A Real Options Approach to Valuing and Hedging Cropland Obligations

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Introduction

In the late 1970's, the United States saw a significant increase in the market price of cropland. In the following years, the country experienced what was believed to be a popping of a cropland 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. The outcome of the 1980's left many unable to fulfill loan payments and ultimately caused many to leave the farm sector altogether.

Once again, farmland prices are rising at record rates. Over the last 10 years cropland prices have grown 278.8% with an average yearly increase of 10.7% since 2000. This has been the largest growth in cropland 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%.

Over 80% of farm sector assets in the U.S. are held in farm real estate. As of 2014, U.S. farm real estate was valued at over two trillion dollars, with close to two hundred billion dollars of farm real estate debt on the balance sheet. Farm real estate and in particular, cropland values, have historically driven changes in farm sector assets.[1] In recent years, cropland values have increased substantially, leading many to re-address the literature that arose from the 1980's bubble in cropland.

Literature Review

Much of the literature for valuation methods of cropland has been criticized due to the simplicity of the models and the assumptions they require. Largely, the literature has focused on representing the relationship between the asset's return and its value. Using this framework,

[1] Farm Sector Assets and Equity Forecast to Fall, Farm Debt to Rise in 2015, ERS

development of the return to the land has varied with respect to the use of macroeconomic factors such as interest rates and inflation (Robison, Lins and VenKataraman 1985, Moss 1997), non-agricultural demand for the land and non-agricultural issues (Robison, Lins and VenKataraman 1985) and parcel specific characteristics (Vantreese, Skees and Reed 1986) and even the inclusion of all these factors in a single model (Just and Miranowski 1993).

While all these models provide economic intuition to the relationship between cropland and its major determinants, they each fall subject to limitations and constraining assumptions that reduce each model's robustness. Pope et al. (1979) find a lack of robustness in the models. When updated, sign changes and loss of significance occurred for many variables' coefficients.

Other literature has forced a classic market structure to the valuation procedure. Additionally, these models, especially the capitalization models, have difficulty choosing the discount factor and determining how or if it should evolve over time.

The model addressed in this paper attempts to combine research from two areas that have not directly been applied to cropland. Firstly, Dixit and Pindyck (1994) develop an alternative approach to the traditional net present value approach to valuing assets. They use a real options approach that includes a "flexibility option" which addresses the value associated with the possibility of information becoming available in the future that may affect or change a decision. The traditional net present valuation does not include this valuation directly and can lead to overly optimistic decision-making.

Additionally, Cochrane and Saa-Requejo (2000) develop a valuation method for illiquid or non-traded assets that cannot be fully replicated by traded assets. When an asset cannot be fully spanned, issues arise in the determination of the discount factor. If replication is possible, the risk free rate can be used; otherwise, methods such as the Capital Asset Pricing Method are used to determine a discount factor. Cochrane and Saa-Requejo (2000) develop a discount determination method that evolves over time with the intuition that investors' sentiment affects the discounting of an asset and that evolves in accordance to the investing environment. The stochastic discount factor, as it is referred to, create "good-deal bounds". Upper and lower bounds, created by an upper and lower discount factor, are determined for the asset being valued. These bounds are advantageous because they do not depend on the assumption of a representative risk aversion parameter for investors and avoid determining discount factors using empirical modeling. The only disadvantage is the need to impose a restriction on total volatility of the stochastic discount factor (Floroiu and Pelsser, 2013).

Methodology

Asset Pricing Using a Stochastic Discount Factor

If the risk associated with the price of the investment is fully diversifiable, the risk free rate can be used to discount future cash flows. In the case of cropland, the risk cannot be completely replicated. Cochrane and Saa-Requejo (2000) develop a method for deriving a discount factor that is not exogenously determined but inferred by the model directly. Intuitively, investor's sentiments determine how they discount future cash flows. A model that allows the discount factor to vary in different states of the world takes into consideration investor's expectations which as a result, motivate asset prices.

The "Good-Deal Bounds" create a range of possible values for an asset. The upper and lower bounds of this range are solved for by maximizing or minimizing, respectively, the following equation, with respect to the stochastic discount factor, m. The problem is, essentially, looking for the minimum variance discount factor that generates the arbitrage bounds.

$$L_{Upper} = \max E[mx^L], \text{ wrt } m$$
$$L_{Lower} = E[mx^L], \text{ wrt } m$$

s.t. (1) $p = E[mx]$

(2) $m \geq 0$

(3) $\sigma \leq \dfrac{h}{(1+r_f)}$

Where x^c is the focus payoff to be valued, $x^c = \max(S_T - K, 0)$, p and x are the price and payoffs of the basis assets, h is the pre-specified volatility bound, and R_f is the risk-free rate.

The first constraint is a Law of One Price assumption stating that the underlying traded asset, the futures contract on corn, is taken as given to learn about the value of the asset, cropland. The second constraint is a no arbitrage assumption essentially asserting that the discount factor must be greater than zero. The first and second constraints create arbitrage bounds that are too big to be useful. To tighten and strengthen the bounds a third constraint employed by Cochrane and Saa-Requejo (2000) is added which is an upper limit on the Sharpe ratio. Investments with large Sharpe ratios are not likely to persist and therefore, can be ruled out. This is essentially a way to remove unreasonable discount factors within the arbitrage bounds.

Cropland values are calculated by summing the discounted net revenue to the land through time. The income to the land, rent, is estimated through the use of a stochastic process that addresses both the hedgeable and unhedgeable risk associated with changes in the rent prices. The hedgeable portion of the risk is captured through the use of the December corn futures contract. The relationship between rent, the hedgeable risk and unheadgeable risk is developed using a simple regression of the log change in corn futures contract on the log change in rent prices. Using the regression output the following estimation of the change in log rent was estimated:

$$dlnRt = (-\mu - 0.5\,\sigma_w^2 - 0.5\sigma_z^2)dt - \sigma_w \epsilon_w \sqrt{dt}\ \pm\ \sigma_z \epsilon_z \sqrt{dt}$$

Where the first term is the drift term, the second term is the stochastic process associated with the underlying futures contract on corn that is our hedgeable risk and the final term is associated with the risk that is not hedgeable. Both epsilon terms are distributed standard normal and are orthogonal.

The mortgage payment, which represents the cost associated with the land, is calculated as a fully amortized constant-payment loan. These payments are calculated as a yearly payment on a per acre basis.

The discount factor, taking into consideration each of the constraints is solved using the following function:

$$dln\Delta_t = [-r - 0.5A^2]dt - h_f \epsilon_z \sqrt{dt}\ \pm\ \sqrt{A^2 - h_f^2}\, \epsilon_w \sqrt{dt}$$

The change in the log of the discount factor is determined by a drift term, $[-r - 0.5A^2]dt$, and a factor associated with the underlying traded asset, $-h_f \epsilon_z \sqrt{dt}$, and a final term that takes into consideration both variations in the market as well as the underlying traded asset, $\sqrt{A^2 - h_f^2}\, \epsilon_w \sqrt{dt}$. The final term is added when calculating the upper bound and subtracted for the lower bound.

The land value is then calculated as the sum of the discounted net revenue with rent as the income to the land and the mortgage payment as the cost associated with the owner of the land into the future.

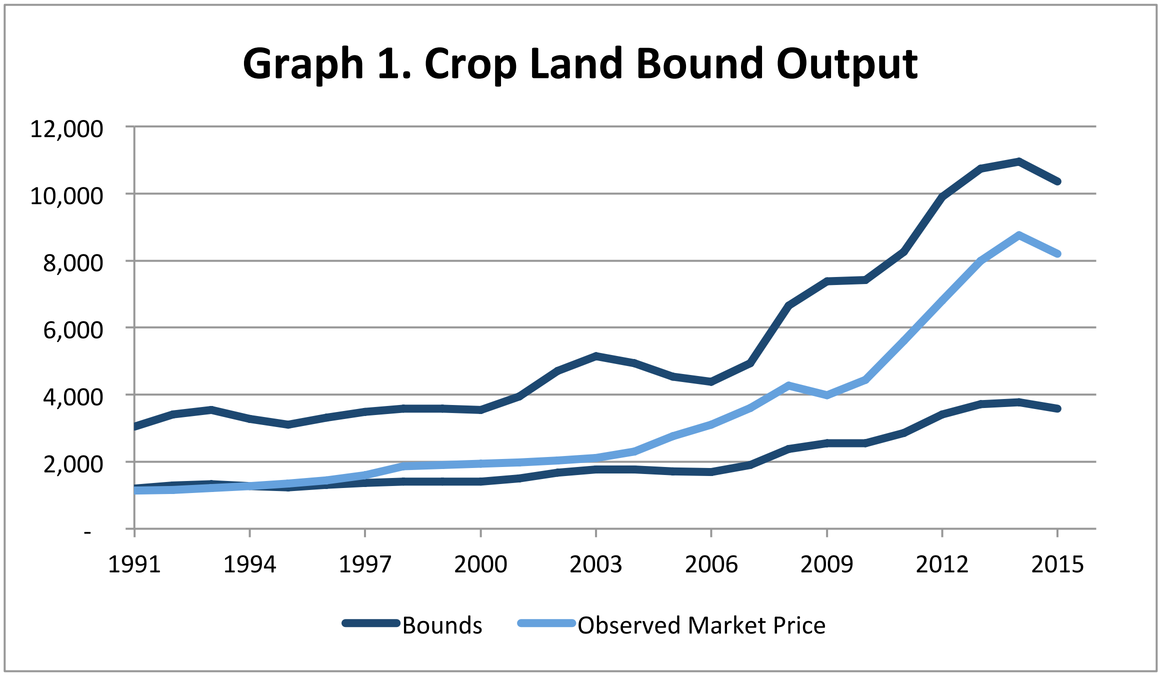
Data

Both national and state data were needed for the analysis of cropland values and hedging strategies. The Midwest has seen the largest growth in cropland values compared to the rest of the United States. Iowa's main crops— corn and soybeans— were both considered for the analysis yet the prices for the two crops were highly correlated (correlation coefficient estimated at .95) therefore only corn data was used to avoid issues of multicollinearity. Yearly values for Iowa cropland and rent from 1921 through 2014 were obtained from the USDA's NASS terminal and Iowa State University summaries for earlier observations. The Iowa State University summaries are also USDA data.

Futures data was collected from the Chicago Board of Trade for the December corn futures contracts and from Quandl from 1969 to 2015. Trading observations range from 12 to 14 months prior to expiration. Macroeconomic data on monthly 10 year Constant Maturity Treasury Rate from January 1962 through 2015 were obtained from the Federal Reserve Economic Data website, managed by the research division of the Federal Reserve Bank of St. Louis.

Results

Calculated bounds showed positive results that encompass the historical market prices for farmland. Market price bounds have been calculated for the periods of 1991 to 2014 and can be seen in Graph 1 below.



The bounds, on average, have widths of about $3,500. The widths of the bounds increase overtime with a maximum width of $7,177 in 2014. Future research will focus on tightening the bounds to strengthen the analysis gained from the results. The bounds were found to be sensitive to a number of the specified parameters. The parameters from the rent estimation using corn futures prices, the market Sharpe ratio constraint specification and risk free rates all affected the magnitude of the bounds.

Future research will also extend the analysis to before and during the rise and fall of market prices in the 1980's. Extending the analysis to this time period will allow for the testing of the model. The drastic changes in prices in the 1980's are today recognized as a bubble in farmland values. If this model detects this issue of prices during that time period we can be reasonably confident in our models' ability to indicate issues associated with market prices in the future.

Conclusions

The approach by Cochrane and Saa-Requejo (2000) for valuing non-traded or illiquid assets was applied to the case of cropland using rent and mortgage payments as proxies for income and cost to land, respectively. Through the use of stochastic discount factors, upper and lower bounds on cropland values were estimated. The bounds calculated showed positive results towards the development of this method. Opportunities exist to improve the bounds calculated which will in turn improve the implications of the outcomes. Future research will address each parameter input to the stochastic discount factor calculation. Better understanding of the sensitivity of the bounds to the inputs will allow for better calibration and will likely lead to the tightening and strengthening of the outcomes.

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