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1 July 2014

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Forthcoming, *Land Economics*

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* The views expressed here are the authors' and should not be attributed to the Economic Research Service or the USDA.

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We study how increases in wealth from rapid appreciation of farmland influenced farmer decisions to borrow, buy land, and expand. Exploiting periods of high and low appreciation and a panel data model that allows for correlation between prior growth trends and the share of land owned, we find that a dollar increase in paper wealth led younger farmers to increase real-estate-secured borrowing by 48 cents. Land purchases accompanied the increase in borrowing, supporting the view that collateral-based lending may be contributing to the recent run-up in farmland prices. We find no effect of land wealth on production or acres harvested.

Key words: real estate appreciation; borrowing, collateral, farm wealth

JEL Codes: Q1, R1

I. INTRODUCTION

Because collateral can affect the cost of borrowing, changes in the wealth of small business proprietors could influence their decision to borrow and expand. When real estate is an important component of small business assets, large changes in real estate prices could have important consequences for business decisions and the real economy. The link between real estate prices, wealth, and proprietor decisions is perhaps strongest for agricultural households. Land is often the most valuable asset in a farmer's portfolio, so land prices will affect the collateral available for loans, and consequently land purchase and tenure decisions. An extensive international development literature has explored the role of land tenure, wealth, and credit on household investment (Holden and Yohanees 2002; Carter and Olinto 2003; Kompas et al. 2012). Yet we are unaware of farm-level econometric studies, international or otherwise, that estimate how wealth gains from land appreciation influence farmer decisions.

The large increase in farmland values in the U.S. in the mid-2000s caused large wealth gains for some farmers and small gains for others. We use the variation in gains to study how wealth affects the decisions of farmers to borrow, buy land, and expand production. Our identification strategy exploits a three-period panel dataset and an increase in land values that gave a farm owning most of the land operated a larger wealth gain than a similarly sized farm owning less land. In real terms, farm real estate appreciated by 44 percent from 2002 to 2007, with the faster appreciation occurring between 2004 and 2007 (see Figure 1).

Figure 1.

The greater appreciation in part reflected the 2005 Energy Policy Act, which required more biofuels to be mixed with gasoline sold in the U.S. market. The Act doubled use of corn for ethanol: in 2004 the ethanol industry accounted for 14 percent of U.S. domestic corn consumption; by 2007 it accounted for nearly 30 percent. Corn prices followed suit, doubling from 2005 to 2007 (USDA-ERS 2013a). Greater use of soybeans for biofuels, a weak dollar, and greater demand from China also supported the price increase (Abbott, Hurt, and Tyner 2008). Higher crop prices in turn increased agricultural land prices (Westcott 2007).

As land appreciated, farmers who owned more of the land they farm had a larger wealth gain than those with similar farms but who depended more on renting land. By linking farms surveyed in the 1997, 2002, and 2007 Censuses of Agriculture we observe farm-level changes in borrowing, land ownership, and acres harvested. We identify the wealth effect by comparing changes in outcomes over the low appreciation period (1997 - 2002) compared to the high appreciation period (2002 - 2007) for farms owning different amounts of the total land operated by the farm.

Our strategy has similarities to that of Campbell and Cocco (2007) whose empirical model interacts 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). Our approach has several strengths compared to that of Campbell and Cocco. First, whereas most people either own or rent their home, most crop farmers rent some of the land that they farm, allowing us to exploit variation in ownership shares within the renter group, which we define as those owning 10 to 90 percent of the land that they farm. Second, observing the same farm in three different years allows us to control for the possibility that owners (farmers who own a greater share of land) tend to expand more quickly (or slowly) than renters (farmers who own a smaller share).

The third and perhaps most important strength of our approach is that instead of relying on spatial variation in appreciation rates, we rely on a widespread increase in land appreciation across time. This addresses a challenge facing any empirical work linking local asset prices, wealth, and entrepreneurial activity: variation in asset appreciation across space is likely correlated with local conditions affecting business decisions. For example, farmers have the greatest incentive to expand in areas best suited to grow the crops whose prices have increased the most. But, these are also the areas where farmland will appreciate the most, inducing a spurious correlation between spatial variation in real estate appreciation, farmer wealth, and changes in acres harvested or owned.

In looking at borrowing and land purchases we also assess the possibility that collateral-based lending is helping to support the demand for farmland. Collateral-based lending could amplify the effect of an initial increase in land prices, with the land-related increase in wealth leading to more borrowing to buy land, which further increases prices and wealth (Adrian and Shin 2010; Rajan and Ramcharan 2012). Higher crop prices since the mid-2000s and expectations of continued strong global demand for agricultural commodities have heightened public and private sector interest in farmland markets globally, including the U.S. (Deininger and Byerlee 2011). In each year from 2010 to 2012, Iowa farmland appreciated by more than 15 percent and a similar trend has been observed nationally (USDA-NASS 2012; Duffy, Johanns, and Klein 2013).

Little empirical work explores the link between capital gains from land appreciation, borrowing, and land purchases. Following the farm crises of the early 1980s Lowenberg-DeBoer wrote a seminal book looking at capital gains from land appreciation and its consequences for farm decisions such as land purchases (Lowenberg-DeBoer 1987). He developed a dynamic programming model that illustrated how under the conditions of the 1970s, farmers would have borrowed more and bought more land. We build on this work by using farm-level data and econometrics to look for evidence that increases in land wealth cause farmers to borrow to buy more land. Our empirics test the implication of a simple theoretical model that illustrates why farmers with larger wealth gains from rising land values might borrow and buy more land than those with smaller gains.

After disaggregating the results by proprietor age, we find that younger farmers who experienced larger gains in land wealth increased their real-estate-secured borrowing – a result not observed for older farmers or for borrowing not secured by real estate. Younger farmers also bought more land but did not expand production more than farmers with smaller gains. Consistent with the theory that collateral-based lending can amplify an initial increase in land values, for each $10,000 dollar increase in wealth younger farmers acquired roughly $4,900 more real-estate-secured debt and bought about six more acres. To explore whether the findings reflect land-induced increases in wealth or a poor empirical approach, we re-estimate the model for the 1992 to 2002 period when land appreciated at a stable rate. The effects on borrowing and land purchases disappear, giving us greater confidence that the estimates from the 1997 to 2007 period reflect a causal link between land wealth, borrowing, and land purchases.

II. WEALTH AND FARM BUSINESS DECISIONS

Collateral and Borrowing

Much of the literature on household wealth and business activity centers on the role of wealth as a direct source of financing or as collateral for a loan. In modeling occupational choice, Banerjee and Newman (1993) assumed that becoming an entrepreneur requires a minimum investment and because capital markets are imperfect and require collateral for loans, only individuals with sufficient initial wealth become entrepreneurs. This view has been supported by several studies documenting a positive relationship between wealth and the probability of starting a business (Evans and Jovanovic 1989; Evans and Leighton 1989; Holtz-Eakin et al. 1994b; Quadrini 1999; Gentry and Hubbard 2004).

The correlation between initial wealth and subsequent business entry could be confounded by unobservable factors correlated with wealth such as ability. Several early studies used inheritances as a presumably exogenous source of wealth (Holtz-Eakin, Joulfaian and Rosen 1994a; Blanchflower and Oswald 1998). Hurst and Lusardi (2004) and Disney and Gathergood (2009), however, showed that inheritances are a poor instrument for wealth since past and future inheritances are correlated with self-employment. Unanticipated changes in housing values provide another potentially exogenous source of variation in wealth. Increases in home equity should allow potential entrepreneurs to more easily obtain financing. Hurst and Lusardi (2004) and Disney and Gathergood (2009) found no statistically significant correlations between housing capital gains and entry into entrepreneurship. More recently Fairlie and Krashinsky (2012) used a more geographically-specific measure of housing prices and found a positive effect of appreciation on self-employment.

Wealth and access to financing should be important for entrepreneurs in industries like agriculture that require substantial capital. Even farmers who rent land and machinery need access to substantial funds for operating expenses. Growing corn in the U.S. Heartland on 174 acres – the average size of the beginning farm – would require more than $95,000 in working capital (Ahearn and Newton 2009; USDA-ERS 2013b). Land wealth in particular often serves as collateral for agricultural loans (Van Tassel 2004). The role of land as collateral explains why the boom and bust of farmland prices in the U.S. in the 1970s and the early 1980s contributed to a rate of farm bankruptcies not seen since the Great Depression (Stam and Dixon 2004; Rajan and Ramchara 2012).

Wealth arguably matters the most to younger sole proprietors. Unlike firms owned by several people at different life stages, the growth of a sole proprietor business, which characterizes the majority of farm businesses, is linked to the life cycle of the proprietor. Over time, proprietors can accumulate assets that they can leverage to obtain credit for expansion. For farm and non-farm sole proprietorship households in the U.S., the median net worth of proprietor households increases until the 55 to 64 age cohort and then declines for those 65 and older (Katchova 2008). Because a proprietor has more assets to leverage when she is older, credit constraints are likely to bind earlier in life, causing younger proprietors to respond more to wealth gains. Younger farmers in particular are also more likely to want credit since they tend to expand acreage faster than older farmers (Gale 1994).

A Model Exploring Capital Gains, Land Purchases, and Farm Expansion

Lowenberg-DeBoer and Boehlje (1986) suppose that the cost of borrowing to purchase land decreases with the farm's debt-to-wealth ratio. An unrealized capital gain from land appreciation serves as equity when applying for a loan, thereby reducing the risk to the lender that the borrower defaults (Plaxico and Kletke, 1979). Here we posit a simple model to better understand a farm proprietor's response to higher crop and land prices when borrowing costs depend on wealth.

The model provides two comparative statics relevant for the empirics: higher crop and consequently land prices 1) cause farmers owning more land to borrow more and purchase more land relative to farmers initially owning less land; and 2) have an ambiguous effect on farm size. We briefly explain the intuition behind these conclusions and then discuss the model in detail.

An unexpected increase in the crop price increases the demand for land and therefore the price of buying and renting land. If borrowing costs depend (positively) on the proprietor's debt-to-wealth ratio, then the cost of borrowing declines because of capital gains on land owned. Proprietors with a larger decrease in the debt-to-wealth ratio will experience a larger decrease in borrowing costs, causing a larger decrease in the cost of accessing land through purchase relative to renting. They will therefore buy more land than proprietors with smaller wealth gains.

To be clear, the initial increase in demand for land is not the cause of the proprietor's shift towards owning instead of renting land. The cost of acquiring land may actually increase if the increase in the land purchase price more than offsets the decline in borrowing costs. Instead, the shift reflects changes in the cost of renting versus borrowing because the proprietor's wealth gain affects the cost of accessing land through purchase but not the cost of renting land.

The total land in the farm may increase, decrease or stay the same. Which case occurs depends on the change in the demand for land and the rental price, which in turn affects how much land the farmer will rent.

Before deriving the comparative statics, we discuss several assumptions and the stylized facts supporting the model. First, we assume that the farm proprietor starts her farming career with an initial land endowment. The endowment could be thought of more broadly as the initial wealth that the proprietor uses to start her farm. For concreteness, and without loss of generality, we assume that the initial wealth takes the form of land owned outright.

A second assumption is that crop prices increase farmland rental prices. Most land contracts are annual contracts that specify the landlord's compensation as a share of total production (a share lease) or as a fixed cash payment (a cash lease). Under a share lease, higher crop prices at harvest time are directly incorporated into the rental payment since a given share of production is worth more when prices are high. Cash leases specify the rental payment before planting and hold for the remainder of the year. But because most cash leases are annual, payments can change from year to year according to prices. From 2006 to 2007, for example, average cash rental rates for cropland in Iowa increased by almost 10 percent (Edwards, 2009).

A third assumption is that land rents determine land prices. Although nonagricultural factors clearly influence land prices, particularly in urbanizing areas, there is ample evidence of a strong relationship between land rents and land prices (Alston 1986; Falk 1991). In particular, Alston (1986) concludes that net rental income to land explains most of the increase in real farmland prices from 1963 to 1982 (Alston 1986). More recently, Nickerson et al. (2012) show that the price to value ratio for farmland (actual farmland values divided by the present value of a flow of rental payments) was near one for much of the 2000s. This is especially true when focusing on farmland in rural areas (Ifft 2014). The stability of the linkage between land rents and land prices will determine how appreciation affects the decision to own or rent land. Such stability, however, is peripheral to our main comparative static, which compares farmers who receive different wealth gains from land appreciation but who face the same land rental and purchase prices.

Turning to the model, the farm proprietor starts with a land endowment of l_e. If the proprietor can increase profits by farming more acres than her endowment, she will expand by renting land for p_{rent} per acre or through buying land for p_{buy} per acre. We assume that the proprietor debt finances the entire land purchase l_{buy} at an interest rate that is an increasing linear function of the risk-free interest rate and the proprietor's debt-to-wealth ratio, which is initially$p_{buy}l_{buy}/p_{buy}l_e$. Specifically, let the interest rate faced by the proprietor equal $r\left[\alpha\frac{p_{buy}l_{buy}}{p_{buy}l_e}\right]$, where *r* is the risk-free interest rate and the term in brackets is greater than one. The factor α is positive and determines the rate at which the debt-to-wealth ratio increases the cost of borrowing. The linear relationship simplifies the derivation of the comparative statics. In practice, the relationship between borrowing costs and the debt-to-wealth ratio may be nonlinear. What matters for our qualitative results is that α increases monotonically with the debt-to-wealth ratio.

The total land farmed is the sum of the land endowment, land purchased, and land rented ($L = l_e + l_{buy} + l_{rent}$). We focus on decisions regarding land and assume that the proprietor optimally adjusts other inputs. The production function *f* relates the land farmed to total crop output. Abstracting away from other inputs assumes that the proprietor has sufficient liquidity for operating expenses, perhaps by pledging part of production as payment (in the case of share rent arrangements) or as collateral (in the case of short-term operating loans). In the initial period (denoted by the superscript) the proprietor buys and rents land to maximize profits:

$$\pi_1 = p_{crop}^1 f(L) - p_{rent}^1 l_{rent}^1 - p_{buy}^1 r\alpha\frac{l_{buy}^1}{l_e} l_{buy}^1. \quad (1)$$

The crop price implicitly reflects conditions outside the model such as the biofuel mandate and global crop demand and supply. Because the land market is competitive, the land rental price equals the marginal value product of land. The purchase price of land, in turn, is the capitalized value of the rental payments: $\frac{p_{rent}}{R}$, where the rate at which rental payments are capitalized is greater than the risk-free rate $(R > r)$.[1] (Though we do not consider risk in the model, the higher capitalization rate would reflect the variability in returns from farming). Both the capitalization rate (*R*) and the risk-free interest rate (*r*) are determined outside the model and are independent of the crop price.

We consider a proprietor who buys and rents some land, in which case profit maximization implies:

$$p_{crop}^{1} f'(L) = p_{rent}^{1} = 2p_{buy}^{1} r\alpha \frac{l_{buy}^{1}}{l_e}. \qquad (2)$$

The total land farmed (*L*) depends on the crop price, the land rental price, and the marginal productivity of land. Once the proprietor determines how much land to farm, she must decide how much land to buy versus rent. Because the cost of renting land is the same regardless of how much the proprietor rents, buying any land implies that acquiring land through purchase is initially less costly than renting it. As the proprietor buys more land, $\frac{l_{buy}^{1}}{l_e}$ becomes larger, increasing the cost of acquiring land through purchase. The cost increases until it equals the rental price, after which the proprietor's land needs are met through renting.

The land rental or purchase price or, by extension, the crop price determine the total land farmed and therefore whether the farmers rents or buys any land at all. Conditional on the land endowment being less than the total optimal acres farmed, our definition of the land rental rate combined with (2) imply that the optimal acres to purchase, $l_{buy}^{1} = \frac{l_e R}{2\alpha r}$, only depends on l_e *R*, *r*, and α. This counter-intuitive result can be explained by the second equality in (2), which shows that in equilibrium the land rental price equals the cost of acquiring land through purchase.

Because of the fixed relationship between the land rental and purchase price, an increase in the land rental price by one causes the land purchase price to increase by R. (Mathematically, this allows p_{buy}^{1} to be replaced with $\frac{p_{rent}^{1}}{R}$. The p_{rent}^{1} terms on either side of the equality then cancel out.) Thus, as long as prices are such that the farmer wants to buy and rent any land, the acres to be purchased cannot be determined by the relative price of renting to purchasing because this ratio remains constant as more or less land is bought. What changes as more land is bought is the cost of borrowing, and therefore the cost of acquiring land through purchase. The changing relative cost in turn is fully determined by the initial land endowment and R, r, and α.

Now suppose that the crop price increases and with it the land rental and purchase price. When the land price increases (to p_{buy}^{2}) the proprietor earns a capital gain on her land endowment and land previously purchased. The new cost of acquiring an acre of land through purchase is then

$$p_{buy}^{2} r\alpha\left(\frac{\text{debt}}{\text{wealth}}\right) = p_{buy}^{2} r\alpha\left(\frac{l_{buy}^{1} p_{buy}^{1} + l_{buy}^{2} p_{buy}^{2}}{l_{e} p_{buy}^{2} + l_{buy}^{1} \Delta p_{buy}}\right) \tag{3}$$

where wealth is the value of the endowment plus the capital gain earned on l_{buy}^{1}. Using ρ to represent continued payment for land already purchased (whose price and quantity are exogenous to the post-price-increase decision) the updated profit maximization problem is

$$\pi_2 = p_c^2 f(L) - p_{rent}^{2} l_{rent}^{2} - p_{buy}^{2} l_{buy}^{2} r\alpha\left(\frac{l_{buy}^{1} p_{buy}^{1} + l_{buy}^{2} p_{buy}^{2}}{l_{e} p_{buy}^{2} + l_{buy}^{1} \Delta p_{buy}}\right) - \rho. \tag{4}$$

Substituting the expression derived above for the optimal initial land purchase into the first order conditions from (4), we can solve for the land purchased in response to the price increase, which gives:

$$l_{buy}^{2} = \frac{R}{2\alpha r p_{buy}^{2}}\left(wealth - \frac{p_{buy}^{1} l_e}{2}\right). \tag{5}$$

An increase in land prices ensures that the term inside the parentheses is positive, implying that an increase in crop and land prices causes the proprietor to buy more land. The reason is because the wealth increase lowered the cost of accessing land by purchase compared to accessing it by renting.

The comparative static of interest for the empirics, however, is whether proprietors who received a larger capital gain bought more land compared to those with a smaller gain. Variation in the total capital gain across proprietors reflects how much land they initially owned ($l_{buy}^{1}+l_e$), which is determined by the land endowment (l_e). Differentiating (5) with respect to the land endowment shows that proprietors with larger capital gains buy more land[2]:

$$\frac{\partial l_b^2}{\partial l_e} = \frac{R}{2\alpha r p_l^2}\left(p_l^2 - \frac{p_l^1}{2}\right) > 0. \tag{6}$$

Despite the land purchase the total land in the farm ($L = l_e + l_{buy} + l_{rent}$) may not increase. The proprietor rents land until its marginal value product equals the rental price, and this holds before and after the crop price increase. Combining the two conditions corresponding to the periods of higher and lower prices and rearranging gives

$$\frac{f_2^{'}}{f_1^{'}} = \frac{p_r^2/p_r^1}{p_c^2/p_c^1}. \tag{7}$$

The farm becomes smaller if the proportional increase in the rental price (p_r^2/p_r^1) is larger than the proportional increase in crop prices (p_c^2/p_c^1). If so, $\frac{f_2^{'}}{f_1^{'}}$ will be greater than one as long as f is concave, meaning that the proprietor uses less land in the higher price period. The opposite is true if crop prices increase proportionally more than land rents. Which scenario occurs depends on the supply elasticity of land and the marginal rate of substitution between land and other production inputs. The more inelastic the supply of land and the less willing farmers are to replace land with other inputs, the more likely that the land rental price will increase more than the crop price.

III. DATA FROM MULTIPLE CENSUSES OF AGRICULTURE

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”). Each farm’s principal operator has a unique identification number, which we use to link farms in the three most recent censuses: 1997, 2002, and 2007. The long form of the census collects information on business costs including interest expenses on debt. All farms in the 2007 census received the long form but only about a third received it in 1997 and 2002. We use only continuing farms that received the long form.

U.S. agriculture covers distinct agro-climatic regions that produce different commodities and have different land tenure patterns. To reduce the risk that unobserved farm characteristics correlated with the share of land owned and farm behavior confound estimates, we focus the empirics on crop farms (those harvesting at least 25 acres and with less than $10,000 in livestock sales in each census year) in the U.S. Heartland. The U.S. Department of Agriculture’s Economic Research Service defined the Heartland by grouping counties with similar farms, soils, and agro-climatic conditions. The Heartland region accounts for more than half of the cash grains produced in the country – most notably corn and soybeans (Hoppe and Banker, 2010). The region also has active land rental markets. For the five major states of the Heartland – Illinois, Indiana, Iowa, Missouri, and Ohio – 49 percent of the land in farms is rented, of which three-quarters is rented from landlords who do not operate a farm themselves (Nickerson and Borchers, 2011).

For continuing crop farms in the Heartland that do not rent out land, we calculate the share of land operated by the farm that is owned by the farm, where the land operated is the sum of acres owned and acres rented in. We exclude farms that rent out land because they are likely different from farms renting in some land, since they could easily expand by cultivating the land rented to others. The distribution of farms by the share owned reveals a bimodal distribution, with clustering at the end points. We focus on the 66 percent of farms that own 10 to 90 percent of the land operated – farms that we refer to as partial renters. The predictions from the theoretical model only apply to farms renting and owning some land. Farms with corner solutions for land owned or land rented may respond quite differently to marginal changes in their wealth. Focusing on partial renters also reduces the risk of confounding land-related wealth effects with unobserved characteristics associated owning or renting all of the land in the farm.

The number of continuing farms meeting our criteria is 3,592. In 1997 the average farm owned 30 percent of the total land that it operates and produced roughly a half of a million dollars in crops from harvesting 1,339 acres. The census does not ask for the quantity of outstanding debt or the interest rate on existing debt, so we use interest expenses as a measure of borrowing activity. In 1997, the average farm paid $29,990 to service debt. At the time the average fixed interest rate on farm real estate loans in Chicago Federal Reserve District was 8.8 percent, implying about $340,000 in debt (Agricultural Finance Databook 2010). The implied debt is roughly consistent with estimates from the Agricultural Resource Management Survey, which collects debt information from farms. It shows that in 1997 the average farm in the Heartland with $500,000-$999,999 in sales had $367,000 in liabilities (ARMS 2013).

Table 1.

Responses to Land Wealth

To estimate the change in land wealth from appreciation alone, we calculate the farm real estate appreciation rate for each crop reporting district in the Heartland. (Crop reporting districts group agriculturally similar and geographically contiguous counties in the same state.) We use all crop farms in each census year to calculate each district's average value per acre of farm real estate. In real terms the average farm's real estate appreciated by 6 percent from 1997 to 2002 and by 28 percent from 2002 to 2007. The appreciation rates imply that a dollar more in initial land wealth would have caused wealth to increase by 24 cents more in the second period than in the first period (=(1.06 x 1.28 – 1.06)- (1.06-1)). For the average farm, owning rather than renting one percentage point more of the land in the farm corresponds to roughly 14 acres or about $28,000. Increasing the share of land owned by one percentage point would therefore have increased wealth by $6,720 more in the second period than in the first period ($6,720 =$28,000 x 0.24).

For descriptive comparisons, we group farmers into two groups – those that own at least 50 percent of the land operated (major owners) and those that own less than 50 percent (minor owners) – and calculate the log difference in each outcome for the 1997 to 2002 period and for the 2002 to 2007 period. We then calculate the difference between the two periods and the two groups for five outcomes: interest payments on any debt, interest payments on real-estate-secured debt, acres owned, the value of production, and acres harvested (Table 2).

Table 2.

If land wealth permits greater borrowing by increasing a farm's collateral, we would expect to find the largest effect on borrowing secured by real estate. Descriptive comparisons across the two periods and across major and minor owners are consistent with this relationship. For interest payments on any debt the difference across the two groups and periods was 0.06 log points; for payments on debt secured by real estate it was 0.15.

Further comparisons suggest that greater borrowing funded land purchases but not an expansion of production. Relative to the prior period, major owners acquired 0.23 log points (about 25 percent) more land than minor owners, which translates into 122 acres for the average farm. Major owners owned on average 40 percentage points more of the land in the farm, which gave them a $268,880 greater increase in wealth in the second period relative to the first period compared to minor owners ($268,880 = $6,720 x 40). If the borrowing is attributed to the wealth gain, the comparisons suggests that each $10,000 increase in land wealth led farmers to buy 4.5 acres (=$10,000/($268,880/122 acres)). In contrast, the increase in the value of production over the period when land prices boomed relative to growth in the prior period was 0.07 log points less for major owners than for minor owners. The result for acres harvested is similar.

IV. DOUBLE DIFFERENCE EMPIRICAL MODEL

Our empirical strategy compares the responses of farmers who own different shares of the land they operate in periods of small and large increases in farmland values. The base empirical model has three main independent variables: the share of land owned by the farm

(*Share Owned*), a binary variable indicating the 2002-2007 period of rapid land appreciation (*P2*), and their interaction:

$$\Delta y_{it} = \alpha + \delta_1 P2_{it} + \delta_2 Share_i + \delta_3(Share\ Owned_i \cdot P2_{it}) + \delta_4(Share\ Owned_i{}^2) + \boldsymbol{X_{i97}\beta_1} + \gamma_{crd(it)} + \varepsilon_{it}. \quad (8)$$

The dependent variable is the log difference ($\Delta y_{it} = \ln(y_{it}) - \ln(y_{it-1})$) in one of five outcomes over one of two periods, 1997 to 2002 or 2002 to 2007. The outcomes are interest payments on any debt, interest payments on real-estate-secured debt, acres owned, the value of production, and acres harvested. The control vector *X* includes the log of the total land in the farm (owned plus rented), the log of the value of production per acre harvested, an indicator variable for whether the farm is individually owned, and a linear and quadratic term for the age of the farm's principal operator and years of experience operating the farm. The 1997 values are used for all of the control variables. We also include a time-varying crop reporting district effect $\gamma_{crd(it)}$ to control for time-specific local shocks such as the interaction between changing commodity prices and a district's suitability for growing the crops favored by the changes.

Because of a possibly nonlinear relationship between a farm's initial share owned and its expansion of harvested or owned acres, 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. The specification reflects 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 in additional wealth. If wealth matters for farm expansion, we would therefore expect the 100 acre farm that owns one additional acre to have higher growth than a similar 100 acre farm owning one less acre. The example also highlights the importance of farm size as a control variable.

The setup in (8) fits a 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). Because the share of land owned is highly correlated with itself over time, we instrument for the share of land owned in 2002 with the share of land owned in 1997. A first-stage regression shows that the instrument is sufficiently relevant (F-statistic of 103).

Although instrumenting avoids the problem of farms switching groups, the share of land owned in 1997 may be correlated with unobserved characteristics of the farmer, such as wealth endowments, credit constraints, and entrepreneurial ability. In land rental markets, low-ability farmers will generally be outbid by high-ability farmers, thereby reducing their share of land owned (land owned divided by land farmed). Thus, the share owned may be correlated with ability and growth. Equation (8), however, allows farmers who rent most of their land to grow faster (or slower) than those who rent less. The key assumption for identification of the wealth effect is that the difference in growth rates between major and minor renters in the first period would persist in the second period had land values appreciated at the same rate in both periods.

We estimate (8) for the entire sample and then separately for farmers who in 1997 were younger than 50 and those who were 50 or older. Splitting the sample by age permits estimating different effects for farmers who are more likely to have a demand for credit (because they are in a growth phase of the business) and more likely to be constrained by their wealth (because they have had less time to accumulate it).

We estimate (8) using Two-Staged Least-Squares and calculate robust standard errors clustered by farm. The time-specific crop reporting district effect controls for arbitrary correlation in the behavior of farms in the same district in the same year while clustering errors by farm captures correlation in the residuals of the same farm over time.

V. FINDINGS

The more rigorous econometric results confirm the conclusions suggested by the descriptive comparison of major and minor owners, providing further evidence that farmers used their equity in land as collateral for loans. We find a statistically weak effect of land wealth gains on total interest expenses but a strong effect on expenses of real-estate-secured debt of younger farmers. Owning one percentage point more of the land in the farm was associated with 1.43 percentage points in greater growth in interest expenses on real-estate-secured debt (Table 3). Put differently, a $10,000 increase in wealth led to $395 in interest payments (Table 5). The interest rate on farm real estate loans in the 2002-2007 period in the Chicago Federal Reserve District (8.1 percent) implies that total debt increased by about $4,875 (Agricultural Finance Databook

2010). We do not see the same effect for older farmers; for them, greater wealth had a weak negative effect on interest expenses for real-estate-secured debt.

Some observations had zero interest payments in at least one year and were excluded from estimation since the outcome is a difference in logged values. To test the robustness of our finding regarding borrowing, we estimate a linear model where the dependent variable is a difference in levels and the control variables are in levels. For younger farmers each percentage point increase in share was associated with an additional $255 in interest payments on real-estate-secured debt in the second period (Table A1 in the appendix). This is close to the logged model result, where each percentage point led to $265 more in interest payments (Table 5).

The linear model results also show that the increase in real-estate-secured interest payments accounts for almost all of the increase in total interest payments. This is reassuring because we would expect to find the greatest wealth effect on real-estate secured borrowing. Furthermore, the results show that real-estate-secured borrowing did not replace borrowing that was secured by other assets or not secured at all. One could also imagine that if rates on non-secured loans were higher than those on secured loans, farmers may use their new-found equity to switch their debt portfolio towards secured loans as has been found for some UK households when their home equity increased (Disney et al. 2010).

Turning to land purchases, we see that younger farmers with larger wealth gains bought more land. For them, the estimated coefficient implies that each $10,000 increase in wealth led to a purchase of 6.4 acres (Table 5), which would have cost about $16,000 (for the sample, the average value of farm real estate in 2002 was approximately $2,500 per acre). Combined with the effect of wealth on real-estate-secured borrowing, the result implies that the average young farmer in the sample financed roughly 30 percent of land acquisitions through debt (=$4,875/$16,000).

Table 3.

Wealth gains from land appreciation did not cause younger or older farmers to produce more. The results for the extensive margin, acres harvested, further support the conclusion that land-induced increases in wealth had no clear effect on farm expansion. The estimates imply that farmers who gained more from land appreciation replaced land rented from others with land that they purchased.

Tables 4 and 5.

The results presented correspond to farms with a share owned of at least 10 percent but no more than 90 percent. To test the sensitivity of our results to a different cutoff, we re-estimate the model using farms with a share owned of 20 to 80 percent. The estimated coefficients and their statistical significance in most cases are similar to those estimated using the 10-90 percent sample (results not shown). As before, we only observe a positive borrowing effect for younger farmers and no expansion in production or acres harvested for older or younger farmers. We only observe an increase in land purchases for younger farmers, which is slightly different from the 10-90 sample results where there was a small increase in land owned for the older operators. Even there, however, the coefficient for older farmers was one-third the size of that for younger farmers.

Falsification Test Using the 1992-2002 Period

Our identification strategy exploits the increase in farm real estate appreciation during the 1997-2007 period. We now exploit the stable appreciation during the 1992-2002 period: from 1992 to 1997 farm real estate appreciated by 18 percent; from 1997 to 2002 it appreciated by 20 percent (see Figure 1). Because of similar appreciation rates, farms owning a larger share of the land in the farm would not have experienced such a large increase in wealth from 1997 to 2002 period relative to the prior five years. If there is no clear correlation between the share owned and changes in wealth in one period relative to the other, then we should not find a correlation between *Share Owned x P2* and our outcomes. If we do, it would reflect factors other than greater land wealth. We therefore re-estimate the model with the sample of continuing farms in the 1992-2002 period and define 1997-2002 as the second period, when land values were, in fact, not booming.

When looking at the 1992-2002 period, we find small and statistically insignificant coefficients on *Share Owned · P2*, where *P2* now indicates the 1997-2002 period instead of the 2002-2007 period (Table 6). When looking at real-estate secured borrowing for younger farmers, we find a coefficient of 0.176 compared to 1.438 estimated in the 1997-2007 panel. Considering land purchases, we find a coefficient of 0.056 compared to 1.013. Thus, key coefficients from the 1997-2007 period are orders of magnitude larger than those estimated from the 1992-2002 panel when there should have been no wealth effect associated with the share owned. The contrast in results gives greater confidence that our estimates from the 1997-2007 panel reflect the response to greater wealth rather than a correlation between the share owned and time-varying unobservable variables affecting borrowing and land purchases.

VI. CONCLUSION

We add to several lines of research by estimating how a change in wealth from land appreciation affected the decision of business proprietors to borrow, invest, and expand. For our sample of continuing crop farms in the U.S. Heartland, we find that for each dollar increase in land wealth, younger farmers borrowed roughly 48 cents, using real estate as collateral. The finding is consistent with other studies that examined the response to real estate wealth for households in general. Mian and Sufi (2009) found that over the 2002 to 2006 period U.S. households borrowed on average 25 to 30 cents for every dollar increase in home equity. Disney et al. (2010) found a similar result for UK households likely to be credit constrained.

We also find that greater borrowing accompanied purchases of land. Although asset appreciation, borrowing, and further asset purchases are often associated with bubbles, we do not address whether farmland markets have departed from fundamentals (e.g. Gloy et al., 2011). Nonetheless, our finding supports the view that collateral-based lending is potentially supporting some of the increased demand for land. By leveraging their newly acquired equity to buy land, farmers, and especially younger farmers, contribute to further increases in land values. Outside investors could also be contributing to price increases, although their cost of capital is unlikely correlated with land prices as we have argued it is for farmers.

While increases in wealth from farmland appreciation induced greater land purchases, it did not cause farms to become larger. The results underscore the need to distinguish between wealth effects that affect aggregate output from those that merely alter the incentives to rent or own inputs or to outsource tasks or perform them in-house. Our findings suggest that increases in the value of land, which can be used as collateral, lowered the cost of borrowing and therefore increased the incentive to own land versus rent it. That farmers borrowed more but did not increase production suggests that they were not constrained in their output decisions by the price of capital. As our theoretical model illustrated, for a farmer who rents in some land, the rental price of land, which is independent of the farmer's wealth, determines the scale of the farm.

To the extent that our results generalize to other regions or types of proprietors, they imply that increases in wealth from real estate appreciation would have negligible effects on aggregate business output or economic efficiency. On the other hand, rapid appreciation of assets and the associated wealth increase could cause the ownership of land or other productive assets to become more concentrated.

Appendix A

Table A1

Linear Model for Changes in Interest Expenses

	Interest payments on any debt			Interest payments on debt secured by real estate		
	All	Under 50	50 and older	All	Under 50	50 and older
Share owned x P2	10,103	25,537**	-7,282	7,324	24,329**	-11,892
	(6,365)	(10,602)	(9,770)	(5,539)	(9,483)	(8,781)
Share owned	-8,584	-23,925**	10,319	-6,966	-17,641	6,338
	(8,524)	(12,062)	(13,339)	(7,648)	(10,793)	(12,308)
P2	2,946	-8,690	19,605**	-3,004	-20,031***	20,950***
	(5,643)	(7,963)	(8,300)	(5,284)	(7,428)	(7,571)
Observations	6,725	3,912	2,813	6,725	3,912	2,813

Note: The models included all the control variables of prior regressions but in nonlogged form, otherwise they are estimated the same as the interest payment results in table 4.

Source: Author calculations from the 1997, 2002, and 2007 Census of Agriculture.

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Tables

Table 1

Sample Description (N = 3,592)

	Median	Mean	SD
Total value of production	431,000	473,210	333,293
Acres harvested	1,254	1,358	911
Value of machinery	265,650	310,342	230,358
Interest payments on any debt	22,196	29,990	31,207
Interest payments on real-estate-secured debt	12,594	19,354	23,988
Acres owned	355	487	505
Share owned	0.30	0.35	0.20
Acres in the farm	1,339	1,461	994
Value of production per acre	307	395	773
Individually owned farm (=1)	1.00	0.77	0.42
Operator age	47	48	9
Experience	23	24	10
Value of land and buildings	672,822	927,095	955,931
Value of land and buildings per acre	2,000	2,149	1,510

Note: Values are in 1997 dollars.

Table 2

Difference-in-Difference Comparisons of Major and Minor Owners

Outcome	Ownership Category	Log Difference 1997-2002	Log Difference 2002-2007	Difference
Interest payments on any debt	Minor Owners	0.187	-0.064	-0.25
	Major Owners	0.082	-0.113	-0.20
	Difference			0.06
Interest payments on debt secured by real estate	Minor Owners	0.230	-0.144	-0.37
	Major Owners	0.076	-0.151	-0.23
	Difference			0.15
Acres owned	Minor Owners	0.274	0.032	-0.24
	Major Owners	0.032	0.022	-0.01
	Difference			0.23
Value of production	Minor Owners	0.012	0.249	0.24
	Major Owners	0.004	0.173	0.17
	Difference			-0.07
Acres harvested	Minor Owners	0.095	-0.033	-0.13
	Major Owners	0.083	-0.071	-0.15
	Difference			-0.03

Note: Major owners are defined as owning 50 percent or more of the land in the farm; minor owners own less than 50 percent. The sample contains 2,784 major owners and 808 minor owners. Values are in 1997 dollars.

Table 3

Wealth Effects for Borrowing and Land Ownership

	Interest payments on debt			Interest payments on real-estate-secured debt			Acres owned		
	All	Under 50	50 and Older	All	Under 50	50 and Older	All	Under 50	50 and Older
Share owned x P2	0.208	0.724*	-0.317	0.505*	1.438***	-0.540	0.695***	1.013***	0.336**
	(0.256)	(0.392)	(0.374)	(0.274)	(0.424)	(0.385)	(0.144)	(0.313)	(0.141)
Share owned	-0.144	-0.614	0.388	-0.497	-0.821*	0.380	-0.897***	-0.981***	-0.655***
	(0.308)	(0.413)	(0.500)	(0.333)	(0.420)	(0.573)	(0.143)	(0.248)	(0.188)
P2	-0.313	-0.765***	0.335	-0.758***	-1.437***	0.493	-0.575***	-0.783***	-0.284
	(0.191)	(0.250)	(0.305)	(0.211)	(0.268)	(0.328)	(0.164)	(0.233)	(0.237)
Share owned squared	0.005	0.464	-0.512	0.269	0.194	-0.224	0.292**	0.136	0.292*
	(0.325)	(0.464)	(0.497)	(0.348)	(0.466)	(0.569)	(0.146)	(0.281)	(0.176)
Acres in the farm	0.024	0.013	0.028	0.046	0.028	0.051	-0.020*	0.000	-0.044***
	(0.026)	(0.032)	(0.044)	(0.030)	(0.033)	(0.053)	(0.011)	(0.018)	(0.016)
Value of production per acre	-0.031	-0.007	-0.080	-0.026	-0.026	-0.045	0.012	0.022	0.005
	(0.031)	(0.037)	(0.053)	(0.034)	(0.039)	(0.061)	(0.012)	(0.020)	(0.017)
Individually owned farm	-0.007	-0.011	0.006	0.000	0.005	-0.042	0.030*	0.055**	-0.011
	(0.035)	(0.046)	(0.055)	(0.040)	(0.053)	(0.063)	(0.017)	(0.023)	(0.024)
Operator age	-0.027**	0.014	0.067	-0.006	0.060	0.067	-0.006	-0.004	-0.016
	(0.014)	(0.041)	(0.060)	(0.019)	(0.057)	(0.076)	(0.006)	(0.030)	(0.020)
Operator age squared	0.018	-0.034	-0.056	-0.003	-0.082	-0.061	0.004	0.004	0.012
	(0.014)	(0.052)	(0.049)	(0.020)	(0.070)	(0.064)	(0.006)	(0.038)	(0.017)
Experience	0.007	0.004	0.002	0.002	-0.007	0.005	0.005*	0.010	0.002
	(0.007)	(0.012)	(0.014)	(0.008)	(0.015)	(0.016)	(0.003)	(0.006)	(0.004)
Experience squared	-0.016	0.001	-0.009	-0.007	0.014	-0.012	-0.012**	-0.028	-0.007
	(0.014)	(0.037)	(0.025)	(0.018)	(0.042)	(0.029)	(0.006)	(0.018)	(0.007)
Number of observations	5,590	3,399	2,191	4,510	2,804	1,706	7,078	4,091	2,987

Note: Two-Stage-Least Squares estimates using *Share owned* in 1997 interacted with the dummy variable *P2* as an instrument for *Share owned* in 2002 interacted with *P2*. Robust standard errors clustered by farm in parenthesis. The "All" regressions have less than twice the total number of farms because of zero or missing values in 2002 or 2007. Crop reporting district dummy variables interacted with *P2* are included in estimation but excluded from the table.
*,**,*** Significance at 90%, 95%, and 99% , respectively.

Table 4

Wealth Effects on the Value of Production and Acres Harvested

	Value of Production			Acres Harvested		
	All	Under 50	50 and Older	All	Under 50	50 and Older
Share owned x P2	-0.133	-0.148	-0.109	-0.013	0.107	-0.022
	(0.107)	(0.163)	(0.153)	(0.086)	(0.154)	(0.102)
Share owned	0.231	0.170	0.365	0.149	0.055	0.256
	(0.148)	(0.199)	(0.234)	(0.120)	(0.172)	(0.185)
P2	0.029	-0.016	0.085	-0.226**	-0.318***	-0.163
	(0.131)	(0.175)	(0.202)	(0.089)	(0.116)	(0.142)
Share owned squared	-0.130	-0.148	-0.170	-0.088	-0.087	-0.121
	(0.153)	(0.219)	(0.228)	(0.128)	(0.189)	(0.188)
Acres in the farm	0.021*	-0.005	0.046**	-0.006	-0.018	0.002
	(0.012)	(0.018)	(0.018)	(0.009)	(0.014)	(0.013)
Value of production per acre	-0.166***	-0.177***	-0.164***	0.002	-0.003	0.001
	(0.018)	(0.023)	(0.027)	(0.015)	(0.020)	(0.020)
Individually owned farm	-0.033**	-0.007	-0.066***	-0.017	0.003	-0.050**
	(0.015)	(0.020)	(0.023)	(0.013)	(0.017)	(0.020)
Operator age	-0.031***	-0.026	-0.097***	-0.026***	-0.023	-0.092***
	(0.007)	(0.021)	(0.026)	(0.006)	(0.020)	(0.020)
Operator age squared	0.019***	0.016	0.074***	0.016***	0.015	0.070***
	(0.007)	(0.026)	(0.022)	(0.006)	(0.025)	(0.017)
Experience	0.008**	0.010*	0.002	0.007***	0.010**	0.003
	(0.003)	(0.006)	(0.005)	(0.003)	(0.004)	(0.005)
Experience squared	-0.015**	-0.019	-0.006	-0.014**	-0.023*	-0.007
	(0.007)	(0.017)	(0.010)	(0.006)	(0.013)	(0.008)
Number of observations	7,158	4,150	3,008	7,137	4,135	3,002

Note: Two-Stage-Least Squares estimates using *Share owned* in 1997 interacted with the dummy variable *P2* as an instrument for *Share owned* in 2002 interacted with *P2*. Robust standard errors clustered by farm in parenthesis. The "All" regressions have less than twice the total number of farms because of zero or missing values in 2002 or 2007. Crop reporting district dummy variables interacted with *P2* are included in estimation but excluded from the table. *,**,*** Significance at 90%, 95%, and 99% , respectively.

Table 5

Responses to a Wealth Increase for Sample Farmers Younger Than 50 Years

	Interest Payments on Real Estate Debt	Acres Owned
Results - Elasticities		
Estimated Percent Change	1.438	1.013
Associated Percent Change in Wealth	1.122	1.122
Elasticity	1.282	0.903
Results - Levels		
Estimated Absolute Change	$265	4.3 acres
Associated Absolute Change in Wealth	$6,720	$6,720
Change Per $10,000 Wealth Increase	$395	6.4 acres

Note: The estimated response is associated with a one percentage point increase in the share of land owned, which translates into an increase in wealth of $6,720 in the second period relative to the first period. This applies to both the younger and older farmer samples, since they operate farms of similar size. The increase in wealth is then used to calculate the response to a $10,000 increase in wealth. The associated percent change in wealth is 1.12 percent and is calculated by dividing the wealth increase associated with owning one percentage point more of the land in the farm by the initial net farm wealth of the average sample farmer 50 years or younger (roughly 600,000).

Table 6

Falsification Test Using a Period of Stable Land Appreciation Rates

	Interest payments on debt			Interest payments on real-estate-secured debt			Acres owned		
	All	Under 50	50 and older	All	Under 50	50 and older	All	Under 50	50 and older
Share owned x P2	0.360	0.206	0.396	0.312	0.176	0.168	0.187	0.056	0.293*
	(0.247)	(0.420)	(0.333)	(0.243)	(0.399)	(0.336)	(0.118)	(0.183)	(0.170)
Share owned	-0.097	-0.501	0.840	-0.317	-0.735	0.617	-0.701***	-0.908***	-0.075
	(0.324)	(0.437)	(0.619)	(0.368)	(0.479)	(0.727)	(0.176)	(0.225)	(0.304)
P2	-0.343*	-0.114	-0.893**	-0.516**	-0.261	-1.030***	0.055	0.220	-0.365*
	(0.206)	(0.254)	(0.356)	(0.247)	(0.312)	(0.360)	(0.121)	(0.143)	(0.211)
Observations	4,759	3,209	1,550	3,848	2,625	1,223	5,480	3,612	1,868

	Value of production			Acres harvested		
	All	Under 50	50 and older	All	Under 50	50 and older
Share owned x P2	-0.121	-0.170	0.019	-0.133	-0.231	-0.002
	(0.114)	(0.186)	(0.158)	(0.107)	(0.155)	(0.169)
Share owned	0.284*	0.251	0.395	0.316**	0.258*	0.486*
	(0.161)	(0.195)	(0.294)	(0.145)	(0.153)	(0.267)
P2	-0.822***	-0.745***	-1.072***	-0.149	-0.093	-0.289**
	(0.109)	(0.138)	(0.137)	(0.094)	(0.119)	(0.119)
Observations	5,476	3,615	1,861	5,455	3,599	1,856

Note: The models included all the control variables of prior regressions. The results are based on estimating the same model that generated the estimates for tables 3 and 4 but using continuing crop farms in the 1992 to 2002 period instead of the 1997 to 2007 period. In the falsification test *P2* refers to the 1997-2002 period, which in fact saw land appreciate at roughly the same rate as from 1992 to 1997, hence the grounds for the falsification test.

*,**,*** Significance at 90%, 95%, and 99% , respectively.

Figures

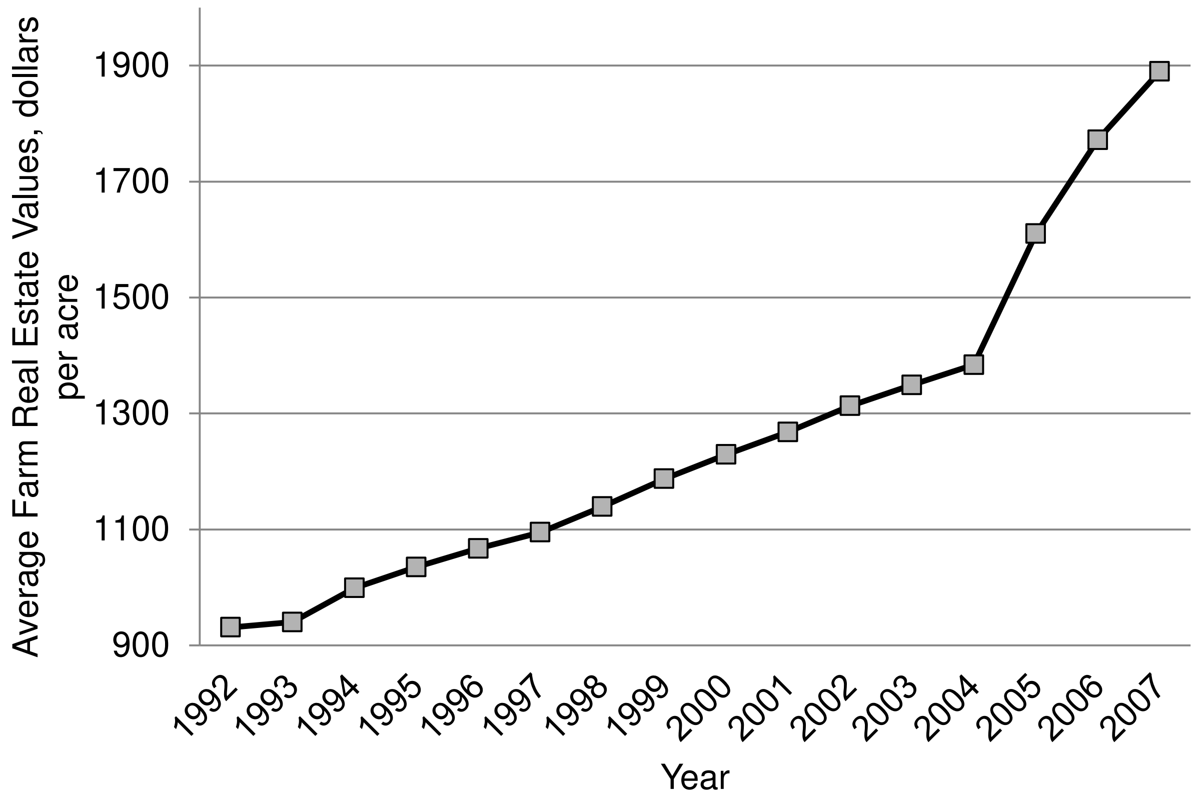

Figure 1. Farm real estate values rose rapidly from 2004 to 2007

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

[1] The model has a profit opportunity for a risk-neutral investor. If the investor has access to funds at the risk free rate, he can buy farmland, rent it out, and earn $R>r$. In practice, corporate or institutional investors, who are more likely to have risk neutral preferences, have little presence in the U.S. farmland market. As of 1999, nonfamily corporations owned only four percent of U.S. farmland (USDA-NASS, 1999). One explanation for the weak presence is the local and often long-term nature of farmland rental contracts. Farmland owners who live near the land they rent out likely have lower transaction costs to find a renter compared with an outside investor. They are also likely to have better information on potential renters, thereby making it easier to select those that care for the land and honor rental contracts.

[2] One may ask, from whom does the proprietor buy land? The two most likely groups are older farmers who are retiring and landlords who are not farmers. In 1999 (the last time nonfarm landlords were surveyed), nonfarmers owned two-thirds of the land in farms. And of the land owned by nonfarmers, the same fraction (two-thirds) was owned by individuals or families. Nonfarm landlords also tended to be older: more than 60 percent were 65 or older (USDA-NASS, 1999).