

Farmland Prices: The Return of a Bubble and Opportunities for Hedging

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**Selected Paper Presented at the American Agricultural Economics Association Annual Meeting,
San Francisco, CA, July 27-28, 2015**

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Introduction

In the late 1970's, the United States saw a significant increase in the market value of farmland. In the following years, the country experienced what was believed to be a popping of a farmland price bubble. Many have speculated to the cause of the 1980's bubble, largely attributing it to a fatal combination of factors beginning with significant increases in demand for agriculture products due to rises in global liquidity, rising incomes and a reduction in competing countries' crop production. Following intense contractionary policies by the Federal Reserve to combat double digit inflation, the Federal Funds rate increased to 19% while the prime rate rose even further to 22%. The outcome of the 1980's left many unable to fulfill loan payments and ultimately caused them to leave the farm sector altogether.

Once again, farmland prices are rising at record rates. Over the last 10 years farmland prices have grown 278.8% with an average yearly increase of 10.7% since 2000. This has been the largest growth in farmland prices since the 1980's where the sector witnessed a 409.9% growth rate in eleven years and an average yearly growth of 23.5%. Today, there have been increases in agriculture product demand similar to that of the 1970's. The increase in demand is largely a function of two things- biofuel production creating an alternative use for crops and an increase in developing countries' income.

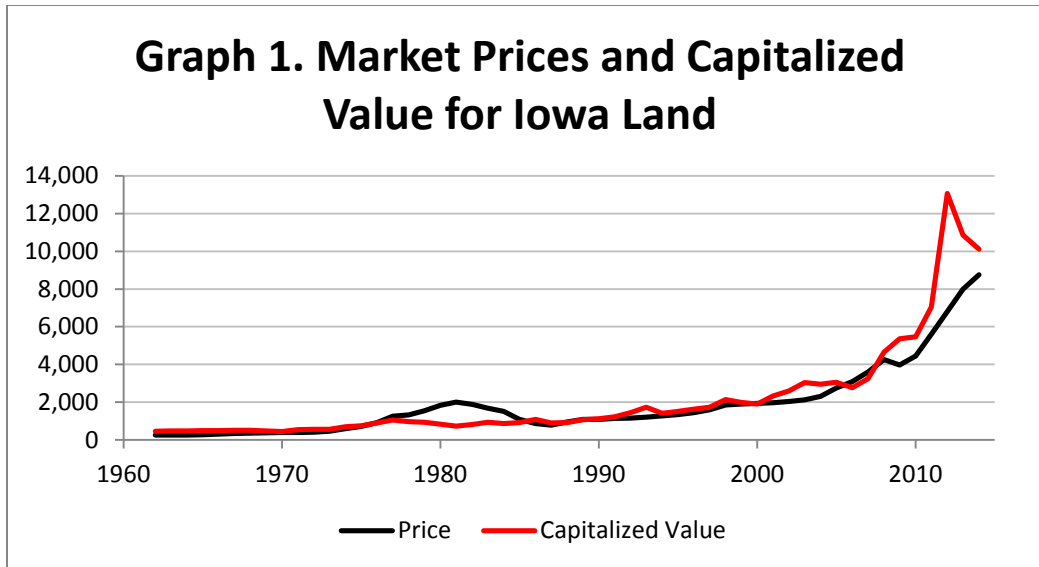
Since the 2008 recession the 10 Year Constant Maturity Treasury rate, a proxy for the risk free rate, has decreased to all-time lows. Currently at 2.19%, it has reached as low as 1.80% (Federal Reserve Economic Database, "FRED"). Current speculation expects interest rates and inflation to grow in the near future which presents the possibility of corrections in farmland prices as interest rates have an inverse relationship to farmland prices. Currently, weaknesses in

rent values have led to declines in farmland value, showing sensitivity to changes in the valuation model and thinness of the market. Similar to the 1980's, hostile economic factors may cause massive decreases in crop prices. Lending practices and better management of debt ratios are what largely separate the 1980's and today. A significant contributor to the crash in the 1980's was the overleveraged positions of the debt holders. Since the crash, debt ratios have remained substantially lower however, the low interest rates and previously high profit levels provide a setting for debt accumulation. nevertheless a realignment of prices may still be inevitable.

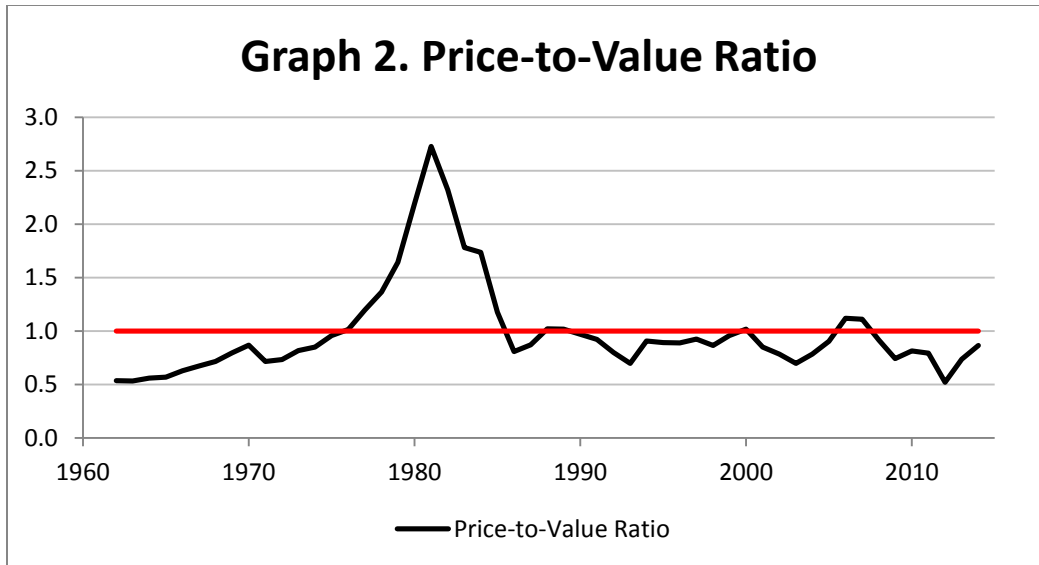
The following paper will elaborate on the possibility of a farmland bubble and its implications for borrowers and lenders. Cross hedging opportunities will then be developed for invested parties.

Market Overview

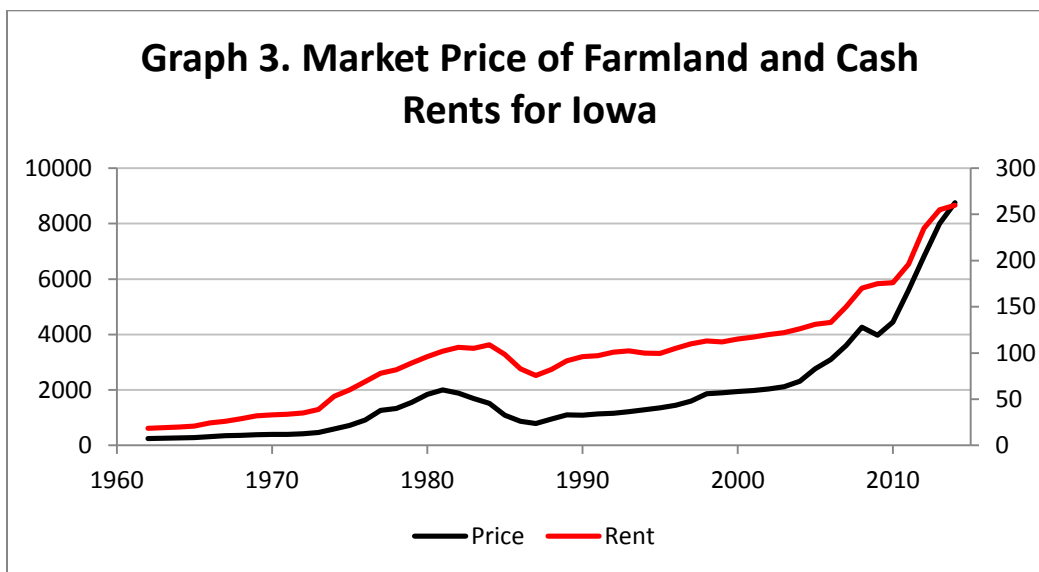
The capitalized valuation measurement has proven a useful tool in assessing the intrinsic value of land based off of the fundamental factors affecting valuation- income to land and interest rates. Using data on Iowa market land prices and market rent prices from the USDA as well as the ten-year CMT rate from the Federal Reserve, the capitalized value is calculated. The graph below shows that the capitalized value since about 2008 is actually higher than recent market price (see Graph 1). History has shown that the capitalized value is more representative of the true value of land. Today, the capitalized value is indicating that the value of farmland is undervalued.

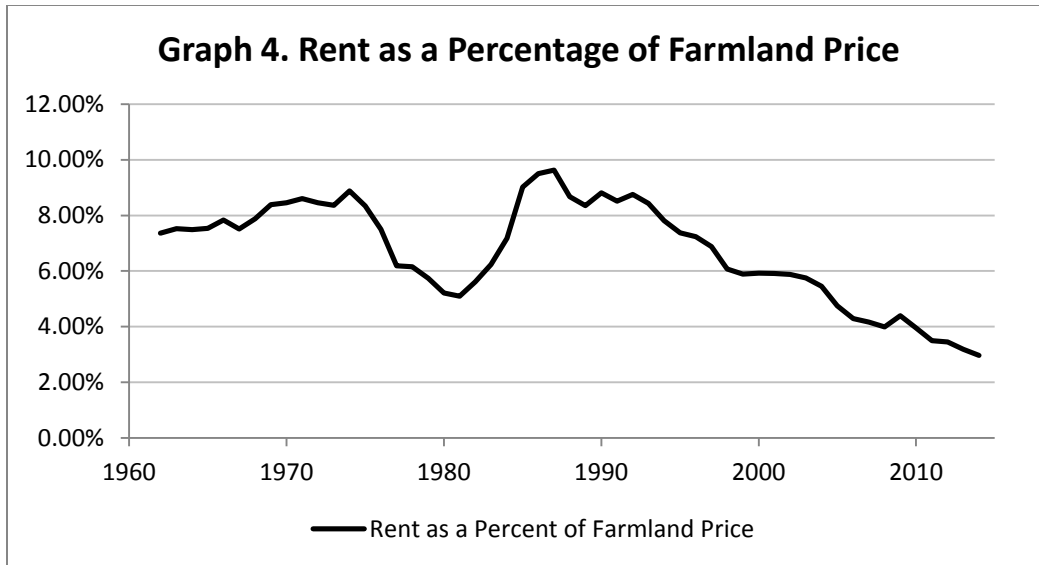


Using the Price-to-Value Ratio, which is the market farmland price divided by the capitalized value, the variation of the two values is better understood. When the market price and capitalized value are equal we see the ratio is equal to one. When the market price is greater than the capitalized value, the ratio is greater than one and vice versus when the market price is less than the capitalized value. This ratio represents the farmland price as a percentage of the capitalized value. As seen in Graph 2 the discrepancy in values in the 1970's and 1980's is obvious. When the ratio is at such a high level, prices will be under pressure to fall. The fundamentals are essentially not supporting prices. Today, we are actually at a magnitude under the unity level which is a sign of undervaluation in the market. If the price and value are in line with each other than a change in the price will be due to changes in cash rents and interest rates, not necessarily a readjustment to fundamental levels as was seen in the 1980's.



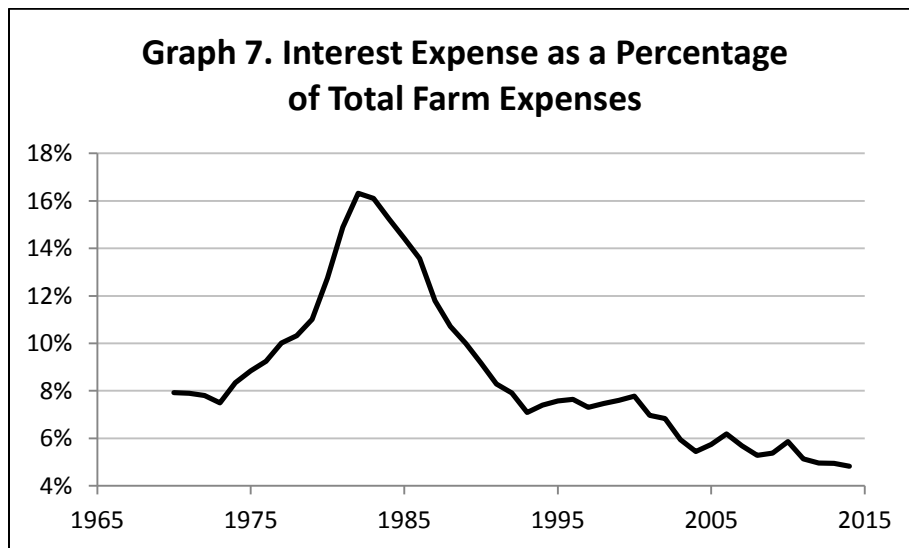
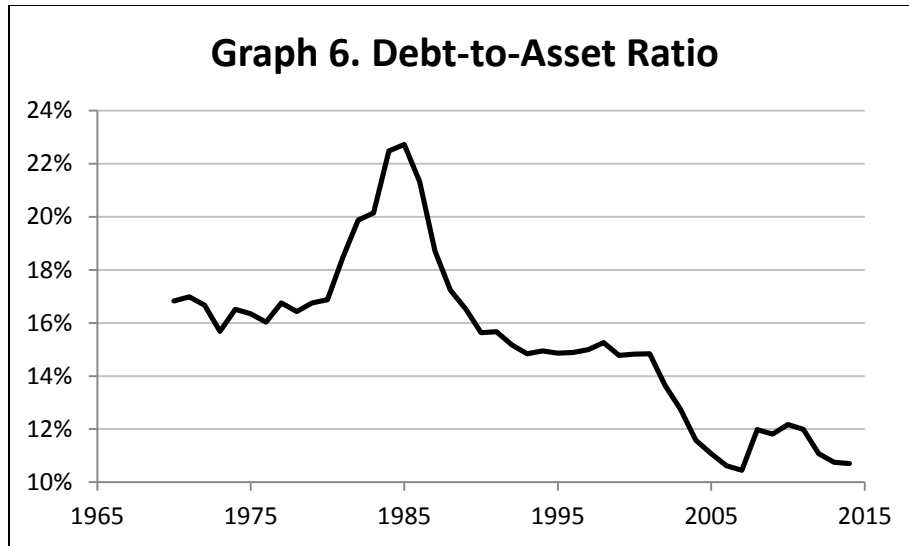
The monetary policy in place keeping interest rates at drastically low levels creates a less than straightforward analysis than simply looking at the Price-to-Value ratio. Interest rates are at lows not seen since prior to the 1960's. As a result, the high capitalized values may be a result of the low interest rate rather than the factors that determine cash rents. Graph 3 shows both rent and market price of land in dollars per acre with the values for rent being on the secondary axis and Graph 4 looks at rent as a percentage of farmland prices.





Both the market price and rent are increasing but rent is increasing at a slower rate and has even started to curb its growth in the last couple of years. Similar to the 1970's and 1980's rent is a smaller percentage of the farmland price and today is decreasing well below previously witnessed levels. Intuitively, this ratio measures to what percentage is the price supported by the cash rents compared to the other factors such as interest rates. A decline in this ratio may imply concern for the future of prices because it is signaling that the return on which farmland is based, is becoming less of a percentage of the farmland price itself.

Debt levels and overleveraging also played a large role in the crash of farmland values in the 1980's. Today as can be seen in graphs 6 and 7 debt levels are not only lower than that of the previous boom-and-bust cycle but they are at lower rates than have been seen in recent history indicating this time may in fact be different than in the 80's. Alternatively, with the lower than normal interest rate and low debt levels are also favorable for debt accumulation.



The current capitalized value is sensitive to increases in the denominator. Considering small increases in rates or even increases to previous levels, show significant declines in the capitalized value. Holding the cash rent equal to the 2014 level of \$260.00 and increasing the interest rate half of a percentage point to 3.07% the capitalized value decreases to \$8,469.06, a 16.29% decrease. An increase of 100 basis points to the current CMT rate decreases the capitalized value 28.01% to \$7,282.01. The St. Louis Federal Reserve Economic Data service publishes stress test scenarios with a baseline change in interest rates of +50% increase and an adverse change of +110%. These percentage increases, increase the CMT to 3.855% and

5.397%, respectively. Applying these rates to the capitalized valuation formula yields a baseline capitalized value of \$6,744.49 and an adverse value of \$4,817.49. This is a 33.33% and 52.38% decrease in the value of farmland, respectively. The following Table 1 illustrates the changes more succinctly.

Table 1.

	CMT	Rent	Capitalized Value	Percent Change In Value
2014 Levels	2.570%	260	10,116.73	-
Increase 50 basis points	3.070%	260	8,469.06	-16.29%
Increase of 100 basis points	3.570%	260	7,282.91	-28.01%
Avg of Last 10 yrs	3.336%	260	7,793.76	-22.96%
Baseline (+50%)	3.855%	260	6,744.49	-33.33%
Adverse (+110%)	5.397%	260	4,817.49	-52.38%

Recent expectations are that the Federal Reserve will begin to increase interest rates. This side of the equation may be the largest factor affecting the capitalized value and may be the cause of an overall shift in the market. The results above show that a large increase in interest rates is not necessary for downward pressure on land prices to occur. If interest rates rise quickly as they did in the late 1970's, the downward move may be dramatic.

Data

Both national and state data were needed for the analysis of farmland values and hedging strategies. The Midwest has seen the largest growth in farmland values compared to the rest of the United States. Iowa was chosen as the example state from the Midwestern region because it has the most contiguous farmland use. The state's main crops- corn and soybeans- were both considered for the analysis yet the yield and prices for the two crops were highly correlated (correlation coefficient estimated of .95) therefore only corn data was used to avoid issues of multicollinearity. Monthly data from January 1908 to January 2015 on corn prices calculated on a per bushel basis for Iowa was collected from the USDA's National Agricultural Statistics

Service (NASS). Additionally, average yearly yield in bushels per acre for Iowa corn from 1951 through 2014 was also obtained through the USDA's NASS terminal. Yearly values for Iowa farmland and rent from 1921 through 2014 were attained from the USDA's NASS terminal and Iowa State University summaries for earlier observations. The Iowa State University summaries are also USDA data. From the yearly data, monthly values for rent were interpolated using a simple regression of time and corn prices on rent. The time interpolation was the year plus a fraction representing the month.

Futures data was collected from the Chicago Board of Trade for the December corn futures contracts and from Quandl for 10 year Treasury note futures contracts for all contract months (March, June, September and December) from 1983 to 2014. Duration values for the cheapest-to-deliver Treasury bond underlying the futures contract was also obtained from Bloomberg. Macro data on monthly 10 year Constant Maturity Treasury Rate from January 1962 through April 2015 was obtained from the Federal Reserve Economic Data website, managed by the research division of the Federal Reserve Bank of St. Louis. The Farm Credit Services of America provided historical, annual, farmland mortgage interest rates going back to 1968 until 2014. No data was deflated as we are considering hedging outcomes on a year-by-year basis.

Methodology

The capitalized valuation formula for land is a common and widely used tool for calculating farmland by lenders. It is the summation of discounted future returns to farmland calculated as follows:

$$\text{Farmland Value} = \frac{\text{Cash Rent}}{10 \text{ Year Constant Maturity Treasury Rate}}$$

This formula will be used as a basis to model and hedge the value of farmland because of its consistency in accurately measuring farmland in the past. For the assessment of hedging purposes, in place of the 10 year Constant Maturity Treasury Rate (10-year CMT), an interpolated monthly mortgage interest rate is used as the discount rate. A mortgage rate is used in place of the 10-year CMT due to the current anomaly in current treasury rates. The interpolated mortgage rate consistently follows the historically calculated capitalized value. Importantly, its valuation of farmland prices in the boom-and-bust cycle of the 1970s and 1980s is consistent with the 10-year CMT. The two rates also have a .89 correlation coefficient. To calculate the interpolated monthly interest rate, a difference series was created using the annual values of the 10-year CMT and the mortgage interest rate provided by the FCSA (annual mortgage rate – annual 10-year CMT). The annual difference was then added to the June 10-year CMT observation and values between this middle of the year value were averaged so as to create a gradual change from month to month versus a jump in monthly rates.

As a proxy for net returns to the land, annual cash rent is used as it represents the annual cash flow the landowner receives for the use of the land. The rental rate is negotiated prior to the beginning of the marketing year based on expectations of revenue— yield and the price of the crop grown on the land— as well as input cost for production of the land.

To hedge the income related to the farm or the numerator of the equation, a regression for rent relating it to the factors affecting the return on farmland was developed. Several variables were considered for the estimation of rent—corn and soybean prices; corn and soybean yield; input prices such as fertilizer, seed and crude oil (used as proxy for fuel costs); and a year trend value. As noted before, the correlation between corn and soybeans is extremely high and as a result only corn prices and yield were considered. Intuitively, only one crop need be included as

rent rates are likely determined with production and expected revenue of both crops in mind.

Yield overall has increased from the beginning of the sample period due to advances in seed and fertilizer technology. After regressing yield and a time trend on rent, the time trend captured the increases in efficiencies better than the yield data.

The inclusion of input costs provide a better understanding of the rent value and also provide an opportunity to hedge changes in their prices. Unfortunately, when included in the regression, the model was not improved and the signs of the coefficients of the inputs were not consistent with economic theory. Therefore, input prices were not included but will be considered more thoroughly in the future.

With the assumption that rent decisions are made prior to the start of the marketing year, the price of futures contracts on December corn were used as the expectation of harvest price.

The final regression for rent is as follows:

$$\widehat{rent} = -2788.841 + 1.420 Year + 24.302P_{corn}$$

The coefficients for Year and P_{corn} had p-values less .0001. The R^2 of the regression was .961.

Using the Ramsey RESET test and assessing a plot of the residuals, the regression was tested for possible misspecification. All coefficients were not statistically significant therefore, the null hypothesis cannot be rejected and there is no sign of endogeneity. Autocorrelation tests were also performed, as there tends to be a delay in changes in rent to changes in prices of output. The Breusch-Godfrey LM test for autocorrelation showed weak signs of autocorrelation. No lags were included in the model of rent but will be considered in future research.

An interpolated monthly rent value was necessary to create a monthly rolling hedge. Monthly values for the time trend were interpolated by adding a fraction representing the position of the month in the year to the year itself. January, being the first month in the year, did

not have the addition of a fraction to the year. February was calculated as the year plus one twelfth and so on until December with the additional fraction of eleven twelfths. Graphs of the monthly estimates and actual rent values showed similarity in shape and growth patterns.

A long position in farmland is hedged using a monthly, rolling, delta hedge type strategy beginning in November two years prior to the date of interest and ending in October one year prior to the year of interest. For example, if interested in calculating the expected rent values for 2015, observations of the December 2015 contract's settlement prices from November 2013 through October 2014 with expirations in 2015 would be considered. Due to the lack of observations more than a year prior to the contract, the final dataset only included data from 1996 to 2014 yielding 216 monthly observations to test the hedging strategy. The strategy is closely analogous to the delta hedging in options because of the synthetic position created to replicate the returns to holding farmland.

Remaining consistent with the measurements of land in other capacities, all hedging calculations are done on a per acre basis. When calculating the optimal number of contracts for each position, the assumption that fractional contracts can be bought was imposed and determined the most efficient way to apply the ratio to varying farmland sizes.

Corn Hedge Position

The initial hedge for the first out-of-sample observation, 2004, uses data from 1983 to 2001 to estimate the rent regression due to the hedges initiation fourteen months prior to the actual year. The interest rate used for calculations is the interpolated monthly mortgage rate; "i" associated with the observation date or the date in which the hedge is established. The relationship to hedge changes in 2004 farmland is:

$$\widehat{Farmland\ Value}_{2004} = \frac{-2,337.457 + 1.192\ Year + 25.076P_{corn}}{Mortgage\ Interest\ Rate_t}$$

A table of all the coefficients used in each year's hedge is given in Table 2.

Table 2.

Hedge Year	Intercept	Coefficient of Year (beta1)	Coefficient of DecCornP (beta2)
2004	(2,337.457)	1.192	25.076
2005	(2,582.868)	1.316	24.674
2006	(2,788.841)	1.420	24.302
2007	(3,027.706)	1.541	23.647
2008	(3,265.911)	1.661	23.257
2009	(3,449.440)	1.754	23.060
2010	(3,535.664)	1.795	24.839
2011	(3,531.121)	1.793	24.561
2012	(3,535.205)	1.800	20.381
2013	(3,606.811)	1.835	21.274
2014	(3,606.217)	1.834	22.092

The landowner is negatively affected by decreases in revenue to the land. As the price of corn decreases, revenue decreases. Essentially, the landowner is in the same position as a corn producer and therefore, to hedge, he or she will take a short position in the futures contracts. To measure the change in farmland value with respect to a change in the price of corn, a derivative of the estimated farmland value equation with respect to the price of corn is taken:

$$\frac{\partial \left[\frac{\beta_0 + \beta_1 t + \beta_2 P_{Corn,Dec}}{Mortgage\ Interest\ Rate_t} \right]}{\partial P_{Corn,Dec}} = \frac{\beta_{P_{Corn,Dec}}}{i_{mtg,t}}$$

The optimal contract size for the corn position is then calculated by setting the change in the value of the farmland equal to the change in the value of the futures position. The derivation is as follows:

$$\frac{\beta_{P_{Corn,Dec}}}{i_{mtg,t}} \cdot \Delta P_{Corn,Dec} = N \cdot \text{bushels per contract} \cdot (\text{price per bushel})$$

$$N_{Corn,t}^* = \left[\frac{\beta P_{Corn,Dec}}{i_{mtg,t}} \cdot \frac{1}{5,000} \right] \text{ contracts per acre of farmland}$$

Where N is the number of contracts, $P_{Corn,Dec}$ is the settlement price of the December futures contract on corn and there are 5,000 bushels per contract.

Interest Rate Hedge

Calculating the interest rate position is similar to that of the corn position except for the consideration of the duration associated with the 10-year Treasury note futures position. Since the underlying position of the interest rate futures contract is a Treasury note, a duration-based position had to be considered. To calculate the optimal position, the change in the total farmland value is set equal to the total change in the futures position. The change in the farmland given a change in the interest rate is calculated as follows:

$$\frac{\partial \left[\frac{\beta_0 + \beta_1 t + \beta_2 P_{Corn,Dec}}{Mortgage\ Interest\ Rate_t} \right]}{\partial i_{mtg}} = \frac{-\beta_0 + \beta_1 Year + \beta_2 P_{Corn,Dec}}{i_{mtg,t}^2}$$

The optimal number of contracts was then solved for using the following:

$$Acres \cdot \left[\frac{-\beta_0 + \beta_1 Year + \beta_2 P_{Corn,Dec}}{i_{mtg,t}^2} \right] \cdot \Delta i_{mtg} = -D \cdot TY \cdot \left(\frac{\Delta i_{mtg}}{1 + i_{mtg,t}} \right) \cdot 100,000 \cdot N$$

$$N_{TY,t}^* = \left[\frac{(-\beta_0 + \beta_1 Year + \beta_2 P_{Corn,Dec}) \cdot (1 + i_{mtg,t})}{P_{TY} \cdot i_{mtg,t} \cdot (100,000) \cdot D} \right] \text{ contracts per acres of farmland}$$

Where D is the duration of the cheapest-to-deliver Treasury notes associated with the futures contract, TY is the settlement price of the 10 year Treasury note futures contract and N is the number of contracts. The relationship between duration and the bond price is derived using the following approximation:

$$\frac{\Delta B}{B} = -D \left(\frac{\Delta y}{1 + y} \right)$$

where $\frac{\Delta B}{B}$ is the percentage price change for a yield change of Δy .

Results

Two portfolios were compared. The first being one that only contained a long position in one acre of farmland in the spot market. The second portfolio held a long position in one acre of farmland and a short position in a corn futures position and a short position in a 10 year Treasury note futures contract, the size of each position calculated based on one acre of production.

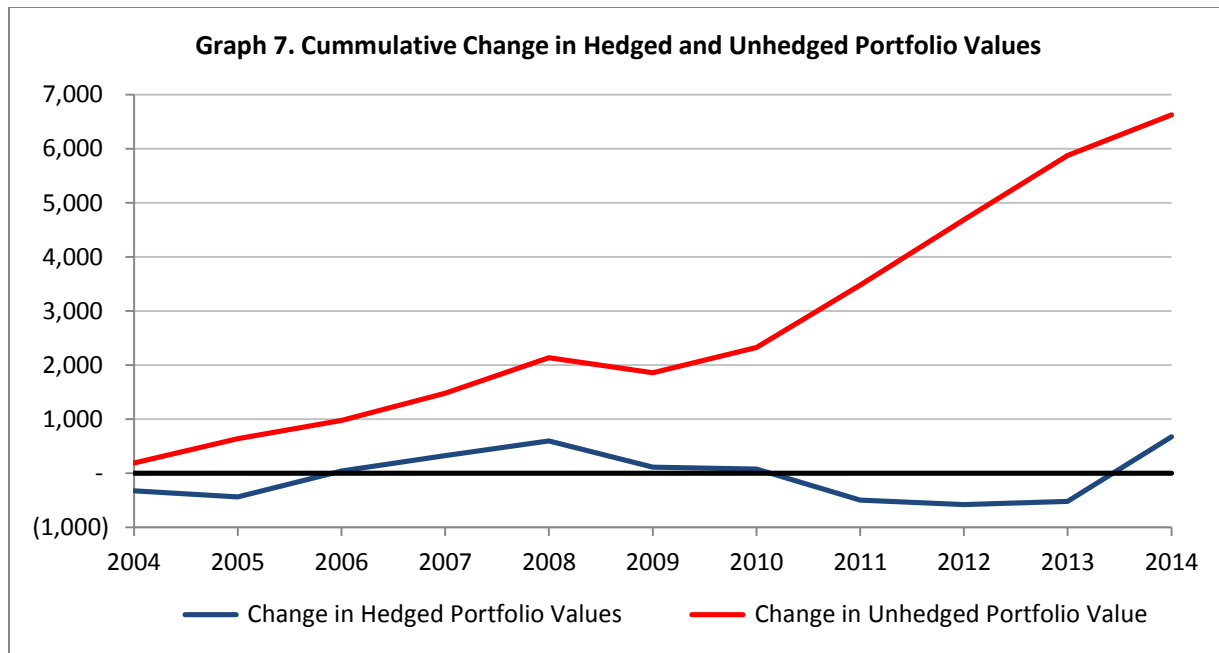
Returns on the short position were calculated as the sum of profits and losses from a monthly rolling hedge from 12 months of data prior to the date the farmland value is realized. Farmland value was also assumed to have been determined at the onset of the year similar to the determination of rent values at the onset of the marketing year. Returns were calculated as the change in the value of farmland from the previous year plus the return from the short futures contract on corn, if one was held.

$$\text{Return on the corn position} = N^* \cdot (C_t - C_{t+1}) \cdot \text{bushels per contract}$$

$$\text{Return on the interest rate position} = N^* \cdot (TY_t - TY_{t+1}) \cdot \text{dollars per contract}$$

$$\text{Yearly Return} = \sum_{Nov_{t-2}}^{Oct_{t-1}} N^* (F_{t-} - F_{t+1}) \text{ units per contract}$$

The cumulative change, the added change over each consecutive year, in the hedged and unhedged portfolios can be seen in Graph 7. As hoped for, the hedged portfolio fluctuates around zero whereas the unhedged increases away from zero over time, which is expected, with the increases in prices in recent history.



Conclusion

Our analysis has shown that using cross hedges for a long term long position in farmland can be hedged using short term contracts to manage adverse changes in the value of farmland. Due to the relationship between farmland values, the production process associated with the land and macro factors such as interest rates, multiple hedging opportunities are available to the holder of farmland. Future research will address the addition of a lag in spot corn prices when modeling rent values as well as the inclusion of cost side variables to hedge factors such as input prices. Considering the unusually low interest rates in the past several years due to the financial crisis, an increase in rates combined with the recent decreases in corn prices provides invested parties with an opportunity to manage adverse changes in their long term positions. Other future research will be to consider the hedging position of a lender in farmland. In this case, the lender has a nonlinear relationship with land values and a position analogous to shorting a put option. In conclusion, hedging a long term position in a non-liquid asset such as farmland is possible and may minimize some of the repercussions witnessed by land owners and lenders in the 1980's.

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