the rate at which younger farmers catch up to older farmers in terms of land ownership because older farmers generally own a larger share of the land in the farm. To illustrate this pattern, we show the mean share owned for each age decile (figure 3). The share owned generally increases with age and is highest for the sixth, eighth, and ninth deciles. Farmers in the third age decile (age 40 to 43) owned on average 39 percent of the land in the farm while those in the ninth decile (age 58 to 63) owned 51 percent. Using the estimated coefficient for acres owned, the differences imply that holding all else constant land appreciation caused farmers in their early sixties to accumulate land 2.7 percentage points faster than farmers in their early forties (2.7%= 0.224 x (51%-39%)).

Statistics from the nationally representative Agricultural Resource Management Survey are generally consistent with our finding that greater land appreciation widens the land tenure gap between younger and older farmers. Considering farms with $10,000 or more in crop production, the ARMS data show that between 2002 and 2011 the share of land owned by the average farmer 40 years or younger declined from 38 to 32 percent of the land in the farm (table 6). In contrast, it increased from 79 to 83 percent for the average farmer in the 70 or older group, meaning that the difference in ownership shares between the oldest and youngest group widened by 10 percentage points.

Because of the inverse relationship between farm size and the share owned, the findings also suggest that rapid appreciation lessens the consolidation of land ownership into large farms. The share of land owned decreases monotonically from the first (less than 180 acres) to the ninth (1,222 to 1,760 acres) farm-size decile, declining from 49 percent to 31 percent (figure 3). The difference in ownership implies that higher land appreciation caused farms in the first size decile to increase their acres owned 3.8 percentage points faster (=0.224 x (49%-31%)) than farms in the ninth decile.

Trends shown by ARMS data also show a decline in consolidation of land ownership in the hands of large farms (table 6). Considering farms with crop sales of $10,000 or more we break farms into five categories based on sales. The smallest two farm size categories saw the largest increases in the share owned while the largest farms saw the largest decrease. From 2002 to 2011, the share owned increased by 7 percentage points for the smallest crop farms ($100,000 or less in sales) and decreased by 9 percentage points for the largest farms (More than 1 million in sales).

Conclusion

Because land accounts for most of the value of the assets held by U.S. crop farmers, rapid land appreciation can cause large increases in wealth for some farmers. The average crop farmer in our sample experienced an increase in land wealth of almost 190 thousand dollars between 2002 and 2007. Despite the importance of land assets in farmers' portfolios, we find little evidence that wealth gains from land appreciation influence farm survival or affect the growth rate of the survivors. This finding suggests that farmers are able to make optimal land use decisions and are not hindered in their access to land rental markets by credit market constraints.

In contrast to the effect on farm size, we find strong evidence that wealth gains from land appreciation permit, or motivate, farmers to purchase additional land. This finding, combined with the fact that older operators generally own more of their land, provides a potential justification for programs to assist beginning farmers. Because older farmers own more of the land in the farm, a rapid increase in land values could slow the transfer of land from older to younger farmers. Indeed, our econometric findings and ARMS data from the 2002-2011 period suggest that this has happened. The USDA Farm Service Agency and states like South Dakota, Illinois, Minnesota have programs to lower borrowing costs for beginning farmers to purchase farmland. These programs may "level the playing field" for beginning farmers by countering some of the advantages of older farmers have in terms of accessing credit markets. Williamson and Katchova (2013) find that the program helped beginning farmers become full owners of the land they operate. On the other hand, borrowing costs do not seem to inhibit farm size growth, so the efficiency gains from increasing land ownership are unclear. It is also possible that in the current environment promoting land purchases by subsidizing borrowing costs encourages speculation in land markets.

The dramatic increase in farmland values since 2010 has prompted discussions of a possible bubble in farmland values (Shiller 2011; Gloy et al. 2011; Henderson 2012). The potential for rapid price depreciation and the sustainability of current debt levels of commercial farms has also become a concern of policy makers and regulators, with the 2011 Federal Deposit Insurance Corporation "Don't Bet the Farm" conference and the Federal Reserve Bank of Kansas City 2012 conference "Is This Farm Boom Different?"

Our results provide indirect evidence that one casual channel of a possible bubble is at work. If collateral helps farmers obtain more or cheaper financing, it may amplify an initial increase in land prices, with a land-related increase in wealth leading to more borrowing to buy land, which further increases land prices and wealth (Adrian and Shin 2010; Rajan and Ramcharan 2012). Our empirics indicate that farmers incurring larger wealth gains from land appreciation bought more land than they would have otherwise compared to farmers with smaller gains. Although we provide no direct evidence of greater borrowing to buy land, borrowing to purchase farmland is common: in 2011 the average corn farm business in the U.S. had more than $125,000 in real estate debt (ARMS 2011). The link between wealth gains and borrowing is therefore an important area for future empirical work.

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Tables

Table 1. Descriptive Statistics for the Full Sample, N= 38,343

	Median	Mean	SD
Total Value of Production	116,000	164,377	165,715
Acres Harvested	498	668	633
Acres Owned	170	288	381
Acres in Operation	622	851	830
Share Owned	0.33	0.38	0.25
Value of Production Per Acre	210	211	110
Age of Principal Operator	48	49	11

Note: The sample includes continuing individual or family operated grain farms that owned 1-99 percent of the land in the farm in 1997 and that were in a state with greater cropland appreciation in 2002-2007 than in 1997-2002.

Table 2. Changes in Acres Harvested, Acres Owned, and Wealth, 1997-2002 and 2002-2007, By Share Owned

		Mean Change in Log(Acres Harvested)			Mean Change in Log(Acres Owned)		
All Farms	Farms	1997-2002	2002-2007	Difference	1997-2002	2002-2007	Difference
All	38,343	0.013	-0.044	-0.057	0.236	0.107	-0.129
Own 25 percent or less	14,657	0.033	-0.033	-0.066	0.439	0.189	-0.250
Own 25-50 percent	12,091	0.010	-0.050	-0.060	0.165	0.079	-0.087
Own more than 50 percent	11,595	-0.009	-0.052	-0.043	0.052	0.032	-0.020
		Change in Wealth					
	Farms	1997-2002	2002-2007	Difference			
All	38,343	31,271	189,190	157,919			
Own 25 percent or less	14,657	14,858	135,554	120,695			
Own 25-50 percent	12,091	33,062	201,997	168,934			
Own more than 50 percent	11,595	50,151	243,636	193,485			

Note: The sample includes continuing individual or family operated grain farms that owned 1-99 percent of the land in the farm in 1997 and that were in a state with greater cropland appreciation in 2002-2007 than in 1997-2002. The wealth gains are estimated using state-level cropland values from the USDA-NASS June Area Survey and land holdings from the 1997 Census of Agriculture.

Table 3. Wealth and Farm Survival – Results from a Pooled Probit Model

	Propensity to survive
P2	-0.381***
	(0.096)
Share Owned	0.184***
	(0.054)
Share Owned x P2	0.011
	(0.018)
Share Squared	-0.110*
	(0.056)
Log(Acres Operated)	0.144***
	(0.005)
Log(Value of Production Per Acre)	0.055***
	(0.007)
Age	0.049***
	(0.002)
Age Squared	-0.001***
	(0.000)
State x Period Controls	Yes
X x Period Controls	Yes
Observations	198,392

Note: Robust standard errors clustered by farm are in parenthesis. The initial sample includes all individual or family operated grain farms that owned 1-99 percent of the land in the farm in 1997 and that were in a state with greater cropland appreciation in 2002-2007 than in 1997-2002. The dependent variable equals 1 if the farm survived and zero if not, either for the 1997-2002 or 2002-2007 panel. Farms not observed in the 2002 Census of Agriculture are considered to have exited in the 1997-2002 period. Farms observed in 1997 and 2002 but not in 2007 are considered to have exited in the 2002-2007 period. Farms that exited in the 1997-2002 period are excluded from the 2002-2007 panel.

Table 4. Land Appreciation and Growth in Acres Harvested and Owned, 1997-2007

	Acres Harvested	Acres Owned
P2	-0.226	-0.388
	(0.142)	(0.187)
Share Owned	0.031	-0.573***
	(0.025)	(0.047)
Share Owned x P2	0.056**	0.224***
	(0.022)	(0.030)
Share Squared	0.023	0.024
	(0.019)	(0.037)
Log(Acres Operated)	-0.054***	-0.068***
	(0.004)	(0.006)
Log(Value of Production Per Acre)	0.016**	0.015**
	(0.007)	(0.007)
Age	-0.021***	-0.012***
	(0.002)	(0.002)
Age Squared/100	0.009***	0.007***
	(0.002)	(0.002)
State x Period Controls	yes	yes
X x Period Controls	yes	yes
Observations	76,686	76,686

Note: *** p<0.01, ** p<0.05, * p<0.1. The sample includes continuing individual or family operated grain farms that owned 1-99 percent of the land in the farm in 1997 and that were in a state with greater cropland appreciation in 2002-2007 than in 1997-2002. The independent variable is the change in the log of acres harvested or acres owned from 1997 to 2002 or 2002 to 2007. All control variables correspond to 1997. Robust standard errors clustered by farm are in parenthesis. The interaction term *Share Owned X P2*is the share owned in 2002 interacted with the second period dummy variable, which is instrumented with the share owned in 1997 also interacted with the second period dummy variable.

Table 5. Falsification Test: Evidence from 1992-2002

	Acres Harvested	Acres Owned
P2	-0.196	0.021
	(0.143)	(0.171)
Share Owned	-0.023	-0.087
	(0.031)	(0.055)
Share Owned x P2	0.048**	-0.011
	(0.022)	(0.032)
Share Squared	0.080***	-0.358***
	(0.024)	(0.045)
Log(Acres Operated)	-0.040***	-0.063***
	(0.004)	(0.005)
Log(Value of Production Per Acre)	-0.031***	0.007
	(0.006)	(0.006)
Age	-0.020***	-0.010***
	(0.002)	(0.002)
Age Squared/100	0.008***	0.005**
	(0.002)	(0.002)
State x Period Controls	yes	yes
X x Period Controls	yes	yes
Observations	76,690	76,690

Note: *** p<0.01, ** p<0.05, * p<0.1. The sample includes continuing individual or family operated grain farms that owned 1-99 percent of the land in the farm in 1997 and that were in a state with greater cropland appreciation in 2002-2007 than in 1997-2002. The independent variable is the change in the log of acres harvested or acres owned from 1992 to 1997 or 1997 to 2002. All control variables correspond to 1992. Robust standard errors clustered by farm are in parenthesis. The interaction term *Share Owned X P2*is the share owned in 1992 interacted with the second period dummy variable, which is instrumented with the share owned in 1992 also interacted with the second period dummy variable.

Table 6. The Share of Land Owned, 2002-2011, by Age and Farm Size

	Age				
Year	40 or younger	41-50	51-60	61-70	Older than 70
2002	38	48	60	70	79
2011	32	50	62	65	83
Change, 2002-2011	-6	2	2	-4	4
	Farm size ($1000s)				
	100 or less	101-250	251-500	501-1,000	More than 1,000
2002	65	43	39	38	44
2011	72	57	45	38	36
Change, 2002-2011	7	14	6	0	-9

Source: Agricultural Resource Management Survey, 2002, 2011. Tabulations are by the authors.

Note: The share owned is calculated as acres of land owned divided by the acres operated by the farm. Only farms with $10,000 or more in crop sales are considered.

Figures

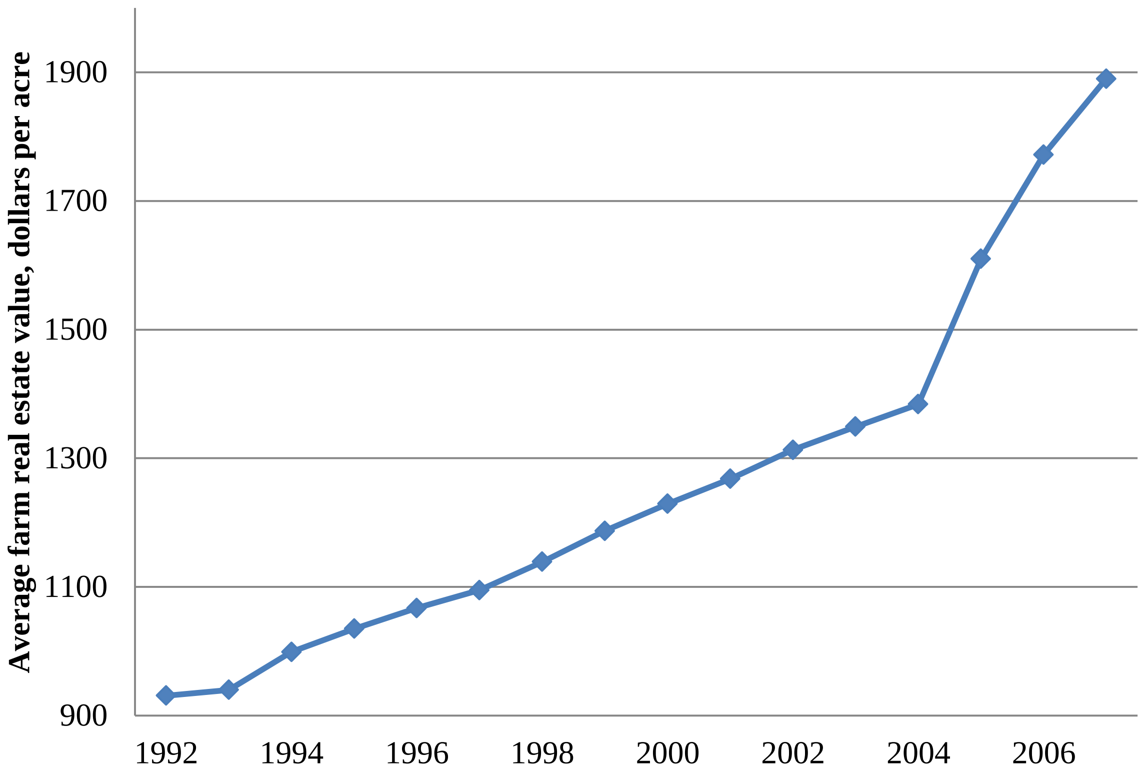

Figure 1. Farm real estate values rose rapidly from 2004 to 2007

Note: USDA-NASS, Land Values and Cash Rents Summary, multiple years. Prices are in 2005 dollars.

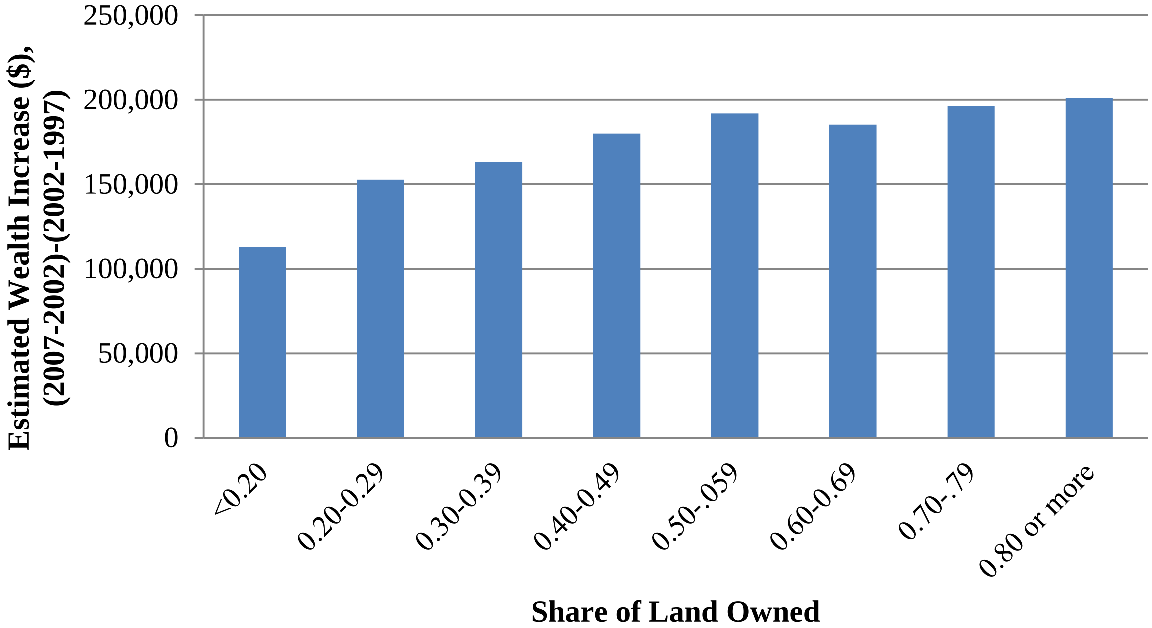

Figure 2.Share of land owned and estimated wealth increases from cropland appreciation

Note: The sample includes continuing individual or family operated grain farms that owned 1-99 percent of the land in the farm in 1997 and that were in a state with greater cropland appreciation in 2002-2007 than in 1997-2002. The wealth gains are estimated using state-level cropland values from the USDA-NASS June Area Survey and land holdings from the 1997 Census of Agriculture.

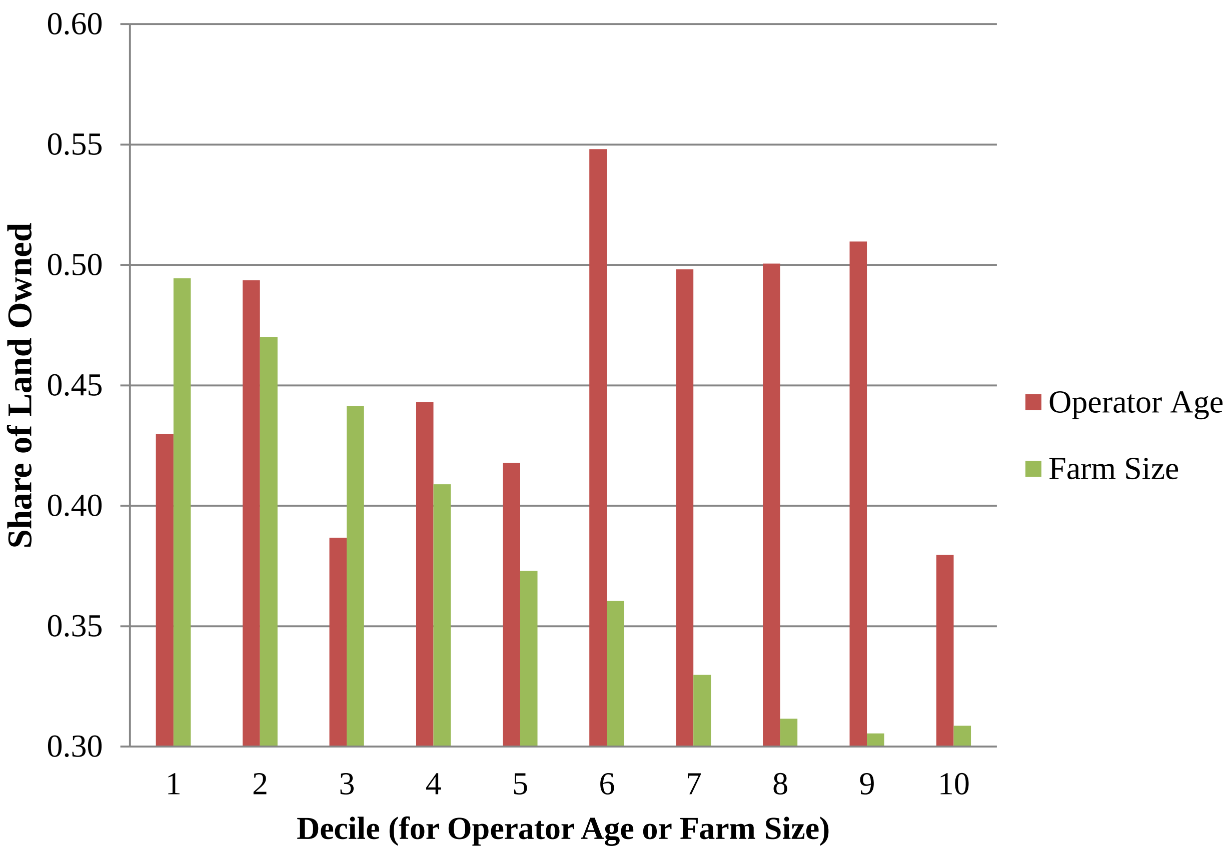

Figure 3. Land ownership, farm size, and farmer age

Note: Data are from the 1997 Census of Agriculture. The sample includes continuing individual or family operated grain farms that owned 1-99 percent of the land in the farm in 1997 and that were in a state with greater cropland appreciation in 2002-2007 than in 1997-2002.