THE NUANCES OF CROPLAND MARKETS: ESTIMATING PRICES AND RENTAL RATES AND A LOOK THROUGH TIME AT THE FARM BUSINESS SECTOR DURING CYCLES

A Dissertation

by

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ABSTRACT

Land values are a central part of the farm business sector and are the vast majority of assets on the farm business sector's balance sheet. Land is the single largest collateral backing for agriculture debt with farm real estate representing about two hundred billion dollars of debt. In total, U.S. farm real estate is valued at over two trillion dollars. Farm real estate, and in particular, cropland values, have historically driven changes in farm business sector assets.

In the past century, the farm business sector has witnessed three major boom-and-bust cycles, land values being at the center of each. Once again, cropland prices have increased at record rates. The recent growth in prices has brought into question the sustainability of the market price for cropland.

This work addresses major shortcomings and gaps in the previous literature on cropland valuation. The work here has three goals. First, develop a model that replicates market land prices by addressing characteristics of the market that have previously been overlooked. The model uses a relative pricing approach which addresses the incomplete market structure of cropland markets. The approach implements the good-deal bound methodology to calculate the value of land given yearly rental income discounted by a stochastic discount factor. The model also uses a dynamic optimization framework allowing state variables, which determine each of the contract prices, to vary over states throughout time.

Second, a further investigation into the determination of rental rates is performed. The outcome from the first analysis and earlier research has shown the difficulty in estimating land prices as a function of the income to land. A consensus has been made by previous literature that rental rates are the best proxy for income to land. The difficulty in determining rental rate deals with how they are "sticky" over time. The second analysis uses an error correction model to test the existence of asymmetric price transmissions between rental rates and crop prices. The error correction model tests for the presence of asymmetric price transmission between change in the income to land and the cropland prices. The model also allows for analysis on a short-run and long-run basis.

Third, the paper discusses the connection between the current boom in cropland prices and previous cycles in the farm business sector. The analysis addresses the likely causes of the contractions of these markets by looking at capital expansion leading to unsustainable credit risk in the market. Capital expansion is analyzed structurally to allow for forecasting possible future changes in it. Data from the Federal Reserve Bank regional surveys are also considered to understand the creation of credit risk both from the perspective of the lenders and borrowers. Addressing both the demand and supply of debt considers, holistically, the composition of financial risk in agriculture markets and how both the demanders of debt and the suppliers of debt create and manage risk in the farm business sector.

DEDICATION

To Chris, Mom, Dad & Derek.

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CHAPTER I

INTRODUCTION

Land values are a central part of the farm business sector. Cropland amounts to 85% of the assets on the U.S. farm business sector's balance sheet (USDA ERS- FIWS). It is the single largest collateral backing for agriculture debt. There is about two hundred billion dollars of debt associated for all farm real estate. In total, U.S. farm real estate is valued at over two trillion dollars. Farm real estate, and in particular, cropland values, have historically driven changes in the farm business sector's assets.

In the past century, the farm business sector has witnessed three major boom-and-bust cycles, land prices being at the center of each of these cycles. Cropland prices grew nearly 410% in the most recent cycle, in the 1970s and 1980s (USDA NASS). As cropland prices increased, operators expanded their business operations and as a result put themselves in risky, over-leveraged positions. Inevitably, the farm business sector was unable to support the debt positions it created and witnessed one of its largest recessions. Many farm operations, farm input suppliers and banks with significant farm loan portfolios went out of business as a result.

Once again, cropland prices have increased at record rates. From 2000 to 2014, national cropland prices grew 180% with average yearly increases of 8.0% (USDA NASS). The Midwest or "Corn Belt" region has seen the largest growth in cropland prices, increasing 243% from 2000 to 2014, on average (USDA NASS). The increase in cropland prices coincides with the increase in demand for agriculture products. The increase in demand has been a function of a number of factors. Several free trade agreements in the mid to late 1990s and 2000s made exporting goods to other countries easier. Second, expansion in both the population and income of developing countries has increased demand for U.S. exports. Finally, the boom in biofuels significantly increased domestic demand for row crops.

The recent rapid growth in cropland prices calls into question the sustainability of the market price for cropland. The volatility in the price of cropland is concerning for the overall stability of the farm economy. The farm business sector supports many rural economies, with a varying but large portion of employment in rural communities across the nation directly related to agriculture or to the agricultural services and processing industries. Instability in the farm business sector has sent ripple effects throughout the economy through increased food and fiber prices in the past (Assets, Debt, and Wealth 2015).

The rapid growth in cropland prices has led many to re-evaluate the literature that arose from the 1980s bubble in cropland. Much of the literature for valuation methods of cropland has been criticized for its over-simplified modeling and the restrictive assumptions placed on parameters. Cropland prices, in general, are difficult to model and previous attempts to do so have encountered substantial challenges. The objectives of this paper are to address two of the substantial shortcomings of previous valuation literature. The paper will consider the unique characteristics of cropland to estimate market cropland prices, test a commonly cited theory of the structure of land pricing and analyze the boom and bust pattern created by the suppliers and users of debt in the farm business sector.

Addressing the shortcomings of previous cropland valuation techniques

This work will address two major shortcomings of previous work on the subject of cropland valuation. Previously, models have not considered the incomplete market structure that defines cropland markets. Additionally, the model will not assume the underlying state variables that determine the cropland price and will allow them to evolve over varying states of the world.

The model developed in chapter II addresses these issues in two ways. First, a relative pricing approach developed by Cochrane and Saa-Requejo (2000) will be applied to address the incomplete market structure of cropland prices using a stochastic discount factor. The stochastic discount factor values an asset by discounting the income as a function of the state the income is paid out in. Second, the contract values calculated from the relative pricing approach will be applied to a dynamic optimization framework to allow the state variables determining each of the contract prices to vary over states and time. Backward induction will then be used to determine an initial cropland value.

Re-addressing sticky rental rates

Chapter II analyzes the presence of autocorrelation of rent using a maximum likelihood estimation to model the relationship between rent and long-run crop prices. Previous literature has described the stickiness in rent being a result of rent responding to positive and negative changes in income at different rates. The presence of an asymmetric price transmission between rent and income has been discussed by several authors, but it has not been tested empirically. Chapter III tests for the presence of asymmetry cropland price using an error correction model.

The re-emergence of previous boom and bust patterns in today's cropland markets

The boom and bust cycle of the 1970s and 1980s brought about a plethora of literature on the causes and the 1970s boom in cropland values. The recent boom in agriculture markets have brought with it a discussion of cropland valuation as well as concern over markets repeating the bust of the 1980s. Chapter IV highlights a pattern that has occurred in several of the previous boom and bust cycles. Ultimately, the pattern shows market participants becoming overleveraged and unable to service debt leading to the busts witnessed throughout the farm business sector. Furthermore, the chapter models the actions of both supplier and users of liquidity in the farm business sector to understand the development of the debt positions created during boom periods. By considering both the demand and supply of debt, the analysis will address, holistically, the composition of the financial risk positions of agriculture market participants and how both the demanders of debt and the suppliers of debt create risk in the farm business sector.

CHAPTER II

A GOOD DEAL BOUND APPROACH TO VALUING FARMLAND

In the late 1970s, the United States saw a significant increase in the market price of cropland. In the following years, the country experienced what was characterized as a bursting of a cropland price bubble. Many have speculated as to the cause of the 1980s bubble, largely attributing it to a fatal combination of factors beginning with significant increases in demand for agricultural products, caused by rises in global liquidity; rising incomes and a reduction in competing countries' crop production (Peters, Langley and Westcott 2009). Intense contractionary policies by the Federal Reserve to combat double digit inflation led to the Federal Funds rate increasing to 19% along with the prime rate rising even further to 22%. The outcome of the 1980s left loan payments unfulfilled and ultimately caused many to leave the farm business sector altogether.

Once again, cropland prices have increased at record rates. From 2000 to 2014, national cropland prices grew 180% with an average yearly increase of 8.0% (USDA NASS). The Midwest or "Corn Belt" region has seen the largest growth in cropland prices, increasing 243% from 2000 to 2014, on average (USDA NASS). This has been the largest growth in cropland prices since the 1980s where the farm business sector witnessed a 410% growth rate in eleven years and an average yearly growth of 24% (USDA NASS). Today, there have been increases in demand for agriculture products similar to that of the 1970s. The cause of the current cycle's increase in demand has largely been a function of the enactment of several trade agreements, biofuel production creating an alternative use for crops and increases in developing countries' income.

On a macro level, the 10 Year Constant Maturity Treasury rate, a proxy for the risk-free rate, has decreased to all-time lows since the 2008 recession. Currently at 2.19%, it has reached as low as 1.80% (Federal Reserve Economic Database, "FRED"). The Federal Reserve has already begun to increase the federal funds rate and speculation expects interest rates to continue to rise and inflation to grow in the near future. The rate increases present an opportunity for a correction in cropland prices due to the inverse relationship of interest rates and cropland prices. Similar to the 1980s, hostile macro-economic factors may lead to massive decreases in crop prices.

Cropland comprises the vast majority of assets on the farm business sector's balance sheet, totaling about 85% (USDA ERS- FIWS). It is also the single largest use for collateral for farm loans. As of 2016, 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 prices, have historically driven changes in the balance of the farm business sector's assets. The growth in cropland prices came to a halt in 2014 with the decline in row crop prices. The national average corn price in 2012 was $6.89 and has since declined to $3.61 (USDA NASS). Depressed crop prices put a strain on operators' ability to break even as rent has also risen following the rapid increase in land prices.

When there is volatility, or rapid changes in the price of cropland, there is cause for concern about the overall stability of the farm economy. Stability in the farm business sector provides stability in rural economies, with a varying but large portion of employment in rural communities across the nation directly related to agriculture or to the agricultural services and processing industries. Instability in the farm business sector can send ripple effects throughout the economy through increased food and fiber prices (Assets, Debt, and Wealth 2015). In recent years, cropland prices have increased substantially, leading many to re-evaluate the literature that arose from the 1980s bubble in cropland. Much of the literature for valuation methods of cropland has been criticized due to either over-simplified models or the restrictive assumptions placed on parameters.

Largely, the literature has focused on the relationship between the asset's return and its value. Using this framework, 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), parcel specific characteristics (Vantreese, Skees and Reed 1986) and even the inclusion of all these factors into 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 have limitations or constraining assumptions that reduce the robustness of their models. Pope, et al. 1979 finds that when some of these models are updated, sign changes and loss of significance occur for the variables' coefficients. These results indicate previous models do not reflect relevant structural changes or the true characteristics of cropland markets.

Cropland, in general, is difficult to model for several reasons. The finite supply of land does not allow for the classic market structure modeling of supply. There are also many "difficult to quantify" factors affecting a market participant's motivations to buy or sell cropland, ones that do not apply to the classic profit maximization framework. Variables include the desire for contiguous land, desire to hold land for familial purposes or desire for portfolio diversification from institutional investors. Furthermore, there are structural issues that many models, especially the capitalization models, have difficulty addressing such as choosing an appropriate discount factor and determining how or if it should evolve over time.

Previous cropland valuation models have lacked in their ability to capture the relevant underlying characteristic of cropland markets. Over time, this has become apparent as their models are updated with new data and model results have lost significance or seen sign reversals. This paper will address several of these models' shortcomings.

The model developed here will address these two issues in two ways. First, a relative pricing approach developed by Cochrane and Saa-Requejo (2000) will be applied to address the incomplete market structure of cropland prices. Second, the contract values calculated from the relative pricing approach will be applied to a dynamic optimization framework to allow the state variables determining each of the contract prices to vary over states and time. Backward induction will then be used to determine an initial cropland value.

Literature Review

Cropland Valuation

There literature on valuing and understanding the determinants of cropland is abundant. Much of the literature arose from and was in response to the large increases and then plummeting of prices in the 1970s and 1980s. This literature primarily focused on understanding the causes of such price fluctuations.

In the 1960s, Herdt and Cochrane (1966), Tweeten and Martin (1966) and Reynolds and Timmons (1969) developed simultaneous equation models attempting to explain cropland valuation using a classic market framework. This type of modeling requires strict assumptions to create a supply and demand framework. Because cropland is fixed, it is difficult to create an appropriate proxy for its supply. For example, the number of available cropland acres is often used as a proxy for supply, yet changes in this number are usually insensitive to the price of the asset. As a result, the price of cropland is largely, if not wholly, determined by demand.

Herdt and Cochrane (1966) attribute large gains in cropland to the expected gains associated with technological advances. Their intuition is that the decrease in per unit cost associated with technological advances increases producer's net income, which causes them to expand their operations and as a result cropland prices increase. The expected gains are captured in the price increases in cropland. Pope et al. (1979) tested this model with more recent data and found many coefficients either lost significance or the signs of coefficients changed. Tweeten and Martin (1966) use three econometric models; ordinary, recursive and autoregressive least squares, to answer the question, "are land prices too high?" They use annual, national land data and their results show that the causes of the increases in land prices are not stable nor based on fundamental factors.

Many empirical models have also been estimated to determine the causes of changes in cropland value. Klinefelter (1973) explains Illinois cropland values using four explanatory variables associated with farm production– net rent, average farm size, number of voluntary transfers of cropland and the expected capital gains. Klinefelter (1973) states that any excess income above current costs occurring from technological advances in production equipment, better management practices, and greater capital inputs, will be capitalized into the value of the non-reproducible land resource following the Ricardian theory of rents. As the value of cropland increases from the capitalization process, the cash rental rate charged by the landowner will increase to compensate them for the annual use of the land. Excluding the 1980s, cash rental rates have historically aligned with the returns to farming operations and one would expect cash rental rates and returns to farming operations to continue to align, in the long run. Pope et al. (1979) find that Klinefelter's model, when updated, remains the most robust out of all the models tested.

Others such as Alston (1986) focus on macroeconomic factors to try to explain the drastic changes in cropland prices. Specifically, Alston (1986) considered the relationship between inflation and cropland prices. One motivation was to consider hedging opportunities against inflation using investments in cropland. Using a tightly parameterized empirical model, he concludes that there is no support for the notion of cropland as a hedge for inflation and net rental income was the primary driver for most of the real growth in U.S. land prices during the 20 years prior to 1982.

Less common models are that of Shalit and Schmitz (1982) and Phipps (1984). Shality and Schmitz (1982) use a life-cycle utility maximization of farmers to create a derived demand model for cropland. They focus on savings, income minus consumption, and cropland debt as the primary determinant of cropland prices. The intuition is that cropland prices are both affected by the income derived from the land and the debt it carries. They conclude that as banks increase the supply of credit to farmers, prices will increase faster compared to times when no liquidity is available. Phipps (1984) uses Granger causality to test temporal hypotheses for the source of cropland price movements. The results of the Granger causality test show cropland prices are caused by residual farm return. Using these results, Phipps (1984) develops a structural cropland price model using primarily farm business sector variables.

Just and Miranowski (1993) attempt to explain changes in cropland prices using previous literature's determinants. The authors identify the relative roles of each models' influence using mainly a theoretical framework with some empirical analysis. They consider farm and nonfarm returns, inflation, credit, the real interest rate on farm real estate debt, government payments, taxation and more. Their results indicate inflation, net returns, and the discount rate are the largest contributors. Using these results, Just and Miranowski (1993) found that they could successfully predict land prices using current and lagged rent, with lags of up to 5-8 years. They note that while lagging rent by those amounts proves effective, it lacks substance in terms of "defensible economic rationale." Featherstone and Baker (1998), and Falk (1991) agree that these techniques, while proving strong in terms of an r-squared, are not applicable.

Studied even more often than the determinants of land prices, is testing the relationship between the capitalized value of land and the price seen in the market. In theory, rent, a representation of the income to land, capitalized by a market interest rate, usually the risk-free rate, should represent the value of the cropland and therefore should equal the price determined in the market. Several studies have focused on the ability of the present value model to hold given the market-determined prices for rent, cropland and the interest rate over time.

Melichar (1979) originates the use of cash rent as a proxy for income, placing emphasis on expected changes in rent. Melichar's (1979) work arose from the rapid increases in farm asset prices. He notes the importance of understanding where the capital gains are occurring—from the return to the asset or from other influences. He states the increases in returns to land, over labor, are the primary cause of the increases in land prices. "Over the last twenty-five years, the proportion of the total return that could be ascribed to operators' labor has dropped from 63% to 17%, while the proportion that could be regarded as a return to production assets has risen from 25% to 69%" (Melichar 1979). To properly assess the income to land price relationship, Melichar (1979) states net farm income cannot be reliably used for several reasons. First, net farm income is an aggregate measure whereas land prices are a unit price. Using net farm income to represent return to land alone, ignores the number of other productive assets that are included in the net farm income measure. Additionally, net farm income lacks comprehension of the non-operator landowner. When considering the substantial portion of land owned by non-operators, income from rent and interest payments on debt should be included in income while operator's dwellings should also be excluded.

Several authors have developed the relationship between rent and land prices showing it is not a direct, straightforward relationship. Phipps (1984) uses Granger-Causality to show the existence of a fundamental relationship between rent and cropland. Past rents and land prices explain the dynamics of future land price changes. Vantreese, Skees and Reed (1986) previously looked at the use of net farm income as the primary determinant of farmland value yet ultimately agree with Melichar's (1979) work and re-iterate that net farm income includes returns to factors other than land such as labor, machinery, buildings, etc. Vantreese, Skees and Reed's (1986) model develops a rent specification using parcel specific characteristics. Through the use of ordinary least squares, the authors determine the magnitude to which each factor characterizes the rent amount. The estimated rental rate is then used in the capitalization formula to solve for the value of the cropland. Burt (1986) compliments this research by addressing the issue of the need for lags in the capitalization of rent into cropland value. Burt (1986) includes input prices, farm commodities and technological changes as primary explanatory variables and estimates a second order rational multiplicative distributed lag on rent to determines changes in land price movements. The change in value is the sum of two components– (1) the previous year's rent and land prices and (2) the expected change in rent and land prices for the upcoming year. Ibendahl and Griffin (2013), provide intuition on why the lags are important in determining the land price. They explain there exists an asymmetric relationship between changes in rent and land prices. The asymmetries are created when the lessee chooses to share varying amounts of information during productive and non-productive years. The authors determine that this asymmetric relationship between lessee and landowner is the basis for the need to use lags in determining land prices.

Robison, Lins and VenKataraman (1985) try to improve on the capitalized valuation model by including the expectations of changes in factors. The growth rate in cash returns to land, inflation expectations, income and capital gains taxes are included in their model. They determine that inflation and non-agricultural demand are important influencers. Similarly, Moss (1997) considers the effects of returns, interest rates and inflation on cropland values, concluding inflation is the biggest driver of land values.

Schmitz (1995) takes a closer look at the involvement of government policy and its effect on value with a focus specifically on boom and bust cycles. He finds that cropland values and inflation are positively related. He states these results show inflation was a significant contributor to the rise in cropland prices in the 1970s and 1980s.

Falk and Lee (1998) incorporate a vast number of influences by categorizing them into three areas– permanent fundamental components, temporary fundamental components and non-fundamental components. They find in the long-run that the present value formula is a strong predictor of prices; but in the short-run the models tend to overreact to fundamental and non-fundamental factors. Falk (1991) considers rent the primary determinant of cropland prices noting that in the short term, land prices will likely be more volatile than cash rents.

Falk (1991) and Lloyd (1994) create a series of tests to determine the usefulness of the present value models. Lloyd (1994) states two reasons the present value model is attractive. First, the present value model is the quintessential example of the economic theory that in the long-run the income and value of an asset should not diverge. Second, the simple and tractable nature of the present value formula is a benefit. Falk (1991) is more critical of the model. He uses two criteria to determine if the model is robust. First, he states the two series should follow the same process, i.e. be stationary, first difference stationary, etc. Rent is determined to follow a difference stationary process and therefore, if the two variables are related, cropland should also follow a difference stationary process. Second, theory imposes both Granger causality and cross equation restrictions on the vector autoregressive representation of the spread and the changes in rent. Falk (1991) concludes that both criteria fail. Cropland prices and rent movements are highly correlated yet cropland price movements are more volatile. Additionally, testing of the cross-equation restrictions imposed by the present value model failed to support the restrictions and therefore the model itself failed. Falk (1991) states the cause of the failure is likely economic factors such as a rational bubble or the presence of a time varying discount factor.

During the period preceding the 1980s land prices were increasing at a rate that outpaced multiple series thought to be an indicator or driver of cropland value. The rapid increase in price led to the research interest and proliferation of literature pertaining to the topic of forecasting land prices. Following the “collapse” of cropland value in the mid to late 1980s the majority of the literature pertaining to cropland prices transitioned into “post-mortem” ideology attempting to explain the rapid decrease in cropland prices. The literature for cropland valuation is now abundant. Since the late 1980s and early 1990s little modeling research has been added to the literature and many of the previous literature has come to contradictory conclusions on the usefulness of certain models and the primary determinants conveying the relationship between income and cropland values. Two articles, Pope (1985) and Clark, Fulton and Scott (1993), even go so far as to state that net farm income, a common proxy for the return to the land, is incapable of capturing the level of land value. Furthermore, as previous models have been applied and updated over time, sign changes as well as the loss of significance of variable’s coefficients have occurred (Pope, et al. 1979).

The Effect of Government Payments on Land Prices and Rental Rates

Government payments play an essential role in the farm business sector and as a result likely have an influence on the pricing of assets in the sector. The study of the effects of government payments on the price of land have been studied thoroughly, usually in the midst of changes or proposed changes in farm bill programs. The literature is reviewed here in determining whether government payments should be included in the modeling of cropland prices.

Roberts, Kirwan and Hopkins (2003) provide intuition on the relationship between government payments and land prices, “a large component of land values (much like stocks and bonds) includes the belief held by landowners and potential landowners in future net returns and government payments, which are uncertain and therefore intangible." Roberts, Kirwan and Hopkins (2003) as well as other authors considering this subject look specifically at the effect of government payments on cash rental rates and how, as a result, those changes cause land prices to change. Roberts, Kirwan and Hopkins (2003) state, "…we focus on cash-lease rents, rather than on land values, so that we can focus squarely on current expectations, which are more tangible than the amalgamation of current and future expectations that land values encapsulate."

Prior to the 1996 Farm Bill, Featherstone & Baker (1988) analyze two scenarios of land prices—one under the 1985 farm program and the other under a free market scenario. Using data from Indiana, the authors determine a sequence of causality from the farm payments to land prices. The farm payments, at the time, were tied to commodity prices. Therefore, the government programs changed the realized commodity price, which in turn, sets the level of rent charged and result in changes in the price of the land. The authors simulate grain price distributions under the alternative policies to determine how rental rates are set based on the varying market commodity prices. The model output has rent, and therefore, land prices, lower and more volatile under the market scenario. Specifically, the authors found that the market scenario would lead to a 16% decrease over a four-year period.

Barnard et al. (1997) divide the United States into 20 regions to measure the effect of the 1996 Farm Bill on a regional basis. Barnard et al. (1997) again show the capture of government payments into cash rental rates. The authors measure the effect of both the returns to production and government payments on rent by estimating the elasticities using both parametric and non-parametric estimators. By dividing the United States into 20 regions, the authors are able to estimate the effects on a regional basis. The regions with the largest elasticities, or those who are affected the most by government payments, are parts of Texas, Georgia, Alabama, the southern Corn Belt, and parts of North Carolina. These regions have elasticities ranging from 22% to 50%. North Dakota, Kansas, the southern Lake States, and the northern Corn Belt elasticities ranged from 10% to 20% (Barnard, et al. 1997).

Roberts, Kirwan and Hopkins (2003) use the 1992 and 1997 Agricultural Census data to assess how the decoupling of payments from crop prices affected land prices. "Because the payment level does not depend on farmers' current production decisions, they should not cause farmers to alter them, so the payment should be fully reflected in higher rents" (Roberts, Kirwan and Hopkins 2003). Their analysis yielded an increase in rent of \$0.33 and \$1.55 for every dollar of government payment, respectively.

Shaik, Helmers and Atwood (2005) look at the effects of government payments over time and how they may have changed given the changes in farm programs. They find that over time, the portion of land values determined by government programs has declined. The effects of farm programs have ranged from 30% to 70% of agricultural land value from 1938 to the 2002 Farm Bill. In the 1960s and 1970s, the authors found that farm program payments attributed to about 40% of land value. At the time of the article, value attributed to government payments declined to about 15-20%. The authors conclude, "…although real per acre government payments have been increasing over time, it appears that their distorting effects upon land markets have diminished with time. If true, then future efforts to reduce net subsidization of agriculture would not be expected to have the catastrophic effect upon land prices, as would have been the case in the 1960s and 1970s."

Based on the conclusions made in the articles and the relationship between rent, the proxy used for income, and government payments, an additional value should not be added to the model for expected government payments. Intuitively, government payments can be considered an additional income source for a farmer. Since all income is considered in the determination of rental rates, it would be redundant to add an additional amount to the stated rental rate for government payments.

The History of Government Payments to Agriculture

Farm bills and programs originated as part of President Roosevelt's New Deal in 1933. The hope was to help producers rebound from The Depression. Since then, the "Farm Bill," as it has been termed, has gone through six major structural modifications. For the purposes of this paper, the Acts in 1996, 2002, 2008 and 2014 will be reviewed.

<u>Federal Agriculture Improvement and Reform Act of 1996</u>

On April 4, 1996, the Federal Agriculture Improvement and Reform Act of 1996 ("1996 Farm Bill") was signed. The major changes the 1996 Farm Bill brought about was the elimination of target prices for income supports, a defined outlay of $35.6 billion to be split among commodities by fixed percentages, basic nonrecourse commodity loans were made available, and the elimination of the requirement to purchase crop insurance to be eligible for farm program payments (lack of purchase of crop insurance did waive the producers' eligibility for emergency crop loss assistance on a crop specific basis). The market loans and specified contract payment level remained as they were before. The removal of target price for income supports was done to give producers more flexibility when it comes to planting decisions. Previously, if more than 15% of a producer's base acreage was planted to other crops or sitting idle, payments would be reduced. With the change, any crop could be planted, and the planting decision became a function of the market place and no longer one of government programs (Young and Shields 1996).

The 1996 Farm Bill also delineated $35.6 billion dollars to replace expected deficiency payments for the years of 1996 to 2002. The money was divided into fixed percentages for crops based on the projected deficiency payments in the Congressional Budget Office's February 1995 budget baseline. The fixed percentages are found in Table 2.1 (Young and Shields 1996).

Another feature of the 1996 Farm Bill was the requirement of the producers to enter into a production flexibility contract (PFC) to receive government assistance in the PFC payment and loan programs. Producers were required to comply with the conservation, wetland, and planting flexibility provisions as well as keep the land in agricultural use to receive payments and loans on program commodities (Young and Shields 1996).

The programs also lowered the upper limit on the amount of money received by a single producer. The bill restricted payments to $40,000 per person. The bill did include a "three entity rule." A producer can receive up $80,000 in contract payments on three separate entities but the producers stake in the second and third entity must not exceed 50% (Young and Shields 1996).

Farm Security and Rural Investment Act of 2002

The Farm Security and Rural Investment Act of 2002 (“2002 Farm Bill”) was established for the 2002 to 2007 marketing years. The 2002 Farm Bill authorized the use of marketing loans, Direct Payments and Counter-Cyclical Payment programs (DCP), managed by the USDA Farm Service Agency (FSA). The 2002 Farm Bill also provided producers the opportunity to re-determine their base acreage. If producers re-determined their base acreage, they were also given the opportunity to update their count-cyclical payment yield but not their Direct Payment yields (Direct and Counter-cyclical Payment Program 2003).

The Direct Payment program replaced the PFC program from the previous farm bill with some changes in the program to remove the connection between Direct Payments and the production process. The payments would support farm income without distorting producers’ production decisions. The Counter-Cyclical Payments, on the other hand, provided support when there was downturn in commodity prices. The Counter-Cyclical Payments are only issued if the effective price (Direct Payment rate plus the larger of either the national average market price or the national loan rate for the commodity) is less than the target price. The payments were determined using either the updated base and Counter-Cyclical yields or the base acres and payment yields established in previous farm bills (Direct and Counter-cyclical Payment Program 2003).

The eligibility requirements of these programs were that the owner, operator, landlord, tenants or sharecroppers must have some risk in the production of the crop on the base acres of a farm enrolled in the DCP program. The producer was also required to report the farm's cropland acres annually. The land itself was required to be in compliance with the cropland and wetland protection requirement and the planting and flexibility requirements. Finally, the acreage must be used for agriculture or a related activity, and the land should be protected from erosion and control for weeds. Table 2.2 shows both the eligible crops and their Direct Payment rates and the target prices for the Counter-Cyclical payments (Direct and Counter-cyclical Payment Program 2003).

<u>Food, Conservation and Energy Act of 2008</u>

The major change that came from the Food, Conservation and Energy Act of 2008 ("2008 Farm Bill") was the additional choice given to producers of the Average Crop Revenue Election (ACRE) program. The 2008 Farm Bill also expanded the eligible commodities for the DCP program. Specifically, the 2008 Farm Bill added dry peas, lentils, small chickpeas (garbanzo bean, desi) and large chickpeas (garbanzo bean, Kabuli) to the list of eligible crops for the Direct and Counter-Cyclical Payment Programs. Table 2.3 states the Direct Payment Rates and the target prices for the Counter-Cyclical payments. Once again, the Counter-Cyclical payment is only paid out if the effective price is less than the target price. The effective price is determined as outline in the 2002 Farm Bill (Direct and Counter-Cyclical Payment (DCP) Program 2008).

The ACRE program was a revenue-based program alternative to the previous price focused payment programs. The eligibility for the program was similar to that of the DCP programs. The ACRE program uses the base acres as specified in previous programs and the payment rate is 80% of the DCP Direct Payment rate. The ACRE program is triggered when revenue is below both a historical state average (the Actual State Revenue is less than the State ACRE Guarantee) and the farm average (the farm's Actual Farm Revenue is less than the Farm ACRE Guarantee) for planted and considered planted acreages (Direct and Counter-Cyclical Payment (DCP) Program 2008).

<u>The Agricultural Act of 2014</u>

The Agricultural Act of 2014 ("2014 Farm Bill") was signed into effect on February 7, 2014. The 2014 Farm Bill repealed the Direct and Counter-Cyclical Program and the Average Crop Revenue Election program. In their place, the Price Loss Coverage (PLC) and the Agricultural Risk Coverage programs (ARC) were put into place. The only eligibility requirements for these programs were that the producers must be "actively engaged" in farming. The 2014 Farm Bill was tasked with defining this requirement. The designation of actively engaged became explicit that the entity "must provide significant contributions to the farming operation. Contributions consist of capital, land, and/or equipment, and active personal labor and/or active personal management. The management contribution must be critical to the profitability of the farming operation and the contributions must be at risk" (Payment Eligibility and Payment Limitations, 2014 Farm Bill Fact Sheet, December 2015) Sunflower seed, rapeseed, canola, safflower, flaxseed, mustard seed, crambe and sesame seed were all added to the list of covered crops. Cotton was removed from the list of eligible crops (What's in the 2014 Farm Bill for Farm Service Agency Customers 2014).

The 2014 Farm Bill allowed producers the choice to maintain the previously determined base acres from 2013 through 2018 or reallocate the base acres. Producers were also offered the opportunity to update their program payment yield for each covered commodity using 90% of the farm's 2008-2012 average yield per planted acre (What's in the 2014 Farm Bill for Farm Service Agency Customers 2014).

The PLC is similar to the Counter-Cyclical payments in that it pays out when the effective price of a commodity is less than a reference price for the specific crop. The ARC payments are determined based off average revenue measures. Producers can elect either the county ARC or individual ARC program. In the case of the county ARC, a producer is issued a payment when the actual county crop revenue is less than the determined ARC county guarantee. The ARC county guarantee is determined using base acres, not planted acres. Payments cannot exceed 10% of the benchmark county revenue. The individual ARC program issues payments when the sum of crop revenue, across all crops, is less than the individual ARC guarantee summed for the covered commodities on the farm. The individual ARC payments also cannot exceed 10% of the individual benchmark revenue (What's in the 2014 Farm Bill for Farm Service Agency Customers 2014).

Producers must have at least 10 base acres or more to be eligible for PLC, and county or individual ARC. Producers with an adjusted gross income greater than $900,000 are also not eligible for any of the programs provided by FSA or the Natural Resources Conservation Service. The 2014 Farm Bill no longer distinguishes this adjusted gross income between farm and non-farm income. Combined payments for

PLC, ARC, marketing loan gains, and loan deficiency payments are not allowed to exceed $125,000 per crop per year (What's in the 2014 Farm Bill for Farm Service Agency Customers 2014).

Real Options

Real option analysis has grown in popularity for situations such as illiquid assets and investment decision-making. Dixit and Pindyck (1994), in their book, Investment Under Uncertainty, describe in detail the advantages of moving away from the net present value (NPV) method of valuing an asset and to the use of a real option approach. NPV modeling assumes a now or never scenario and does not consider the value associated with the arrival of new information or opportunities. Dixit and Pindyck (1994) explain the value of that information is an opportunity cost that should be included in the cost of an investment. Leaving this additional cost out of the analysis leads to overly optimistic decision-making.

Dixit and Pindyck (1994) describe two essential factors that must be present when including the additional value of an opportunity cost to the NPV framework. First, a portion of the investment must be irreversible. In the case of an option, the sunk cost is the initial cost of investment. If no portion of the investment is sunk per se, one could simply uninvest at any time without consequence. Second, the ability to wait or invest in the future must be possible. If the investment opportunity is only available in the present, the option to wait for information has no value.

Du and Hennessy (2008) model Iowa cropland rents by adding the value associated with an Iowan farmer’s ability to change its planting decision after a rent agreement has been made. The rental rate is determined using a maximization of the expected income from planting either corn or soybeans. The rent is determined from the maximization of the NPV valuation calculated as the sum of discounted expected cash flows from either corn and soybean crop production. Under cash rent agreements, the gap from fall to spring proves important for cash renters' valuation of the land. The NPV approach does not consider the tenant's ability to switch from that original expected maximum as more information arrives between the time of the agreement and planting. Their results found that the average cash rent for the real options approach were 11% higher than that of the NPV method.

Moreno et al. (2009) use real option theory to value the return to cropland adding additional value to the flexibility associated with owning land. They consider the valuation from the perspective of a cropland owner whose sunk cost is the initial purchase of the land and who has the option to sell the land at a price in the future or continue to collect revenue from planting crops or renting it out. Moreno et al. (2009) show the option value associated with owning the land accounted for a quarter of the land value determined.

The use of real options in mortgage real estate research has also become substantial. Hendershott and Van Order (1987), Archer and Ling (1993), Kau, Keenan and Muller (1993), and Kau and Keenan (1995) address better valuation techniques of mortgages by including options. Most of the research has expanded to and focused on the use of options to determine probability of default (Kau, Keenan and Kim 1994) and patterns of prepayment (Bartholomew, Berk and Roll 1988, Chinloy 1989, Follian, Scott and Yang 1992, Kau and Springer 1992, Archer and Ling 1993, Deng, Quigley and Van Order 2000).

Research in the area of real options shows promise for use in valuing illiquid assets such as cropland. Du and Hennessy (2012) find positive results in better valuing rental rates and Moreno et al. (2009) show the option value is a significant part of the total value of land. The expansion and use of real options in the literature regarding mortgages, a related asset to cropland, shows research in this area has potential to expand into the current valuation literature. The added benefit of fusing the dynamic framework of real options is the limited number of constraining assumptions placed on parameters. The state variables used in the modeling of the state space are allowed to evolve over time.

Incomplete Markets and "Good-Deal" Bounds

Cropland markets are unique in that their prices are not traded on an exchange and sales are illiquid and infrequent. Assets with these traits are considered to be a part of an incomplete market and suffer from the inability to completely hedge the asset's risk. Overall, there does not exist a portfolio of assets to fully span the asset. Therefore, the asset carries both hedgeable and unhedgeable risk. The presence of unhedgeable risk does not allow for the standard risk neutral valuation method. Methods such as Black-Scholes are not applicable and may yield results that are even opposite of what should occur (Floroiu and Pelsser 2013). As an alternative, the asset can be hedged partially with a portfolio of basis assets. The basis assets are chosen such that they closely mirror the focus asset's payoffs. Once this portfolio is created, the only uncertainty concerning the option value that remains is the pricing of the residual risk.

Cochrane and Saa-Requejo (2000) develop a technique for calculating the option value for an asset in an incomplete market. The method uses a stochastic discount factor in place of defining assumptions to arrive at a market price of risk associated with an asset. Many times, the method for estimating a market price of risk results in output that is sensitive to the defined assumptions. The stochastic discount factor is a random variable that varies across states, both within and across time periods, discounting appropriately to the state. It is chosen using the method of "good-deal bounds" developed by Cochrane and Saa-Requejo (2000). Cochrane (2005) describes the methodology of "good-deal" bounds as "a systematic search of all possible assignments of the market price of risk for the residual to find upper and lower bounds on the option price." Constraints are imposed to create reasonable values for the market price of risk and eliminate arbitrage opportunities. The bounds should be general yet tight enough to provide insight on the asset's value (Cochrane 2005).

Cochrane and Saa-Requejo (2000) impose three constraints that create informative bounds without being unnecessarily restrictive. The first assumption draws from the "Law of One Price" and applies the idea of relative pricing to enforce that the discount factor must price a set of basis values (Cochrane and Saa-Requejo 2000). Information from the basis assets describes the option price (Cochrane and Culp 2003) and ultimately the prices of these assets describe the discount factor and not vice versa.

Second, and equivalent to the absence of arbitrage opportunities, the discount factor must be positive. If a payoff can be non-negative in every state of nature, then the value of the asset must also be non-negative, implying a positive discount factor (Cochrane and Saa-Requejo 2000). This will, in the end, lead to positive bounds on the option prices (Cochrane and Culp 2003). The first and second constraints create "arbitrage bounds" on the value of the asset. The bounds at this point are too large and not useful for analysis. More information is needed about the discount factor to tighten the bounds.

The third constraint draws from absolute pricing theory to restrict the volatility of the stochastic discount factor. The constraint is equivalent to an upper limit on the Sharpe Ratio of mean excess return. The idea behind this constraint is that an investor will buy any asset with an exceptionally large Sharpe ratio, therefore; the situation is unlikely to persist in the market. The quick resolution of these scenarios leads them to be ruled out as potential pricing of an asset (Cochrane and Culp 2003). This constraint is an easy way to eliminate unreasonable discount factors within the arbitrage bounds, leaving non-volatile discount factors.

The addition of the third constraint yields the "good-deal" bounds, which enforce the assumptions that investors will buy any asset with a high Sharpe ratio and pure arbitrage opportunities. As the correlation between the basis asset and the traded asset increase, the bounds will tighten. In general, small or tight bounds imply good approximations for the replication of the underlying asset and large bounds indicate that the replication is likely a poor approximation (Cochrane and Saa-Requejo 2000).

Methodology

The model developed here can be broken down into two components, each addressing the two major issues noted from previous literature—the assumption of a complete market structure for land markets and the restrictive nature of previous models. First, by implementing a relative pricing approach developed by Cochrane and Saa-Requejo (2000), the model accepts the incomplete market structure that define cropland markets. The approach solves for stochastic discount factors that avoid the necessity of choosing or exogenously determining a discount factor. The method solves the single period problem of valuing the income to land. The proxy for land used here is statewide averages of cropland rental rates. The incomplete market structure measures the price of rent with the understanding that the values carry both hedgeable and unhedgeable risks. The hedgeable risk is the price of the predominant crop produced in each state. The residual from this formulation is the unhedgeable portion of the risk.

The second component of the modeling process is employing the relative pricing approach in a dynamic optimization framework. Structuring the model in this way minimizes the number of strict or unrealistic assumptions that would otherwise be placed on the parameters of the model. A two-dimensional tree is developed to capture the movements in rent as the underlying state variables are allowed to fluctuate over varying states of the world for a certain period of time. The model uses real-world probability measures to define movements to each value in the state space. At a designated final time period, a terminal value is estimated. The initial cropland value is then determined considering the value at the terminal time step plus the income received at each node and a value associated with an intrinsic utility of owning the land itself.

Calculating the Income and Contract Values

The first component of the model addresses the rent contract value given that the asset is in an incomplete market. The ultimate value of the land is calculated as the sum of the income that arises from the production on the land and the utility associated with the ownership of the land. The income is represented by an annual rent payment paid to the landowner. The rent is modeled as a function of hedgeable risk, the long-run commodity price and unhedgeable risk, the residual of the estimation equation:

$$Rent_t = \beta_0 + \beta_1 F_{c,t} + \epsilon_t \tag{1}$$

Rent at time t is determined by the current expected crop price and the current value of the unhedgeable risk. The coefficients of the model are determined by the regression estimation process using the long-run crop prices.

The relative pricing approach of Cochrane and Saa-Requejo (2000) uses the rent determined in equation (1) to value cropland considering it is in an incomplete market. "The good-deal bound finds the minimum and maximum value of the [payoff] by searching over all positive discount factors that price the basis assets and have limited volatility" (Cochrane 2005). The good-deal bound method avoids defining strict and unrealistic discount factors that are used in the literature. The discount factor is no longer assumed a constant nor is it exogenously determined by methods such as the capital asset pricing model. The model is identified broadly as:

$$\bar{V} = \max_{\{m\}} E[mx^c] \quad (2)$$

$$s.t. \quad p = E[mx],$$

$$E[m^2] \leq A^2,$$

$$m \geq 0$$

$$where \quad A^2 \equiv \frac{(1 + h^2)}{R_f^2}$$

The h term refers to the market Sharpe ratio that is assumed to be 1.0 (Cochrane and Saa-Requejo 2000). The Sharpe ratio describes the amount of compensation needed by an investor given the risk of taking on the investment of an asset. R_f refers to the risk-free interest rate. Model output is assessed at varying magnitudes of the risk-free rate. The model output values are not sensitive to changes in the variable; therefore, it is set at 1%.

More specifically, the estimation of the good-deal bounds can be described by minimizing or maximizing the following objective function under the four constraints outlined above.

$$\min_{\{m_i\}} \underline{G_0} = \sum_i \pi_i m_i G_{t=1,i} \quad (3)$$

$$s.t. \begin{cases} m_i \geq \ 0 \ \forall_i & (4) \\ \sum_i \pi_i m_i F_{t=1,i} - F_0 = 0 & (5) \\ \sum_i \pi_i m_i - \frac{1}{R_f} = 0 & (6) \\ A^2 - \sum_i \pi_i m_i^2 \geq 0 & (7) \end{cases}$$

$G_{t,i}$ is the contract price at time t and state in i; π_i is the objective probability of state i; m_i is the stochastic discount factor; and $F_0$is the traded asset price.

The objective function states that the contract value should equal the sum of the expected discounted payoffs in future states. Depending on the bound being estimated, the objective function is either minimized or maximized. The first constraint of the model is a "no-arbitrage" constraint merely stating the discount factor must be greater than one. The second constraint is a relative pricing assumption that states the model will take the traded asset, the long-run commodity price, as given to learn about the basis asset, the rent contract in this case. The third and fourth constraints are volatility constraints where first, unrealistic discount factors are eliminated and second, there is an upper bound or limit placed on the Sharpe Ratio. The upper limit on the Sharpe Ratio is an assumption that assets with overly large Sharpe Ratios are likely not to persist in the market and therefore, can be eliminated. These additional constraints tighten the bounds and make them useful for analysis.

To solve for the stochastic discount function, a Jacobian vector is calculated. The vector allows for element-wise multiplication of the probability of moving to a state with the contract value at time t and state i.

$$\frac{\partial G_0}{\partial m_i} = \pi_i G_{t=1,i} \tag{8}$$

$$Jacobian\ Vector = \begin{bmatrix} \pi_1 G_1 \\ \pi_2 G_2 \\ \vdots \\ \pi_n G_n \end{bmatrix} \tag{9}$$

$$Jacobian\ Constraints: \begin{cases} \dfrac{\partial E5}{\partial m_i} = \pi_i F_{t=1,i} \\ \dfrac{\partial E6}{\partial m_i} = \pi_i \\ \dfrac{\partial E7}{\partial m_i} = 2\pi_i m_i \end{cases} \tag{10}$$

where *E5*, *E6,* and *E7* reference equations 5, 6 and 7.

Estimation of the Rent Function

To model rent, the long-run expected price of the new crop price is regressed on rent. Intuitively, it can be expected that previous rental rates likely have an effect or are correlated with current or future rent. As a result, when tested, the models exhibit substantial autocorrelation that is defined as the correlation of a variable with itself over time. Essentially, there is a systematic relationship between the residuals of the regression and time, i.e. the value of an error in one period has an effect on the value of an error in a future time. In this case, it is that rent is "sticky".

In time-series analysis, ordinary least squares (OLS) disturbances are ideally independent across time periods. The resulting parameters of an OLS estimation with the presence of autocorrelation are unbiased (as long as the explanatory variables are strictly exogenous) or consistent but they are not efficient. The OLS standard errors and test statistics are therefore no longer valid, even asymptotically, and cannot be used for testing purposes (Wooldridge 2015). Commonly, the correlation between the variables and the error terms are positive which cause the variance associated with each independent variable to under-state the actual variance of the estimator. The downward biased variance of the coefficients leads to larger t-statistics and the overstatement of the statistical significance of the variables (Wooldridge 2015). If the data are stationary and weakly dependent, the goodness-of-fit measures such as R-squared and adjusted R-squared, are still valid (Wooldridge 2015).

The following equation shows the correlated relationship between the error terms. The numerator is the covariance relationship between the residual at time t and the residual at time t-s. The denominator of the equation is the standard error of the residuals.

$$Corr(\epsilon_t, \epsilon_{t-s}) = \frac{Cov(\epsilon_t, \epsilon_{t-s})}{\sqrt{Var(\epsilon_t)} * \sqrt{Var(\epsilon_{t-s})}} \tag{11}$$

The Breusch-Godfrey (BG) test for autocorrelation on the regression of rent as a function of the new crop futures' settlement price is used for its ability to generalize to any order of autocorrelation. The more commonly used test, the Durbin-Watson, is restricted to testing only the presence of a first-order autoregressive disturbance or an AR (1) processes where 1 is the order of autocorrelation. The BG test is a Lagrange multiplier test. Using the residuals from the OLS estimation of the original equation, the BG test regresses lagged residuals up to lag q and the original independent variables on the residuals in time t.

$$\epsilon_t = \rho_1 \epsilon_{t-1} + \cdots + \rho_q \epsilon_{t-q} + \beta_1 x_t + u_t \tag{12}$$

The joint test is of the first q autocorrelations of the residual. The null hypothesis is that there is no autocorrelation present and the ρ coefficients equal zero. The alternative hypothesis is that there is an AR(q) process present. Since the BG test uses a joint test of significance, determining the important number of lags to test can be difficult. This test is also only valid asymptotically.

The BG test shows that the null hypothesis of no presence of autocorrelation is rejected at the 1% level (p-value = 0.0). The series is determined an AR (1) process where 1 is the order of autocorrelation. The AR (1) function is presented as follows:

$$\epsilon_t = \rho\epsilon_{t-1} + u_t \tag{13}$$

where ρ ranges from negative one to positive one. The u_t term, by substitution, captures all historical values of the ϵ series with more weight given to terms in the recent past. The following are assumed of the error of the regression:

$$E[u_t] = 0 \tag{14}$$

$$E[u_t u_t'] = \sigma_u^2 I \tag{15}$$

$$cov(u_t, u_s) = 0, \text{where t} \neq \text{s} \tag{16}$$

The first property indicates consistency in the series, the second states the variance of the residual is constant over time hence the lack of a t subscript, and third, that the residuals are not correlated over time i.e. the disturbances are independently and identically distributed. Under these assumptions, ρ can be estimated using OLS.

Estimating the Coefficients in the Presence of Autocorrelation

For the estimation of the rent regression, a maximum likelihood estimation process presented in Greene (2000) is implemented to account for the presence of serial correlation. Specifically, we are interested in estimating the following coefficients:

$$Rent = \beta_0 + \beta_1 F_{c,t} + \epsilon_t \tag{17}$$

$$\epsilon_t = \rho_0 + \rho_1 \epsilon_{t-1} + \mu_t \tag{18}$$

From the OLS assumptions, ϵ_t has a mean of zero; therefore, it will be assumed that ρ_0 will equal zero. β_0, β_1 and ρ_1 remain to estimate. A maximum likelihood (ML) estimation process is used. The coefficients are solved for by maximizing the following log-likelihood function with respect to β, σ_ϵ^2, and ρ:

$$lnL = -\frac{\sum_{t=1}^{T} u_t^2}{2\sigma_u^2} + \frac{1}{2}\ln(1-\rho^2) - \frac{T}{2} ln\sigma_u^2 \tag{19}$$

where the coefficients are maximized as follows:

$$\frac{\partial lnL}{\partial \beta_i} = \frac{1}{\sigma_u^2} \sum_{t=1}^{T} u_t F_{*c,t} \tag{20}$$

$$u_1 = \sqrt{1-\rho^2}(Rent_1 - F_{c,t_1}{}' \beta_i) \tag{21}$$

$$\begin{gathered} u_t = (Rent_t - \rho Rent_{t-1} - \left(F_{c,t} - \rho F_{c,t-1}\right)' \beta_i \\ for\ t = 2, \dots, T \end{gathered} \tag{22}$$

$$F_{*c,1} = \sqrt{1-\rho^2} F_{c,1}\ and\ \ F_{*c,t} = (F_{c,t} - \rho F_{c,t-1}) \tag{23}$$

$$\frac{\partial lnL}{\partial \sigma_u^2} = -\frac{T}{2\sigma_u^2} + \frac{1}{2\ \sigma_u^4} \sum_{t=1}^{T} u_t^2 \tag{24}$$

$$\frac{\partial lnL}{\partial \rho} = \frac{1}{\sigma_u^2} \sum_{t=2}^{T} u_t \epsilon_{t-1} + \frac{\rho \epsilon_1^2}{\sigma_u^2} - \frac{\rho}{1-\rho^2} \tag{25}$$

where $\epsilon_t = Rent_t - F_{c,t}' \beta$.

The epsilon value evolves according to a mean-reverting stochastic process. It can be described by the following structure:

$$\Delta\epsilon_t = \kappa\bar{\epsilon} - \kappa\epsilon_{t-1} + \mu_t \tag{26}$$

where κ is the rate of long-run mean reversion and $\bar{\epsilon}$ is the mean of epsilon. $\bar{\epsilon}$ minus ϵ in the previous time period is a measure of the deviation from the long-run mean or the magnitude of deviation. The process is fitted imposing the prior knowledge that the long-run expected value of the error, $\bar{\epsilon}$, is zero. Forcing $\bar{\epsilon}$ to zero fits the regression with no constant.

The specification of the epsilon equation is determined using:

$$\epsilon_t = \rho\epsilon_{t-1} + u_t \tag{27}$$

which can be re-written as

$$\epsilon_t - \epsilon_{t-1} = (\rho - 1)\epsilon_{t-1} + u_t. \tag{28}$$

$$\Delta\epsilon_t = \kappa(\bar{\epsilon} - \epsilon_t)\Delta t + \sigma\epsilon\sqrt{\Delta t} \tag{29}$$

As stated before, by assumption, ϵ has a long-run mean of zero; therefore, $\bar{\epsilon}$ equals zero and the equation becomes:

$$\Delta\epsilon_t = -\kappa\epsilon_t + \sigma\epsilon\sqrt{\Delta t} \tag{30}$$

Using the estimation results from above, the rate of mean reversion is calculated as:

$$-\kappa = \rho - 1 \tag{31}$$

$$k = 1 - \rho \tag{32}$$

To recover the goodness-of-fit for each equation, the r-squared values can be calculated using transformed variables given the recovered rhos from the maximum likelihood output. Essentially the transformed regression is as follows:

$$\tilde{y} = \tilde{\beta}\tilde{x} + u_t \tag{33}$$

$$\text{where } \tilde{y} = y_t - \rho\, y_{t-1} \tag{34}$$

$$\text{and } \tilde{x} = x_t - \rho x_{t-1} \tag{35}$$

Creating the State Space—Magnitude and Probability Changes, Reserve Rent & Terminal Value

The second component of the model uses the estimation of the contract prices and applies them to a dynamic optimization problem. The contract price represents the rent and income associated from rent payments. The state variables that create the tree include the hedgeable risk, the long-run crop price, and the unhedgeable risk, the epsilon. The different stochastic processes present in each variable, determine both the magnitude of change and the probability of moving to the next node. Each state variable can move in two directions—up or down— creating a tree with four possible evolutions at each node: $\{(\boldsymbol{F_t^+}, \boldsymbol{\epsilon_t^+}), (\boldsymbol{F_t^+}, \boldsymbol{\epsilon_t^-}), (\boldsymbol{F_t^-}, \boldsymbol{\epsilon_t^-}), (\boldsymbol{F_t^-}, \boldsymbol{\epsilon_t^-})\}$. The "+" represented an upward movement and the "-" represents a downward movement in the tree. Associated with each of these movements, is an objective probability calculated from the product of the individual probabilities for each variable. Figure 2.1 provides a two-step example of how the variables can evolve. The variables evolve on a monthly basis and pay out a rental rate at the end of each year. Therefore the "$\boldsymbol{\Delta t}$" in this case is one twelfth.

<u>Magnitude Changes for the Crop Price</u>

The long-run price used in the model is the settlement price on a futures contract. The futures price follows a simple Brownian motion (Hull 2006). As explained in Black (1976), because of the mark-to-market nature of futures contracts, the drift associated with the contract should be zero. Therefore; the drift is set equal to zero in the stochastic formulation. The futures contract is considered in its logarithmic transformation as:

$$dlnF = \sigma_F dz \tag{36}$$

The changes throughout the tree for the settlement prices of the futures prices move multiplicatively as follows:

$$F_{c,t+1}^{+} = F_{c,t} * e^{\sigma_{F_c}\sqrt{\Delta t}} \tag{37}$$

$$F_{c,t+1}^{-} = F_{c,t} * e^{-\sigma_{F_c}\sqrt{\Delta t}} \tag{38}$$

where $F_{c,t+1}^{+}$ is the upward magnitude movement and $F_{c,t+1}^{-}$is the downward movement. $F_{c,t}$ is the current price of the variable or contract in the current time step, σ_{F_c} is the standard deviation of the contract price, and Δt is the size of the time step.

<u>Magnitude Changes for Epsilon</u>

The evolution of ϵ is determined using Hahn and Dyers's 2008 paper, "Discrete Time Modeling of Mean Reverting Stochastic Processes for Real Option Valuation." In the case of the mean-reverting stochastic process, the movements are additive and reflect the local variance.

$$\epsilon_{t+1}^{+} = \epsilon_t + \sqrt{\Delta t}\,\sigma_\epsilon \tag{39}$$

$$\epsilon_{t+1}^{-} = \epsilon_t - \sqrt{\Delta t}\,\sigma_\epsilon \tag{40}$$

ϵ_{t+1}^{+} and ϵ_{t+1}^{-} are the upward and downward movements in epsilon, respectively. ϵ_t represents the current value of the epsilon, $\sqrt{\Delta t}$ is the square root of the size of the time step, and σ the standard deviation of ϵ.

Development of the Probabilities Associated with the Movements Throughout the Tree

The final probability of moving up or down to a specific state is determined by the product of the individual variable's probabilities of that up or down movement. The orthogonal nature of the OLS regression's independent variable with its error term allows for an objective probability of the ϵ and the crop contract price to be calculated as the simple product of the two individual probabilities.

$$Objective\ Probability_{t+1}^{i,i} = \Pi\left[Prob\left(F_{c,t+1}^{i}\right), Prob\left(\epsilon_{t+1}^{i}\right)\right] \tag{41}$$

The i subscript signifies the up or down movements that must be calculated. In each step, four probabilities are calculated for the combined up and down movements of the futures contract and epsilon value.

The probability associated with the movement of a futures contract is a random walk (Black 1976) therefore equal weight will be assigned to both the up and down movement. On the other hand, the probability of the mean-reverting stochastic process of the ϵ is conditional on the current state and time, and censors the probability calculation between 0 and 1. Conditioning the probabilities this way provides dependence on the state of the ϵ at that time and takes into account the local drift. This probability structure developed by Hahn and Dyer (2008) is as follows:

$$Prob(\epsilon_t) = \begin{cases} \frac{1}{2} + \sqrt{\Delta t}\,\frac{v(\epsilon,t)}{2\sigma} & if\ 0 \leq \frac{1}{2} + \sqrt{\Delta t}\,\frac{v(\epsilon,t)}{2\sigma} \leq 1 \\ 0 & if\ \frac{1}{2} + \sqrt{\Delta t}\,\frac{v(\epsilon,t)}{2\sigma} \leq 0 \\ 1 & if\ 1 \leq \frac{1}{2} + \sqrt{\Delta t}\,\frac{v(\epsilon,t)}{2\sigma} \end{cases} \tag{42}$$

$$\text{where } v(\epsilon, t) = \kappa(\bar{\epsilon} - \epsilon_t) - \frac{1}{2}\sigma^2 \tag{43}$$

The parameters of the probability estimation include Δt, the time step; σ, the annualized volatility of the epsilon; κ, the annualized mean reversion factor estimated from the maximum likelihood estimation of the AR (1) process; $\bar{\epsilon}$, the mean value of epsilon which in this case is zero; and ϵ_t, the current observation of epsilon. This formulation can be simplified to the following specification:

$$prob(\epsilon_t) = \max(0, \min\left(1, \left(\frac{1}{2} + \sqrt{\Delta t}\ \frac{v(Y,t)}{2\sigma}\right)\right)) \tag{44}$$

Reserve Rent

The model pays out a rental rate once a year. Since the model can evolve both positively and negatively, there is a possibility that the model could return a negative rental rate. Intuitively, cropland is unlikely to reach a negative value or even a value substantially smaller than the previous years' value due to the availability of alternative uses for the land other than crop production. Therefore, a reserve rent is invoked if the rental rate moves lower than the reserve rate value. Based on historical decreases in rental rates, the reserve rent is calculated as 20% of the most recent historical rent observation.

Terminal Value

The problem assumes ownership will continue indefinitely; therefore, the model is an infinite horizon problem. A finite solution to an infinite horizon problem is to apply a terminal value function at the end of the specified valuation period. The terminal value used in this case is a perpetuity of the final rent paid in time T capitalized by a capitalization rate.

$$V_T = \frac{\left[\beta_0 + \beta_1 F_{c,T} + \epsilon_T\right]}{Cap\ Rate} \tag{45}$$

States tested and forecast evaluations

Following estimation, three forecast evaluations measure the success of the model output in predicting market prices. The goal of each of these measures is to minimize the values. As a point of reference, the capitalized value of land is also estimated and the outcome of the forecast evaluations are compared. The three measures used are root mean squared error (RMSE), mean absolute percent error (MAPE) and mean error (ME). The evaluation metrics are calculated as follows:

$$RMSE = \left[\frac{1}{M}\sum_{t=1}^{M}(F_t - A_t)^2\right]^{\frac{1}{2}} \tag{46}$$

$$MAPE = \frac{1}{M}\sum_{t=1}^{M}\left|\frac{F_t - A_t}{A_t}\right| * 100 \tag{47}$$

$$ME = \frac{1}{M}\sum_{t=1}^{M}(F_t - A_t) \tag{48}$$

M is the number of periods included in the forecast; F_t is the forecasted value and A_t is the actual value. Each of these measures provides a different intuition on how well the forecasted values performed. The RMSE evaluates the average unit amount the forecast is off over the forecast period. The MAPE measures the average percentage error of the out-of-sample forecast from the actual observation. The RMSE and MAPE values are good in providing average values of how much the forecasts are off in terms of magnitude. The ME provides a picture of whether the forecasts are consistently under or over forecasting the cropland prices and on average, by how much.

Data

Historical data on land and rent prices are available through two USDA NASS publications. Data from 1967 to 1994 is obtained from the NASS publication, "Agricultural Land Values Survey (ALVS)." More recent data, 1994 to 2016, is obtained from the NASS Quick Stat platform and designated as historical "ag land, cropland." The USDA receives the data from state extension offices. Both the cropland prices and rent are statewide averages.

Cash rent agreements and land prices in general, vary across states and regions. As shown by Robinson, Lins and VenKatarman in "Cash Rent and Land Value in U.S. Agriculture," studies of rent and land must take place on a state or region-wide basis as there are significant differences across local land markets and even due to local non-agricultural demand for land. Rent is the payment of a non-owner operator to a landowner in exchange for the use of that owner's land for production.

There are two primary lease agreements for cropland rent—cash and share. Cash rent is a pre-specified cash payment paid to the landlord. The tenant assumes all risk and return associated with the production of the land. Cash rent is typically agreed upon prior to, and remains constant over the growing season. A share rent agreement, is an arrangement between the tenant and landowner where both parties share a portion of the risk and return of production. Contracts can vary but the landowner, to some extent, pays for a portion of production expenses and receives a portion of production revenue. Share rent agreements inherently consider a premium needed to assume a portion of risk.

Rent agreements can also vary in terms of specified periods. Cash rent agreements and land prices in general, vary across states and regions. The model is applied to 24 states. Figure 2.2 shows a map of the states the model is applied to and the crop used to represent each state.

For the purpose of representing the information available to landowners and renters at the time of negotiation, the settlement price of the new crop futures price is used as a proxy for the intended income to the land. Assuming negotiations for rental rates takes place post-harvest and pre-planting, it is expected that negotiations and information collecting will take place in the late fall to winter. Du and Hennessy (2008) provide intuition, "When making planting decisions, farmers observe and use price information for the futures contracts expiring right after harvest time to formulate harvest price expectations. When deciding what can be paid for rented land, farmers will use futures prices to establish what they may plant, how intensively they will farm, and the values of what they will reap. On the Chicago Board of Trade (CBOT), the December contract for corn and the November contract for soybeans are the first available futures contracts after harvest time." Taking this into consideration the new crop futures contract on the upcoming year's crop is used as an indication of producers' sentiment or expectations for the coming year's prices. The daily settlement price is averaged for the trading days in the month of either October, November or December one year prior to the estimation date of interest depending on data available. For example, if the goal is to estimate the value of the rent contract in 2018 for the state of Iowa, the average settlement prices for observations in December of 2017 for the December 2018 futures contract on corn would be consulted as what producers expect corn prices to be as they were negotiating their contracts. Four contracts were used depending on the state of interest—December corn, November soybean, September Chicago Wheat and July Kansas City Wheat. Corn and soybean contracts are exchanged on the Chicago Board of Trade. The Chicago Wheat and Kansas City Wheat contracts are traded on the Chicago Mercantile Exchange. Data available for each of these contracts ranged from 1963 to 2016 from the Quandl database. A summary of the data is presented in Table 2.4. The crop used for each state is chosen depending on the crop that produces the largest amount of gross receipts per state. The USDA ERS provides the information for determining this crop ranking on a state-by-state basis.

All price and interest rate data are deflated using the same method implemented by the USDA NASS service. The deflator is a GDP chain-type price index published by FRED. All data is deflated to comparable 2009 levels.

Results

A rolling forecast is used in estimating cropland prices for each state and year. A rolling forecast implements the model for each state in every time period, consecutively updating the available information as the model progresses through the time periods. A total of 456 iterations are performed given the 24 states and 20 time periods from 1997 to 2016. The output from the maximum likelihood estimations is, in general, consistent over the iterations run for each state and time period and the output of the parameters are as expected. The maximum likelihood estimations, on average explained 81% of the variation in rent. Table 2.8 outlines recovered R^2 for each state. The minimum R^2 is 12.9% for the state of Maryland where the crop price used in that state, corn, represents 9.9% of the cash receipts for the agricultural products grown in the state. Maryland receives most of its agricultural income from broiler production, which represents 42% of cash receipts. Due to the smaller representation of the income in the state, it is understandable that the fit is much smaller for rent on a statewide basis. On the other hand, the state of Iowa has a model fit of 95.8%. Corn prices are highly representative of the state's income generation with 31.7% of the state's cash receipts in 2016 coming from corn production, and soybeans representing 20% of cash receipts.

The tree specification also produced results consistent with expectations. The mean reversion characteristic of the epsilon, or the non-hedgeable risk factor, should yield probabilities that converge to zero as the value moves further away from the variable's mean, zero, whether moving in a positive or negative direction. As the epsilon value gets larger, the probability of an upward movement converges to zero, and as epsilon gets smaller, the probability of moving to a more negative state also converges to zero. The rate of mean reversion averages about 0.35.

After running several iterations of the models with varying time horizons, the model output converges in year seven. Therefore, the models are run with a terminal time horizon of seven years at which time the terminal value calculation is executed.

The rho values represent the relationship between the residuals and lagged values of itself. The rho values, as noted, can range from negative one to positive one. In this case, it is expected that the values will be near positive one. The output yields rho values ranging from 0.54 to 0.99 with average being about 0.82. The recovered rho's can be found in Table 2.8 in the appendix.

The model output is measured for forecast accuracy using RMSE, MAPE and ME. As a point of comparison, these measures are compared to forecast output of a capitalized valuation forecast. The capitalized value—the income or rent, discounted by a capitalization rate—is used as a basis of comparison because of its simplicity as well as for how common it is referenced in literature and its use as a reference point for those in the industry looking at the value of land.

On average, the model output has a MAPE of 68.9%. This can be interpreted that the model is off, on average, 68.9% of the time. In comparison, using a capitalized value for each forecast yields a MAPE of 36.2%. Additionally, the average RMSE for the model is about 2,257.20 whereas the RMSE for the capitalized value forecasts average about 1,175.27. The ME also shows that the model output for each state on average, underestimates the market price. In every iteration, the model output is substantially less than the observed market price. The capitalized value both over and underestimates the market price, with over half of the forecasts being underestimated. On average, the model output has a ME of -2,105.25. The capitalized value has an ME of -664.59. The large magnitude of the model ME shows the substantial underestimation of the forecasts.

In general, the simple capitalized value forecast does a better job of estimating market cropland prices using current rent and an assumed capitalization rate. Table 2.9

presents the RMSE, MAPE and ME measurements on a state-by-state basis for both the model output values as well as the capitalized values. Model output for Nebraska, North Dakota and South Dakota are the only states that outperform the capitalized valuation in terms of their MAPE. In six cases, the model produces a MAPE of less than 60%; Arkansas, Kansas, Minnesota, Nebraska, North Dakota and South Dakota. North Dakota performs the best with a MAPE of 49.1%. Maryland performs the poorest, as expected with the lowest model fit, with a MAPE of 91.2%. Figure 2.3 through Figure 2.26 graph the model output values on a state-by-state basis from 1997 through 2016 with the actual and capitalized values overlaid for comparison.

Model Implications and Further Research

The model output performs, on average poorly and overall worse the calculated capitalized value of the cropland. In every case, the model heavily underestimates market prices implying there is some margin of price not taken into consideration by the model. There are several potential causes of this significant discrepancy, some which have been debated in previous literature. Commonly noted and discussed is the substantial amount of value placed on non-quantifiable attributes of the land. Therefore, despite the income generation to the land, additional value is added for several other factors. Qualities that have been cited before are locational benefits (contiguous land to currently owned land, proximity to city centers, proximity to water) and even things such as emotional ties to the land (the desire to hold land owned by family and the desire to pass land on to future generations). Essentially, there are several factors that may add value to the price of land that is not logically tied to the income produced from the land.

Therefore, even taking into consideration the incomplete structure of the asset, the model cannot fully capture the above pricing attributes.

These non-quantifiable risks would also not be present in the capitalized values. Therefore, there still remains a certain margin that is unexplained by this reasoning. Another commonly debated feature of cropland valuation models is the proxy used to represent the income to the cropland. It is possible that rent is not the best representation of the income from the land. Although rent is not a perfect representation and concerns of its use are valid, previous research (Melichar (1979) and Vantreese, Skees and Reed (1986)) has concluded that rent is the best proxy available to represent income to agricultural land. Rent is directly correlated to the income strictly from the land. Other income choices such as net farm income consider other sources of income than solely income from the farming operations.

A second issue with the use of rent is its relationship with land prices. The transmission of income to rent to land may not be one-to-one. Rent contracts have proven to be “sticky” with the presence of autocorrelation. The model here assumes a one year correlation of rent with itself. Other research includes a single lag and lags as far back as eight years of lags in the modeling of rent (Burt (1986) and Ibendahl and Griffin (2013)). There are several possible sources of this stickiness. Rent contracts can be set for three to five years and depending on the knowledge of the landowner may not be set as competitively priced as possible. Ibendahl and Griffin (2013) point out that the renter has the greatest amount of knowledge about the farming operations and may choose to share that information with the landowner sparingly depending on how agricultural markets are performing. The alternative theory for the asymmetric price relationship is that the landowner has more power in setting the rental rates and is unlikely to decrease prices on they are set. The asymmetry present in the transmission of rental rates to land prices may not be best represented by the maximum likelihood estimation. Alternative methods used in some of the asymmetric price transmission literature may be better equipped to directly estimate that asymmetric relationship.

The model output also indicates that, depending on the state, there is a wide variation in the percent of risk that is actually hedgeable. Cochrane and Saa-Requejo (2000) note that as the correlation between the asset of interest and the traded asset increases, the good-deal bounds become tighter. Specifically, the percent of hedgeability available can be identified in the variation of R^2 values that arise from the maximum likelihood estimations. "The size of the bounds is directly related to the size of the residual, or the R^2 in a regression of option payoffs on basis asset payoffs (Cochrane and Saa-Requejo 2000)." Intuitively, the R^2 of the regression represents the amount of variation in rent that can be explained or hedged by the traded asset, the crop price futures contract. As noted, the percent of hedgeability ranged from 95.8%, in Iowa to 12.9% in Maryland. Five states have an R^2 less than 65% and the remaining above 70% fit, with 75% of the R^2 being above 80%. Overall, the model fit is relatively good.

Given the level of ability to hedge the risk associated with the income to the land, these results question the reality of the use of real options to understand market prices for some assets in the presence of unhedgeable risk. Although a portion of the asset can be hedged using the income generation of the land, it may be likely that individuals do not actually think about that relationship or available hedging opportunity in actual pricing settings. Therefore, as the asset is priced, a margin is added for the additional risk that is hedged away in this model. The critique of the reality of the use of real options in market pricing is something that has not been discussed in real options literature in much detail. There is a lot of potential for expansion of research into the question of how realistic is the assumption that individuals think in terms of real options when pricing assets.

CHAPTER III

READDRESSING STICKY RENTS: EXPLORING THE POSSIBILITY OF AN ASYMMETRIC PRICE TRANSMISSION RELATIONSHIP

Rent has commonly been described as "sticky" in the literature on cropland prices. For example, Ibendahl and Griffin (2013) show that their lagged rent model performs well when land prices are increasing but not when prices are decreasing. Their output suggests a negative asymmetric relationship between rent and land prices.

While Ibendahl and Griffin (2013) and other literature on cropland prices has offered observations or anecdotal evidence of asymmetry in rent and land prices, the relationship has not been empirically tested.

There are two competing arguments for the presence of asymmetry in rental rates. Rent may be positively asymmetric indicating prices increase more rapidly than they decrease. The argument implies that the landowner has a greater power in setting the rental rate and is reluctant to decrease prices once they are set.

The opposing argument is that there exists asymmetric information shared between the landowner and the operator. The operator has the most information about the profitability of production and chooses to share that information selectively. The operator will share information with the landowner when it is beneficial to them and therefore will likely do so when production is becoming less profitable. The asymmetric information between parties causes a negatively asymmetric relationship between input prices and rental rates. Prices are more likely to decrease rapidly in response to a decrease in profitable and less likely to increase as production becomes more profitable.

Previous asymmetric price transmission models have focused on the relationship between input costs and output prices. In the following analysis, an error correction model is used to empirically test the existence of asymmetric responses in rental rates to changes in the revenue or long-term crop prices.

Literature Review

Asymmetric price transmission is the study of how the price of an asset may increase or decrease at different rates in response to positive or negative input price changes. Largely, the research has focused on how input costs may affect the output price of a good. The literature has also predominantly focused on positive asymmetry where output prices respond more so to cost increases than cost decreases.

The literature is divided between the theoretical description of the causes of asymmetry and the empirical tests of showing the existence of asymmetry in a market or asset price. The theoretical causes of asymmetry have largely been attributed to non-competitive markets and the existence of adjustment costs. Government intervention, inventory management and asymmetric information describe the other, less common stated theoretical causes of asymmetric price transmission. Recently, the literature has focused on empirically testing the existence of asymmetry.

Additionally, the topics covered in the asymmetric pricing literature have been vast. A significant focus has been on agriculture. There have been studies on the beef industry (Bailey and Brorsen 1989 and Goodwin and Holt 1999), pork industry (Miller and Hayenga 2001), fresh vegetable supply chain (Ward 1982), dairy (Kinnucan and Forker 1987) and the food industry in general (Gardner 1975 and Azzam 1999). Other authors have tried to more broadly test for asymmetries in consumer sectors looking at broad indexes that define sectors at various times along their supply chain (Peltzman 2000). Another significant area of focus has been in the energy sector, specifically between the transmission of oil prices into gasoline prices (Borenstein, Cameron and Gilbert 1997; Balke, Brown and Yucel 1998; Bachmeier and Griffin 2003; Chen, Finney and Lai 2005; Radchenko 2005; Adeyemi and Hunt 2007).

Theoretical Explanations

The two main theoretical arguments for causes of price asymmetry will be reviewed. The arguments are non-competitive market power and the cost associated with adjusting prices. Other less common explanations have been used—political intervention (Kinnucan and Forker 1987), asymmetric information sharing and price reporting (Bailey and Brorsen 1989), and inventory management in general and specific to FIFO management and non-negative inventory constraints (Balke, Brown and Yucel (1998), Blinder (1982), Reagan and Weitzman (1982)). These arguments will not be covered in extended detail but are still interesting to mention.

Market power has been the most commonly cited explanation for asymmetry in agriculture markets. Non-competitive markets for processors and retailers in agriculture take the blame for distorting price movements from the farmer to the consumer (Kinnucan and Forker 1987; Miller and Hayenga 2001). Many refer to oligolopolist structures that punish non-collusive behavior (Ward 1982; Balke, Brown and Yucel

1998). Ward (1982) believes the oligopolist structure causes output prices to respond more quickly to price decreases, also known as negative asymmetry. Firms want to avoid losing market share so are hesitant to increase prices. Balke, Brown and Yucel (1998) believe the opposite will occur in a oligopolist market structure. Firms maintain the collusive arrangement by increasing prices accordingly to changes in input costs but are hesitant to reduce prices and signal they are compromising the collusive agreement. Damania and Yang (1998) also emphasize the importance of a potential punishment in an oligopoly or competitive duopoly setting. When there exists a threat of punishment firms are likely to increase prices when demand is high but are reluctant to increase prices when demand is low. Many others have argued similar scenarios but few have tried to test empirically due to the difficulty in defining market power. For example, Peltzman's (2000) empirical results contradict one another. He finds that fewer firms create more asymmetry but high market concentration yields less asymmetry.

Menu costs, or the cost associated with adjusting prices, dominates as another common cause of assymetry. The application of the theory of menu costs varies in the application and results are contradictory, overall. Bailey and Brorsen (1989) and Peltzman (2000) highlight the inherent asymmetry in costs associated with production. The fixed costs packers in the beef markets face are much larger than the fixed costs of feedlots (Bailey and Brorsen 1989). The packers will reduce margins to remain competitive when input prices increase and therefore do not reduce input supply. The absorption of the increase price by packers creates a positive asymmetry for farm prices. Peltzman (2000), similarly, raises the point of input management. He states it is easier for producers to reduce input use as costs increase, rather than increase the use of inputs due to either production constraints or the cost of sourcing additional supply. Ultimately, Peltzman (2000) determines there is no connection between menu costs and price asymmetry.

Heien (1980) and Ward (1982) provide contrasting perspectives on the effects of shelflife on price asymmetry. Heien (1980) presents the argument that products with long shelflives are negatively price asymmetric. The products have a larger time cost and therefore, alienating customers caused by an increase in prices is too risky. Ward (1982), on the other hand, proposes the alternative—negative asymmetry exists in fresh food products. Sellers of fresh products will do what they can to maintain demand to avoid spoilage of their product.

Another interesting argument for the cause of asymmetric price transmission is the relationship between inflation and modifiying prices. Ball and Mankiw (1994) and Buckle and Carlson (2000) present an argument for positive price asymmetry in the face of positive trend inflation. They reason that a positive input price shock is more likely to cause a price adjustment than a negative input price shock. Inflation is a natural adjuster for the negative price shocks. Buckle and Carlson (2000) use unique data from a business survey in New Zealand to confirm the inflation and price asymmetric relationship.

Empirical Explorations

The articles in this section have attempted to test for the existence of asymmetric price transmissions and measure the extent to which it exists. The earliest model of Tweeten and Quance (1969) models aggregate farm output as a function of censored lagged prices received by farmers for production inputs, beginning of the year stock of productive farm assets and a productivity index of farm output to input. The results from Tweeten and Quance (1969) show positive supply responses but low magnitudes. They conclude that the outcome of their results would be difficult to convey specific policy implications for policy makers on the effect of increases in prices to farm output.

Wolffram (1971) addresses several mathematical errors in Tweeten and Quance's (1969) work. Wolffram (1971) notes two major issues. First, the incorrect method of quantifying irreversible supply reactions to increasing and decreasing prices; and second, identifying the partial influence of independent variable in distinct periods. The author explains each issue and how to correct the methodology but does not in fact update the model nor give alternative conclusion from results.

Ward (1982) applies the model updates from Wolffram (1971) to study the asymmetry of prices at the retail, wholesale and shipping levels for fresh vegetables. One extension of the model is the addition of lags of the independent variables. The author finds that decreases in wholesale pricing is reflected more fully in both the retail and shipping prices compared to price increases, indicating negative price asymmetry.

Boyd and Brorsen (1988) expand on earlier analysis to test for not only direction of price adjustments but also the speed of those adjustments in the U.S. pork industry. They also improve on Wolffram and Houck's models by accounting for prices changes that take longer than the contemporaneous time period to affect changes in output prices. Boyd and Brorsen (1988) also expand the model used by Ward (1982) by including measure of wage to account for the magnitude of the margins. The authors find that wholesale and retail prices are not “sticky downward” and state that wholesalers respond consistently to farm price increases and decreases.

A recent innovation in the empirical study of asymmetric price transmission is the use of error correction models, which take into considertaion cointegration between the input and output prices. V. Cramon-Taubadel (1998) and V. Cramon-Taubadel and Loy (1996) point out the necessity of recognizing the cointegrating relationship and recommend the use of an error correction model with asymmetric adjustment terms to properly understand the asymmetric relationship. The long-run relationship between the input and output prices are understood through a simple regression of output prices as a function of input prices. If a cointegrating relationship exists, the coefficient on the input prices will be statistically significant and the residuals of the regression will be censored into positive and negative series. The positive and negative series along with contemporaneous and lagged, censored price differences are regressed on the diferenced output price series. The authors then suggest an F-test to test for the existence of asymmetry. The use of an error correction model to study price symmetry has been applied to several areas of research.

The application of the error correction model to study price asymmetry has been extensively used in the energy sector. Borenstein, Cameron and Gilbert (1997), Kilian and Vigfusson (2011) and Bachmeier and Griffin (2003) are just a few examples of the application of the error correction methodology to better understand the effects of energy prices on gasoline and the macro economy in general. Borenstein, Cameron and Gilbert

(1997) conclude there is a positive asymmetry in the relationship of crude oil prices and gasoline prices yet do not state at which point along the supply chain these asymmetries occur. They do presume the asymmetry could likely be a result of the cost of inventory adjustment or even the reduced searching consumers perform decreasing the elasticity of demand for retailers. The model the authors use do not censor their long-term dynamic variable in the error correction model.

Bachmeier and Griffin (2003) also look at the relationship between oil prices and gasoline prices using an error correction model with spot gasoline and crude oil prices from 1985 to 1998. The authors estimate two models—a symmetric and an asymmetric error correction model. They then use the two models to comparatively test for the existence of asymmetries but ultimately conclude one does not exist.

Kilian and Vigfussion (2011) use a vector autoreggression to assess the effects of oil prices on macroeconomic factors, looking specifically at real gross domestic product. The authors find no support for an asymmetric relationship between oil prices and real gross domestic product or admit that if they do exist "they are too weak to be detected in aggregate data" (Kilian and Vigfusson 2011). The authors also state that the impulse response functions estimated from the vector autoregression model are fundamentally misspecified and therefore the parameter estimates will be inconsistent and conclusions made from them are not valid.

Several authors also presented the idea that asymmetry may be present but not until there is a large enough price deviation from the long-run equilibrium that was of a certain magnitude or that surpassed a threshold. In this case, the authors used a threshold error correction model. Tong (1983) presents this idea and states that thresholds are not necessarily uniform for positive and negative price changes. Azzam (1999) believes the threshold theory is plausible when adjustment costs are present. Originally, Enders and Granger (1998) apply the threshold method to interest rates. Enders and Siklos (2001) update the article by testing for asymmetry in interest rates for instruments with different maturities. The results of Enders and Siklos (2001) models suggest there is an asymmetric relationship among interest rates with varying maturities.

Non-linearity in threshold error correction models has also been studied by several authors. These authors recommend using multiple thresholds if linearity is rejected (Goodwin and Holt (1999); Balke and Fomby (1997); Tsay (1989); Goodwin and Piggott (2001)).

The theories for causes of price asymmetry as well as the applications have been numerous. As for the theory, it is largely not unified. In addition, the empirical research is contradictory with about half of the studies showing the existence of asymmetry. Even when applied to the same subject, authors reach opposing conclusions. In general, the methodology has centered around the use of an error correction model but a consensus has not formed a standard model to use for the empirical testing of asymmetric price transimissions.

As shown, the previous literature on asymmetric price transmission has focused on the effect of changes in input costs to output prices. The analysis of this paper will consider how changes in the income of an asset affect changes in the asset’s value.

Specifically, the effect of changes in the long-run crop price on changes in rental rates is considered.

The study of asymmetric price transmissions has not directly been applied to cropland prices. Many theoretical arguments have been made for the existence of asymmetryic price responses in cropland prices and rental rates but the relationship has not been tested empirically. Burt (1986) states the need for lagged rental rates to describe the relationship between rental rates and land prices. Ibendal and Griffin (2013) mention the existence of asymmetries due to asymmetric information between landowner and operators. This paper serves to fill a hole in the cropland literature and to expand the use of the asymetric pricing methodology to another subject and how it is applied.

Methodologies

An error correction model describes both the co-integrating, long-run relationships as well as the short-run dynamics that is of interest for the input and output price relationship. In general, to understand the short-run dynamics, the differences of the price series are taken when the series are non-stationary. While necessary for the analysis, this procedure eliminates interesting information about the long-run effects. The error correction model eliminates this issue by first modeling the long-run relationship in levels and then includes them as independent variables in the difference model of the short-run dynamics.

Once again, changes in rent are specified as a function of changes in long-run crop prices. Three panel models are estimated. The models are delineated based on the major crop produced in each state. The error correction model develops both the long-run and short-run effects of input prices to an output price with a two-step regression process. The first regression provides the long-run relationship between rent and the crop price. The long-run output is then employed in the second regression which estimates the asymmetric relationship for the long-run effects and the immediate and lagged short-run effects.

Long-Run Effect Estimation and Tests

The long-run effects of crop prices and state dummy variables on the respective rental rate is determined using an ordinary least squares (OLS) regression. The values are measured in levels in the regression. Equation (49) shows the OLS regression.

$$Rent_{t,s} = \beta_0 + \beta_i D_s + \beta_p P_t + \epsilon_t \tag{49}$$

Where *s* is the associated dummy variable for each state and *p* is the crop price associated with that state grouping. The equation for the corn price will include 15 state dummy variables with one state, Delaware, dropped to avoid perfect collinearity. The soybean equation has six states with Alabama excluded. Wheat has a total of two states and excludes Oklahoma.

Following estimation, the error terms are tested for long-run stationarity using an augmented Dicky-Fuller (DF) test developed by Levin, Lin and Chu (2002) for panel data. Typically, the DF test is used for times series data and not for models using panel data. Levin, Lin and Chu (2002) develop a test of the unit root hypothesis for strongly balanced cross-sectional time series. Their results indicate a high power for the panel-based unit root test as compared to running separate unit root tests for individual time series.

The test's null hypothesis assumes all of the panels have the same autoregressive parameter, i.e. not specific to an individual state, and that they contain a unit root. The models are tested with one lag. A t-test is used to test the significance of the coefficient associated with the lagged error term. If the coefficient is significantly different from zero, then the null hypothesis that the error term contains a unit root is rejected.

$$\Delta\epsilon_t = \alpha_0 + \alpha_1\epsilon_{t-1} + u_t \tag{50}$$

If the unit root test is rejected, the error terms are recovered from the estimation and separated into positive and negative series. The series are censored such that the positive series only have positive errors and are zero otherwise, and so forth for the negative series. Once separated, the two series are differenced. The long-run relationship answers the question of whether two-series trend together, without drifting apart, over time. It is not always necessary for the co-integrating relationships to have economic meaning but it is not uncommon to discern an intuitive meaning between the two. The economic meaning also helps when forecasting future output prices given changes in input prices.

Short-Run Effect Estimation

The second step of the regression is to combine the long-run residuals with the short-term dynamics. The second equation will include lagged dependent variable observations, contemporaneous and lagged crop prices and the lagged co-integrating series. The final equation will reveal the presence of asymmetry in the short-run and long-run effects. If the coefficients are statistically significant and different, it shows there is likely an asymmetric relationship present.

Three pools of data are specified, in which the major delineating factor is the major crop produced in the state. Corn, soybean and wheat production are the primary crop productions. The independent variables are the crop prices which are a single time series. Rent varies both over the state they are drawn from and time period observed.

The error correction model will include lags of the dependent variable as well as contemporaneous and lagged values of the crop price series. To arrive at the appropriate number of lags, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) are used as indicators of the best set of parameters for each model.

The regression is initially run with the first difference of rent as a function of lagged differenced rent variables and contemporaneous and lagged differenced crop price data. At this point, the long-run parameters are not included in the model. Equation (51) illustrates the equation estimated.

$$\Delta Rent_{c,t} = \zeta_o + \sum \zeta_i \Delta Rent_{c,t-i} + \sum \zeta_j \Delta P_{c,t-j} + \mu_t \tag{51}$$

where *c* represents the crop group the regression represents either corn, soybean or wheat. The *i* and *j* index the number of lags and the coefficient specific to that parameter.

One constraint is placed on the model selection at this point. No years are skipped in the lag selection so as to not over fit the data and include extraneous information that does not contribute to the economic understanding of the relationship presented in the model.

The regression that minimizes the AIC and BIC measures is used as a basis for the second step. In the second step, the crop price data is censored into positive and negative values. The coefficients indicate the pace of change associated with an increase or decrease of an input price. Based on the number of lags determined in the first step, the equal amount is included both for the dependent variable as well as the crop price data. Again, the AIC and BIC criterion is used to determine if the lags found in the previous step are still the best parameterization of the model. A second constraint is imposed at this point. The censored prices must be included as pairs to maintain economic intuition of positive and negative price movements. Equation (52) presents the structure of the second step.

$$\Delta Rent_{c,t} = \phi_0 + \sum \phi_i \Delta Rent_{c,t-i} + \sum \phi_i^+ \Delta P_{c,t-i}^+ + \sum \phi_i^- \Delta P_{c,t-i}^- + \mu_t \qquad (52)$$

The third and final step, introduces the long-run deviations into the specification determined in step 2. Equation (53) presents the final regression with all possible parameters included. The significance of variables is considered and the model is once again determined based on the competitiveness of the AIC and BIC measure.

$$\Delta Rent_{c,t} = \delta_0 + \sum \gamma_i \Delta Rent_{c,t-i} + \sum \delta_j^+ \Delta P_{c,t-j}^+ + \sum \delta_j^- \Delta P_{c,t-j}^- + \qquad (53)$$

$$\alpha^+ \epsilon_{c,t-1}^+ + \alpha^- \epsilon_{c,t-1}^- + \mu_t$$

$$\text{where } \epsilon_{i,t} = Rent_t - \beta_i D_i - \beta_p P_t \qquad (54)$$

On the right-hand side, the independent variables are divided into short-term and long-term effects. The coefficients associated with the crop price variables, $\Delta P_{c,t}$, represent the short-term effects. While the rent variable changes over states, the crop price is of one type, delineated by the *c* subscript, i.e. crop type. The long-term effect is represented by the recovered residuals from Equation (49). The ϵ variables are also censored into positive and negative values to understand how rent changes according to positive and negative changes in the long-term. Table 3.12 presents the parameters included in each step described above, including the final parameterization determined in step three for the error correction model.

Two hypotheses are tested when modeling the error correction model.

$$\begin{cases} H_0^I: \delta_j^+ = \delta_j^- \\ H_a^I: \delta_j^+ \neq \delta_j^- \end{cases} \tag{55}$$

$$\begin{cases} H_0^{II}: \alpha^+ = \alpha^- \\ H_a^{II}: \alpha^+ \neq \alpha^- \end{cases} \tag{56}$$

Intuitively, the hypotheses are asking the question, "do increases and the decreases in the crop prices have symmetric effects on cropland rents in both the short-run and long-run?" A t-test is performed to test these hypotheses.

Each model is also tested for the stability of the coefficients on the long-run co-integrating effects to justify the grouping of the states by major crop production. The procedure tests the statistical significance of the long-run coefficients in the error correction model estimation under the original grouping and a subset of the group. A t-test measures the existence of a statistical difference between the coefficients from the entire group and the coefficient estimated from the subset of states using a 5% criterion. If there exists a statistical difference between the two estimated coefficients, the coefficients are not stable across various groupings and it is not justified to group the states by crop type in the long-run effect equations. The null hypothesis tested is presented in Equation (57). If the hypothesis is rejected, the grouping of states by crop type is not necessarily appropriate.

$$H_0: \beta_i^I = \beta_i^{II} \tag{57}$$

Data

The data used are the same data referenced in chapter II. The difference here is in the application of the data. Whereas chapter II used the data in a strictly time series fashion— regressing historical crop price data on rent data separately for each state—the error correction model combines several rent data series to create both a cross sectional and time series dataset grouped based on the major crop production by state. The data is an unbalanced panel dataset. Observations are both across units, the state observations, and over time. The unbalanced portion of the panel arises from the various available historical data for either rent or long-run crop prices. Corn data is available beginning in 1974, soybean and Kansas City Wheat price data is available from 1968. 10 states in the data set have price data going back to 1968, 13 going back to 1974 and one state beginning in 1978. Table 3.10 outlines each state's beginning observation.

As mentioned, the data used in each of the models is determined by the major crop produced in each state according to cash receipts. Therefore, all state rental rates associated with corn production states are grouped, as well as for the soybean and wheat producing states. Table 3.2 provides the delineation of state groupings based on crop production. One crop-to-state delineation that is modified in the model in this chapter as compared to the model in chapter II is for North Dakota. The long-run crop price used in the model in chapter II uses the settlement price on the nearby Chicago Wheat futures contract. Due to non-stationarity in the regression of the Chicago Wheat price on North Dakota rent, the Kansas City Wheat futures contract is used for both North Dakota and Oklahoma.

Differences are used for each rent and crop price series to get at the relationships between the positive and negative movements of crop prices and rent. The long-run crop prices are censored into positive and negative series depending on the differenced value. The positive price series yield the differenced value if the price is greater than zero, else zero. The negative series contains only negative differenced values, otherwise zero.

Empirical Results

The model output for each crop will be presented individually. A suitable, common model parameterization of the three models is determined and presented in equation (58).

$$\begin{aligned} \Delta Rent_{c,t} = {} & \delta_0 + \gamma \Delta Rent_{t-1} + \delta_0^+ \Delta P_{c,t}^+ + \delta_1^+ \Delta P_{c,t-1}^+ + \delta_2^+ \Delta P_{c,t-2}^+ + \delta_3^+ \Delta P_{c,t-3}^+ \\ & + \delta_0^- \Delta P_{c,t}^- + \delta_1^- \Delta P_{c,t-1}^- + \delta_2^- \Delta P_{c,t-2}^- + \delta_3^- \Delta P_{c,t-3}^- + \alpha^+ \epsilon_{c,t-1}^+ \\ & + \alpha^- \epsilon_{c,t-1}^- + \mu_t \end{aligned} \tag{58}$$

Overall, the estimations show signs of asymmetry for all three crops. The wheat regression has the fewest asymmetric relationships present.

Corn State Results

The long-run estimation, results presented in Table 3.13, yield stationary error terms and stable coefficients over varying groupings of the states. Output for both tests can be found in Table 3.14 and Table 3.15. The dummy variables for three states in the estimation are not statistically significant—Maryland, Michigan and Wisconsin. Otherwise, all other Table 3.13 level.

The error correction model parameters are presented in Table 3.16. All variables are statistically significant except for the positive second lagged price coefficient, single and third negative lagged price coefficient and the negative residual coefficient. In general, we expect positive coefficients for the short-run positive and negative series. A negative movement in crop price will yield a negative change decreasing the dependent variable. All but the second positive lag have positive coefficients. As noted, the coefficient associated with the second, positive lagged price series is not statistically significant. Therefore, all statistically significant variables have the positive relationship as expected.

The cointegration parameters of an error correction model are not necessarily economically intuitive but some intuition is provided here. If a positive residual from the long-run regression is present, rent observation is greater than the predicted value, or rent is overvalued. The coefficient should imply a corrective attitude to reduce the rent amount. The negative residual value, by the same intuition, would indicate there is an undervaluation of the rent. The scenario should cause an increase in rent and, therefore, result in a negative coefficient. The output of the long-run parameters is also presented in Table 3.16. The coefficient of the positive long-run equilibrium deviation is negative, as expected, and significant. The coefficient associated with the negative residual series is positive, but not statistically significant.

A t-test is used to test for a statistical difference between the positive and negative movements for both the long-run equilibrium error and short-run dynamics. The results are presented in Table 3.17. The null hypothesis tested is that the coefficients associated with the positive and negative movements are equal. Results show that the first, second and third lags as well as the long-run effects coefficient differences are statistically significant. The first and second lagged differences are significant at the 5% level with the third and residual differences statistically significant at the 1% level. The rejections of these null hypotheses show asymmetry is present in the rent-price relationships for corn.

The type of asymmetry is defined by the relative magnitudes of the positive and negative coefficients. The relative magnitudes of only the statistically significant relationships will be discussed. Positive asymmetry is present in the first and third lag as well as the long-run residuals. Negative asymmetry is present in the second lag relationship. The relative magnitudes can also be considered in a cumulative fashion as the sum total of short-run effects from positive price changes minus the sum total effects from negative movements in prices. Overall, the short-run dynamics show a cumulative positive asymmetric price transmission. The common positive asymmetry in the short and long-run effects support the hypothesis that the landowner is in a dominant position for setting the rent for corn.

Soybean State Results

The results of the long-run estimation for the soybean grouping are presented in Table 3.18. The results of the long-run stationarity test of the error terms, presented in Table

3.19, show the error terms are stationary. The results of the stability test provided in Table 3.20 show the coefficients are stable over varying groupings of the states. These results indicate the delineation of the states is justified. In the co-integrating regression, all variables are statistically significant at the 1% level.

Table 3.121 presents model output for the error correction model. The coefficients are all statistically significant except for the coefficient on the single lag of the dependent variables and the third negative crop price series. All short-run price change coefficients are positive as expected except for the coefficient on the first positive lagged price series, which was not statistically significant. The long-run, co-integrating coefficients are both negative, as expected.

In terms of asymmetry, the soybean coefficients show signs of asymmetry in the first, second, and third time lags for price changes as well as in the coefficients for the long-run equilibrium errors.

Table 3.22 presents all calculated test statistics for the relationships in the soybean model. The relative magnitude of the first time lag has a negative asymmetric relationship. The second and third time lags and co-integrating relationships all have positive asymmetry. Overall, the soybean model is cumulatively positively asymmetric in the short-run and positive in the long-run effects. This consistency indicates a relationship that, agrees with the corn estimates and favors the landowner as the price setter.

Wheat State Results

Initially, the wheat states, North Dakota and Oklahoma, are estimated individually using the Chicago and Kansas City Wheat futures contract settlement prices, respectively. The output of the North Dakota model using the Chicago Wheat price is not stationary and therefore, is grouped with Oklahoma. The Kansas City Wheat contract price is used as the long-run wheat price. Following re-estimation, the errors are stationary. Results from the re-estimation are in Table 3.23 and the stationarity tests can be found in Table 3.24.

The coefficients of the long-run co-integrating equation, presented in Table 3.23, are all statistically significant yet the R^2 is much lower compared to the corn and soybean regressions. The error correction model has less impressive explanatory ability. The error correction model output for the wheat regression can be found in Table 3.25. The only statistically significant coefficient is the negative, first-period lagged price series. All short-run dynamics are positive except for the negative, two-period lagged crop price series. The positive and negative long-run series coefficients are negative.

The only positive and negative price change effects to show signs of asymmetry is the second-period lagged crop prices. The t-statistic results are available in Table 3.26. The relationship has a positive asymmetry, consistent with the previous models' asymmetric conclusions.

Conclusions

The output of the error correction model shows the presence of asymmetry in rent both in the short and long-run effects. The models show varying directions of asymmetry in each positive and negative relationship but the overarching direction across all models is a positive, both in the short and long-run relationships. The corn and soybean states have the most statistically different positive and negative movements.

The magnitude of the positive or negative asymmetric effects for the corn model are larger than those of the soybean and wheat models. The magnitude of one of the positive or negative coefficients compared to its counterpart indicates the degree of asymmetry present in each positive and negative relationship. The corn regression shows larger differences across all statistically significant relationships. This is an indication of a larger degree of asymmetry in corn producing states than in the soybean and wheat states. The strength of the coefficients for the corn regression may also likely be due to the strength of the model. The states within the corn grouping are more represented by income from corn production compared to the other groups. States included in the soybean model do not necessarily receive a substantial amount of their cash receipts from soybean production, in general. Therefore, soybean prices may only represent a small proportion of the income produced from the state.

The short-run coefficients should all have positive coefficients since they are separated into positive and negative series. The positive or negative effects the series should have on rent will be captured in the sign of the price change present in the series. The only coefficient that does not follow this structure is in the soybean estimation. The first lagged positive series has a negative coefficient. Possibly with better specification of the model, the coefficient may correct.

The long-run coefficients are all expected to be negative. The residuals represent an over or undervaluation of the rent term in the long-run and therefore should work in a corrective manner. A lagged value that is positive indicates a previously overestimated value and a negative residual indicates an underestimated value. The coefficient of the positive lagged residual is negative indicating that when a value is positive, the outcome will decrease the rental rate. Alternatively, the coefficient of the negative residuals is also negative. The two negative values result in a value that will increase the rental rate. The corn group model produces a positive coefficient for the negative residual series but the coefficient is not statistically significant. All other long-run coefficients are negative.

The positive asymmetric results of the model disprove Ibendahl and Griffin's (2013) theory that the asymmetric sharing of information between land operators and owners causes rental rates to be adjusted more slowly when prices are increasing than decreasing. The positive asymmetric results indicate that rental rates are more sensitive to increases in profitability of crop production and therefore increase rapidly to crop price increases. Alternatively, when crop production profitability decreases, rental rates are less reactive. The opposing intuition to Ibendahl and Griffin's (2013) theory is that landowners have more power in the determination of the rental rates or that landowners are reluctant to decrease prices once they have reached higher levels.

The results do not necessarily disprove the possibility of information being shared or known asymmetrically. It could be likely that landowners have less knowledge about the profitability of the production on their land. The inferior knowledge could cause their reluctance to decrease prices. Educating or providing more information to the landowner may reduce some of the asymmetry.

These results may also disprove the conclusions made by Melichar (1979) that land prices change at the same rate as the income to land. If rent is still believed to be the best proxy for the income to land and it does not change proportionally to changes in the crop production prices, it may not be likely that land prices would adjust accordingly. A natural and optimal addition to the analysis would be to use the error correction model framework to test if an asymmetric relationship exists between rent and cropland prices. The supplementary analysis would provide a holistic view of the transfer of revenue from production to final asset value.

Previous research has tried to use lags of rent and land prices to account for the difficulty in measuring cropland price. The authors state that the models are only able to characterize cropland price dynamics in the short-run or long-run due to varying factors. For example, Phipps (1984) states past rents and past land prices explain the dynamics of land prices but their model is only useful in quantifying short-run adjustments. Falk (1991) states that land prices can be determined by rents using the present value formula but only in the long-run estimation of prices. Due to the volatility of land prices in the short-run, the model is not useful for estimating prices for the short-run. The results of this work show that the difficulty found in previous literature to estimate land prices is not in the formulation of lags and whether they are affected by short or long-term volatility, but in fact due to the way value of land responds to changes in the income to land. The use of the capitalization model is also affected. Output will likely only be representative when prices are increasing. When prices are decreasing, the value of the asset is not going to change according to the capitalized relationship of income to asset value.

The positive asymmetry is also an indication that the farm operator is taking on a disproportionate amount of farming risk and does not receive the payoff associated with bearing the risk. When production is profitable, rent increases and more of the profits go to the landowner. When production is less profitable, the rents decrease disproportionately to the reduction in revenue. Therefore, when times are risky, the landowner is shielded from that risk, yet when revenue is good, the landowner retains a disproportionate amount of the revenue compared to the operator who bears the risk. Ensuring operators are receiving a proportionate amount of benefit from the risk they are bearing from operating the land is important to safeguarding the long-term success of the operators and maintaining a stable farm business sector overall. Creating a more symmetric price relationship between revenue and rental rates would be an important policy implication from these findings.

In general, the models would benefit from more granular data yet such data is not available for each state nor for the major crop produced in each state. Aggregation at the state-wide level removes a lot of important variation in the data. The analysis is also restricted to crop production in each state due to available price data. These data limitations require creating assumptions on the grouping of states in each model. States such as Iowa who have uniform state-wide crop production are grouped with states such as Georgia which is not largely a row crop producing state. Georgia's corn production represented about 2.2% of its cash receipts in 2016 (USDA ERS 2016) yet corn prices are still used to represent the state's agriculture income. The state-wide data for rent, especially for states whose crop production is not as uniform across the entire state, may not be as well represented by the crop price chosen for that state.

Data at the county-level would likely improve the modeling of the asymmetric relationship and provide even more interesting relationships for more specific production types. Crop production at the county-level is likely more concentrated than what is produced on a statewide basis.

Additional analysis may also benefit from a stricter criterion for the grouping or even inclusion of states for the analysis. A minimum threshold of production of a crop may strengthen conclusions that can be made from a model's results.

The output of the models across varying states and crop production types is consistent for the relationship between changes in income and rental rates. As noted, the addition of more granular data would create the opportunity to expand the model and tighten criterion on the delineation of regions into crop-based groups.

CHAPTER IV

THEMES IN MACRO AG FINANCE: WHAT HAVE WE LEARNED? WHAT HAVE WE FORGOTTEN?

In the past century, the farm business sector has witnessed three major boom-and-bust cycles, all following a relatively similar pattern. Net farm income increases due to a growth in exports and prices received; with the larger cash flow, deleveraging and an expansion in capital expenditures occur. Once net farm income begins to fall, capital expansion tends to continue for a period of time and debt grows to finance expansion, thereby increasing leveraged positions (Henderson and Kaufman 2013). In the most recent boom, various aspects of the pattern have emerged yet again and have brought into question whether a bust, similar to those that occurred in that past, will follow.

The recent growth in the farm business sector has predominantly occurred in the row crop producing states of the Midwest. Net farm income in the Iowa farm business sector, a representative Midwestern state, expanded nearly 450% from 1999 to 2012 (USDA NASS 2016).[1] The increase in crop prices (corn, +300%) (USDA NASS 2016), yield per acre and demand both domestically and internationally during that time period predominantly caused the increase in net farm income. Demand increases have been attributed to several factors. First, the emergence of multiple free trade agreements in the mid to late 1990s and 2000s made exporting goods to other countries easier. Second, expansion in both the population and income in developing countries increased demand

[1] All data is in real terms using 2009 as the base year unless otherwise noted.

for U.S. exports. Finally, the boom in biofuels significantly increased domestic demand for corn.

The farm business sector booms today and in the late 1970s have several similarities. Both witnessed expansions in demand due to increases in international trade and higher crop prices. As a result, producers have expanded operations, increasing both their capital expenditures and debt positions. These booms have been coupled with rapid increases in farmland prices. The changes in farmland prices during these cycles, play a role in the stability of the debt positions of market participants since farmland is the primary source of collateral for loans.

In the 1970s, the average yearly increase in the value of land in Iowa was 10%. The land prices for the state increased over 400% from 1970 to 1981, the peak of land price increases (USDA NASS 2016). Today substantial increases in the market price of farmland have occurred again, with the Midwest witnessing the largest gain. Cropland prices since the downturn in the 1980s has increased nearly 500%. In 1987, cropland prices in Iowa averaged $1,311 per acre. Today, the average cropland price in Iowa is $7,464. In the past decade alone, farmland prices have increased, 128% in Iowa, peaking at $8,050 per acre (USDA NASS 2016). Figure 4.28 shows the historical farmland prices and net farm income in Iowa. Figure 4.29, for reference, shows nominal and real net farm income for the entire United States.

The average debt level of the farm business sector is a commonly cited difference between the current boom and previous cycles. Figure 4.30 shows the fluctuations in the debt-to-asset ratio since 1959. In 1985, the debt-to-asset ratio peaked at 22%. By comparison, the sector has witnessed much lower values recently. The debt-to-asset ratio was 12% in 2015. Many have cited this as an indication that the sector is significantly less risky.

In previous cycles, debt accumulation continued despite signals of a downturn. For example, Figure 4.31 shows the relationship between national net farm income and outstanding debt. The graph shows outstanding debt does not change direction, or stop growing for many years following a negative turn in net farm income.

As seen in Figure 4.32, capital expenditures tend to continue to increase following several years of decreases in net farm income. Previous busts in the farm business sector have largely been fueled by the producers' inability to support their over-leveraged position from cash flows with farm operations. Yet as the graph shows, as sources of cash flow diminish, the sector continues to increase capital expenditures.

While this boom has seen a relatively lower debt-to-asset ratio, several risks may still exist. The concentration of debt on fewer producer's balance sheets differentiates today from conditions observed in the 1980s. Almost two-thirds of producers reported no outstanding term debt on their balance sheets in 2009 as opposed to nearly 60% of producers in 1986. Additionally, 55% of the outstanding debt was held by farms with multiple loans usually from multiple sources (Harris, et al. 2009). The profile of the likely holders of the outstanding term debt may be another risk. According to the 2012 Census of Agriculture, the average age of the U.S. farmer was 58 and 78% of the producers had been on the farm for more than 10 years (USDA NASS 2016). Therefore, those holding most of the outstanding debt and risk may be newer entrants making significant capital expenditures to begin and expand operations. The profile variation of the borrowers between today and the previous cycles compromises the use of the debt-to-asset ratio over time.

The times interest earned ratio and the debt burden ratio provide a more substantive comparison of the farm business sector over time to the usually cited debt-to-asset ratio. The times interest earned ratio is farm revenue divided by the interest expense for real estate and non-real estate loans. The debt burden ratio measures the debt outstanding divided by net farm income. While the debt-to-asset ratio represents a single balance sheet statistic, these two ratios describe the farm business sector's capacity to service current outstanding debt.

Lenders use a general threshold to determine an enterprise's access to credit. A debt burden ratio of four, or total debt outstanding not exceeding net income by a multiple of four, is most commonly used. As can be seen in Figure 4.33, the average debt burden ratio does not exceed that threshold for most of the historical period examined. The debt burden ratio surpassed the threshold of four in 1976 and reached a peak of 13 in 1983. The debt burden ratio remained around four until 1986. Since that time, the ratio has remained below the threshold until 2015 when it reached 4.41 and has since continued to rise and may reach 6.34 in 2017 given the USDA's projection for net farm income. The spread between the times interest earned ratio and the debt burden ratio also indicates stress in the farm business sector. In 1977, the two ratios reversed their relationship and the debt burden ratio became greater than the times interest earned ratio. The inverted relationship between the two ratios continued through the entirety of the farm business sector downturn and reversed in the late 1980s as the sector began to recover. These ratios have not seen a similar relationship reversal of a significant magnitude until 2016 when the debt burden ratio increased to 4.41 and the times interest earned ratio decreased to 5.37. The USDA's projections for net farm income in 2017, shown in the graph, imply further widening of the spread.

Two market participants play a role in the debt accumulation of the farm business sector. The producer adds risk to their financial position by growing debt when they expand or modernize operations. Lenders add risk by expanding their loan portfolios to satisfy profit maximizing objectives.

The debt positions of the market, overall, play a significant role in the creation and management of risk in the farm business sector. Debt has played a major role in all previous boom and bust cycles. The following analysis serves to decompose each players' role in that creation and management of risk. By better understanding these individuals' actions, future unnecessary risk can be avoided.

Capital expenditures describe the demand for debt for both the expansion and modernization of producer's operations. An econometric analysis of investment behavior will provide insight into factors affecting capital expenditures and forecasting expected changes.

Debt will be analyzed using data collected from regional agriculture banks surveyed by the Federal Reserve district banks. These data display the credit market's interactions with borrowers. The data captures lenders' sentiment towards the current and future farm business sector and their decisions around supplying credit to borrowers. These surveys also give insight to the signals lenders send to borrowers.

The assessment of demand and supply of debt, holistically, analyzes the composition of the financial risk positions of agriculture market participants and how both the demanders of debt and the suppliers of debt create risk in the farm business sector.

Background

Henderson and Kauffman (2013) identified a pattern in the past three expansion and contraction periods—1910-1940, 1940-1960 and 1970-1980. The progression of events begins with an expansion in net farm income, caused by varying factors usually related to increases in trade, exports and prices received. As cash flow increases, producers decrease their leveraged positions, decreasing their debt-to-asset ratios. Both the decreased amount of cash flow required for servicing debt and the increase in net farm income increases the wealth accumulation of producers. The increase in wealth leads to increases in capital expenditures. The farm business sector then begins to contract with a downturn in farm commodity prices. Net farm income decreases and reduces available cash flow to cover the increased debt positions created by capital expansion. Despite the contraction in net farm income, capital expansion continues to grow based in part on an overly optimistic outlook by both producers and lenders. Eventually producers are forced to either expand or restructure their debt positions to service their debt positions (Henderson and Kaufman 2013). The following analysis will identify the pattern in five time periods—1910-1939, 1940-1969, 1970-1979, 1980-1989, and 1990-present. Figure

4.44 provides a timeline of major events highlighting the factors occurring at each point in the pattern for the previous boom-and-bust cycle period.

1910-1939

The 1910s were already experiencing increases in food demand as a result of World War I. The war caused demand for US agricultural exports to double. From 1916 to 1919, exports increased about 10% year over year and accounted for nearly 20% of U.S. food production (Henderson, Gloy and Boehlje 2011). The largest increase in exports was experienced in livestock. Prices received for crops and livestock doubled between 1915 and 1918 (Henderson, Gloy and Boehlje 2011). The price of corn increased from $0.42 in 1910 to $1.34 in 1919 (USDA NASS 2016). Net farm income increased as much as 60% by 1917 and continued at that level through 1919 (Henderson, Gloy and Boehlje 2011). The farm business sector was also going through a period of mechanization of farm operations. Producers were adopting the use of tractors, combines and other farm machinery and equipment leading to surges in the level of productivity. In 1917, producer expenditures on vehicles, machinery and equipment increased 33% from the previous year and continued to expand through the decade with the help of low interest rates creating for cheap debt financing (Henderson and Kaufman 2013).

By 1921, exports had decreased and the onset of a recession suppressed prices and net farm income. Exports returned to pre-war levels by 1922 with commodity prices, overall, seeing about a 40% decline (Henderson, Gloy and Boehlje 2011). Specifically, corn prices dropped nearly 70% from their high in 1919 to their lowest price of $0.41 (USDA NASS 2016). Real net returns to operators decreased 53% as a way to provide liquidity to their operations, many producers expanded and restructured their debt positions.

By 1923 farm bankruptcies began to increase. Following the initial recessionary period, the onset of the Depression in the 1930s caused net farm income to collapse again— net farm incomes reached as low as $26.8 billion in 1932, creating another wave of farm bankruptcies (Henderson and Kaufman 2013).

1940-1969

World War II spurred an increase in prices and demand for US agricultural exports and brought the farm business sector out of the recession it had been in. Exports increased from $4.3 billion in 1941 to $25 billion in 1944 (Henderson, Gloy and Boehlje 2011). Once again, the majority of the increase in the exported goods was livestock and crop exports only increased moderately. Grain prices saw average increases of nearly 400 and 300% for corn and soybeans, respectively. Net farm income in the sector more than doubled from 1940 to 1943 (USDA NASS 2016). Following the increase in income, capital expenditures increased more than three times over the 1943-1949 period (USDA NASS 2016). By 1947, non-real estate investment increased by 73% (Henderson, Gloy and Boehlje 2011). From 1950 to 1956, net farm income was suppressed and debt was expanded to finance previous capital expenditures. Between 1950 and 1960, average farm debt rose close to 10% each year for both real estate and non-real estate transactions (Henderson and Kaufman 2013). Debt levels, overall, remained below historical averages and therefore, the farm business sector avoided a bust following the expansion in the 1940s (Henderson and Kaufman 2013).

Exports overall did not decrease. The development of hybrid seeds in the 1940s created bumper crops that were sold in foreign markets. In 1954 the Agriculture Trade and Development Assistance Act was instated as the U.S.'s major international food assistance program. The goal of the program was to bolster U.S. exports and benefit other countries in need. Over the next three decades, exports continued to increase, as well as agriculture prices and production costs for seed, fertilizer, pesticides and energy. Throughout the 1940s, production costs increased on average 7% year over year, increasing 15% in 1943 and 20% in 1942. In the 1950s and 1960s, production costs increased 15 and 20 percent, respectively, over each of the decades.

1970-1979

The boom in the 1970s was largely a result of an increase in exports and prices following a trade agreement with the Soviet Union in 1972. The year following the trade deal, U.S. agricultural exports and net farm income nearly doubled— net farm income reaching $130 billion (USDA NASS 2016). Net farm income returned to near previous levels following that initial spike in returns but remained 44% higher than the previous decade (USDA NASS 2016). Commodity prices increased substantially as well. Corn increased from $1.04 in 1971 to $2.97 in 1974; a 186% increase in three years. Soybean prices increased from $2.36 to $7.05 from 1969 to 1976; a 199% increase in seven years. Wheat also saw an increase in prices of $1.25 in 1970 to $4.13 in 1974; a 230% increase in prices over four years (USDA NASS 2016). Exports peaked in 1980 at $96 billion (Henderson, Gloy and Boehlje 2011). The substantial increase in net farm income caused an expansion in both non-real estate investments and land improvements. Capital spending began to rise faster than incomes, increasing debt levels by about 5% per year. The substantial leveraged positions and decreases in net farm income resulted in the second farm financial crisis.

1980 - 1989

Farm export and price declines led to a collapse in net farm income at the onset of 1980. Due to bumper crops, production increased and caused crop prices to decline. Corn, soybean and wheat prices decreased 33, 16% and 10%, respectively. Coupled with a strong valuation of the dollar, exports collapsed. Net farm income decreased from about $130 billion to $36 billion in 1980, a decrease of about 72%. All capital expansion halted to minimize the accumulation of more debt but the over-leveraged positions of the market had already been realized. The farm business sector witnessed another decrease in profit in 1983 to $26.5 billion. The massive decline in cash flow coupled with an increase of the Federal Funds rate and the prime rate to 19% and 22%, respectively made servicing debt even more difficult for producers.

Growth in farm debt levels began to slow as soon as 1980 with less than a 1% increase and declined in value from 1983 to 1993. The previous decade showed debt levels rising about 6% each year with a debt-to-asset ratio of about 15%. Although some of the decline in debt accumulation was due to more conservative spending by producers following the decrease in cash flow, a substantial portion was from the number of bankruptcies occurring and the writing off of debt. The slowing of debt accumulation did not remedy the liquidity issues as much as needed. From 1982 to 1987 the debt-to-asset ratios averaged 20% and peaked in 1985 at 22%. These levels did not return to prebust levels of 15% until 1990. Lower net farm income coupled with higher interest rates increasing debt obligations caused massive stress on borrowers to cover their debt positions. By the mid-1980s, the farm business sector witnessed 2.3 bankruptcies per 1000 farms, the highest number of bankruptcies since 1933. From 1985-1987, close to 70 agricultural commercial banks failed per year (FDIC). Between 1985 and 1988, debt per farm decreased 10% annually as lenders wrote off existing debt (Henderson and Kaufman 2013). Farm foreclosures peaked in 1987.

The crashing of the sector reverberated throughout the farm business sector causing massive declines for many such as John Deere, Minneapolis Moline, Oliver Farm Equipment Company and other farm machinery manufacturers. Minneapolis Moline and Oliver Farm Equipment Company closed their doors in 1985. The government intervened with substantial supplemental appropriations and assistance programs to restrict agriculture production to increase prices and net farm income.

1990 - PRESENT

Exports and prices rebounded in the 1990s and early 2000s from the bust of the 1970s and 1980s bubble. Several major drivers caused the increases in demand and commodity prices largely caused by growth in exports and biofuel production. Population growth and rising incomes in developing countries have bolstered international demand. For example, in 2011, China was 20% of U.S. exports (Henderson and Kaufman 2013). Second, the demand garnered from The Renewable Fuel Standard established in 2005 and the amendment in 2007, The Energy Independence and Security Act of 2007, have created an alternative demand for corn and oilseed domestically. Droughts in 2012 throughout the Midwest caused supply issues for major corn and soybean states ultimately affecting the price of grains. Corn reached its highest price in 2012 at $6.92. In 1999, the price of corn was $1.72. Soybeans increased from $4.35 to $14.40 from 2001 to 2012. Wheat was $2.15 in 2000 and increased to $7 in 2012. Net farm income reached a peak of $116 billion in 2013, an increase of 60% from 2002 levels. By 2014, the market was saturated with product and as a result prices started their decline. Corn, soybean and wheat prices in 2016 were $3.50, $8.65 and $3.70, respectively. Input costs for crop producers remained relatively constant over the period. As a consequence, net farm income has declined for the third year in a row.

The question is now as the market begins to contract, will we see a bust similar to previous cycles. One of the continually noted differences between today and the 1980s, is the lack of substantial debt accumulation and the reasonably leveraged positions of the entire farm business sector. In the early part of the decade, 2000-2005, debt levels remained stable and accumulation was minimal. During that time, the average debt accumulation year over year was about 1.5%. In 2007 and 2008, debt levels increased 9% and 6%, respectively. The rise in debt accumulation was during the boom in ethanol production. Recently, debt levels have seen larger percentage increases. In 2013 and 2014, debt increased 4.5% and 8%, respectively. The average debt-to-asset ratio has remained around 12% with a maximum for the decade of 15% occurring in 2002. By comparison, the debt-to-asset ratio peaked at 22% in the mid-1980s.

While these lower levels of the debt-to-asset ratio prove promising, previous cycles have shown that capital expenditures increase well past decreases in net farm income which have just begun. The consistency of today's cycle and those of the past give evidence that the debt accumulation stage may just be beginning. As previously noted, the debt-to-asset ratio does not provide a well-rounded view of the health of the farm business sector as it does not account for important structural changes that have occurred in the sector. The more intuitive measures, the times interest earned and debt burden ratio, both in their relative relationships and magnitude show signs of stress and similarities to the 1980s.

Literature Review

Credit markets, in general, have inherent and important ties to the growth and wealth of an economy. Barry and Robison (2001) reiterate the repeated, proven connection between the two, "Theory and empirical evidence indicate that the sophistication of financial systems and an economy's growth and development are strongly related to one another [Levine (1997) and Gertler and Rose (1996)]." Given the inherent relationship between the credit markets and an economy, overall, the actions of producers and lenders intuitively, influence one another's decision-making. The lending patterns that have developed overtime—the distribution of credit—affect not only local economies but overall market structures. Kaufman (1986) states that while the relationship between access to credit and economic growth has been important to the development of the relationship between the lenders and the markets they serve, they may not be as efficient as they once were. "Historically, the act of creating debt contributed to economic and financial exhilaration. But in the past several years, we have realized that the obligations inherent in debt may impose hardships on lenders and borrowers and indeed, on the economy and the financial markets as a whole."

In the case of agriculture, financial risk expands further than just the farm business sector. Barry and Robison (2001) point out that losses were disseminated to the government and American taxpayer in the previous farm business sector bust. "Between 1980 and 1997, the farm loan losses of commercial banks and the Farm Credit System totaled $4.57 billion and $3.82 billion, respectively, with most of these losses occurring from 1984 to 1988 [ERS (1998)]. In contrast, the last-resort lending program of the U.S. government, [the Farm Service Agency], experienced loan losses of $20.18 billion" (Barry and Robison 2001).

Previous literature has concluded that producers respond to the signals from lenders about the availability of loans. Barry and Robison show that "…preferences of the lender, as expressed the interest rate and non-interest rate terms of the loan contract, may influence the rate of firm growth, risk management practices, resource allocations, and enterprise choices of the borrower." (Barry and Robison 2001). Barry and Robison (2001) asset that the information lenders communicate to borrowers through price and non-price signals influence the production management of firms. Barry and Robison (2001) continue, "The financial intermediary, thus, provides the service of identifying and monitoring the most promising firms, managers and perspective investments." The conclusion from Barry and Robison (2001) asserts that the financial intermediaries are tasked with understanding the risk levels of both the market and individual borrowers.

Therefore, poor lending practices by creditors may result in riskier behavior by borrowers that will affect not only the firm but have potential to reverberate through the entire farm business sector.

Barry and Robison 2001 discuss historical lending patterns in detail. “Past practices in farm lending, which have included more liberal lending in favorable times and more conservative lending in less favorable times, have strongly influenced the size, profitability, and well-being of family farms” (Barry and Robison 2001). These lending patterns may be inefficient and act counter-productively to the stability and growth of the farm business sector. “During the stress times of the 1980s in the U.S., some institutional responses to risk (e.g., floating interest rates, larger risk premiums in loan rates) had the unintended effects of transmitting credit risk and interest rate risk to healthy agricultural borrowers, thus widening and deepening the adversities” (Barry and Robison 2001).

Barry and Lee (1983) delineate loan portfolio risk into six categories—credit risk from potential default, investment risk from capital losses on assets pledged as collateral, liquidity risk from loss of funding sources, cost of funds risk from unanticipated changes in the cost of funds, financial risk from high financial leverage and regulatory risk from unanticipated changes in the regulatory environment (Barry and Lee 1983). These individual risks are not independent. Barry, Baker and Sanint (1981) expand the definition of the first risk, credit risk, to not only include the borrowers risk of delinquency but add the lenders’ ability to cause credit risk to increase by restricting access to additional credit. Increases in the volatility of credit availability diminishes the value of credit as a source of liquidity. Producers must find other, possibly costlier, sources diminishing the producer's efficiency in managing liquidity. Barry, Baker and Sanint's (1981) work shows that the new definition of risk increases the liquidity and financial risk for the producer and decreases their overall use of leverage. Barry and Robison (2001) use the most recent boom-and-bust cycle of the 1970s and 1980s as an example of the risks associated with the additional volatility credit risk. "Swings in credit conditions can magnify changes in the financial well-being of agricultural producers. In the U.S., for example, the boom times of the late 1970s were fueled by readily available, low-cost credit, only to be met by the credit management and loan repayment problems of the early 1980s, and the significant stresses faced by many financial institutions" (Barry and Robison 2001).

The creation of debt positions by borrowers can be described as two types of investment—replacement and expansion (Penson, Jr., Romain and Hughes 1981). Replacement investments refer to expenditures needed to replace existing capital stock that has lost productivity. Expansion investments on the other hand, expand the producer's current capital stock levels. The estimation of expected farm business investment depends upon understanding the various types of expenditures as well as the annual depreciation associated with the resulting capital stock. Penson, Jr., Hughes and Nelson (1977) state, "If firms behave as neo-classical investment theory suggests, their annual capital expenditures are influenced by the current productive capacity of their exitisting captial stock, while the level of firm output depends on flow of productive services provided by capital, other things being constant." The authors suggest that future expansion decisions depend largely on the return to the investment, or in other words, the productive capacity of the capital stock. The consideration of "real productive value of capital" relates to the basic theory that in equilibrium. Capital expansion decisions will be made such that marginal value product will equal marginal investment cost.

In an article by Penson, Jr., Romain and Hughes (1981), the authors discuss the relationship between current capital stock and desired capital stock. The paper is a development of Penson, Jr., Hughes and Nelson (1977) work which determines the most appropriate depreciation pattern of farm tractors based on engineering data. The authors develop an aggregate investment behavior model assuming the theory of the firm in continuous equilibrium. In their work, the partial adjustment theory applies to the adjustment to desired capital stock. Concluding, it may take more than a single period for the producer to adjust from current capital stock to desired capital stock. The partial adjustment factor, likely in the form of a lagged dependent variable, describes the speed of adjustment (Penson, Jr., Romain and Hughes 1981).

The previously cited authors have looked specifically at capital expenditures as a proxy for the accumulation of debt. Henderson and Kaufman (2013) find that the five-year average of net returns and the level of farm equity primarily cause changes in the magnitude of the dependent variables. Previous to Henderson and Kaufman's (2013) paper much exploration into the development of investment behavior and capital expenditures had not been performed since Penson, Jr., Hughes and Nelson (1977) and Penson, Jr., Romain and Hughes (1981) work. Updating these studies with current data provides the opportunity to assess how these relationships have evolved over time and see how the relationships have changed as the farm business sector has moved into a contraction period.

Several authors have developed work focused on identifying variables that capture the sentiment and actions of lenders and borrowers and those that lead to the ultimate creation of credit standards and lending patterns. Barry, Baker and Sanint (1981) show changes in the interest rates are not exhaustive descriptors. Their article states, "Even when rates do vary, the response may be more to differences in loan sizes and costs of lending than to differences in risk. Instead, lenders' risk responses to differences in a producer's creditworthiness primarily occur in non-price ways that include differing loan limits among borrowers and differences in security and documentation and other means of credit administration." The article notes that signals from lenders may be in the form of loan fund availability. Similarly, considering borrowers, an increase in demand for loans may be a sign of expansionary time for production.

Briggeman and Zakrzewicz (2009) article, "Can the Agriculture Credit Survey Predict National Credit Conditions," highlights other variables of interest. The authors use responses from the Kansas City Federal Reserve Bank's quarterly survey of agricultural bankers in their respective districts to test their overall predictability for the nation. The authors specifically look at loan repayment rates and collateral requirements with the goal of assessing the predictability of trends in loan delinquencies and credit standards on a national level. The authors found that over a 28-quarter period, the regional survey correctly predicts the directional movement of national delinquent farm loans 19 times, a 68% success rate. Since the fourth quarter of 2007 to the second quarter of 2009, the forecast rate of loan repayments correctly predicted the path of delinquent farm loans four out of the total six quarters. Overall, they conclude that the regional forecasts are reliable indicators for national activity.

Many of the papers cited thus far and other industry professionals, consider the debt-to-asset ratio an important indicator of the financial health of the farm business sector. The debt-to-asset ratio uses balance sheet statistics to get an overall measure of leverage. As seen in the 1970 and 1980s, the price of farmland became over-inflated in response to market conditions. As a result, the debt-to-asset ratio did not indicate stress until 1982 which likely caused farm lending to continue despite signals of stress in repayment capacity (J. B. Penson, Jr. 1987). Penson's (1987) article, "Evaluating Financial Trends in Agriculture," illustrates the balance sheet indicators provide insufficient assessments of a market as they focus on unrealized capital gains and losses. The debt-to-asset ratio efficiently evaluates current insolvency but does not work as a preliminary indicator of stress. "These statistics highlight the magnitude of current insolvency problems and do not indicate trends that might ultimately lead to insolvency" (J. B. Penson, Jr. 1987). In addition, Penson's paper emphasizes the need to focus on cash flow versus collateral interests, "The 1980s taught us the importance of lending money to farmers based upon their ability to repay from income rather than principally upon collateral considerations—evaluations of financial health of the farm business sector should consider flow-of-funds as well as the balance sheet." In his paper, he shows that three other ratios or indexes gauge financial stress more efficiently by comparing current income to debt and interest obligations.

Penson considers three measures—the times interest earned, the financial leverage index and the debt burden ratio. Comparing the historical changes for each of these ratios with the changes in the debt-to-asset ratio shows that the debt-to-asset ratio did not vary much from its mean. The increase in the debt-to-asset ratio, when it did change, was due not to changes in debt but to decreases in the value of assets from the large decline in farmland prices. The times interest earned and debt burden ratio, on the other hand, both changed significantly throughout the 1970s signaling changes in the farm business sector's stability (J. B. Penson, Jr. 1987).

The authors presented in the literature review thus far have primarily focused their analysis on either one side of the credit transaction assigning risk responsibility to only the market participant considered. In reality, both sides of the transaction determine and are responsible for the risk created in the market. Assigning responsibility to one merely creates a scapegoat for the actions of the other. The following analysis seeks to address the lack of discussion of the interaction of the providers of credit with those who demand it and how both party's signals affects their individual debt management and the actions of the other party.

Capital Expenditure Methodology

Capital expenditures (CE) measure the expansion of operations or modernization of production. Capital expenditures often times use debt to finance the expansions or modernizations. Therefore, capital expenditures will be used as a measure of risk accumulation for producers. Five models are developed to explain changes in capital expenditures and are broken down into real estate and non-real estate transactions. Real estate capital expenditures considers capital expenditures on buildings and improvements but does not include capital expenditures on land due to the unavailability of data. Non-real estate transactions are separated into expenditures on tractors and expenditures on machinery and equipment. Two explanatory variables are used in each equation. Total return on investment (ROI), calculated as revenue divided by operating costs[2], is included in every equation as an indicator of expected return of the investment in the varying capital expansions. The denominator of the ROI measure captures any impact from interest rates.

A lagged value of capital expenditures associated with each dependent variable is also included as an explanatory variable. The lag of the dependent variable for each model accomplishes two goals. First, it captures the dynamic effects present in capital expenditure outlays—current capital expenditures depend on previous capital expenditure levels. The independent variable can be intuitively explained as a speed of adjustment factor. The desired capital stock of a company equals the sum of current capital stock and net investment, capital expenditures, minus depreciation. The company will make capital expenditure decisions to satisfy their desired capital stock level. Second, the relationship between current and previous capital expenditures creates the structural issue of auto correlation in the model. The inclusion of the lagged dependent variable accomplishes the task of removing the autocorrelation present in the

[2]The operating cost value includes capital consumption.

model. Intuitively, the coefficient of the lagged dependent variable should be less than one. The coefficient represents the proportion of the capital expenditures explained by its lagged term.

Initially, an ordinary least squares regression (OLS) is used to estimate the relationship between the total real estate, total non-real estate, tractor, and machinery and equipment variables and the independent variables:

$$CE_{Total\ Real\ Estate,t} = f(ROI_t, CE_{Total\ RE,t-1}) \tag{59}$$

$$CE_{Total\ Non-Real\ Estate,t} = f(ROI_t, CE_{Total\ Non-RE,t-1}) \tag{60}$$

$$CE_{Tractors,t} = f(ROI_t, CE_{Tractors,t-1}) \tag{61}$$

$$CE_{Machinery\ \&\ Equipment,t} = f(ROI_t, CE_{Machinery\ \&\ Equipment,t-1}) \tag{62}$$

Seemingly unrelated regression (SUR) equations are also estimated to determine if more information would be gained if it is assumed that the errors of the equations are contemporaneously correlated. Intuitively, the equations' errors are likely correlated.

A series of robustness tests are executed for each regression. The Breusch-Godfrey test (BG) determines the existence of autocorrelation in a regression. Autocorrelation defines the correlation of the dependent variable with itself overtime. Essentially, there exists a systematic relationship between the residuals of a regression or the magnitude or sign of an error in one period has an effect on the magnitude or sign of an error occurring in a future time period. In time-series analysis, OLS requires disturbances from the typical path of a variable occur independently across periods. The OLS estimation results in the presence of autocorrelation are unbiased (as long as the explanatory variables are strictly exogenous) or consistent but are not efficient. The

OLS standard errors and test statistics are also no longer valid, even asymptotically (Wooldridge 2015). The OLS statistics are invalid and cannot be used for testing proposed hypothesis.

The BG test for autocorrelation generalizes to any order of autocorrelation. The more commonly used test, the Durbin-Watson, restricts testing for AR (1) processes only, where 1 represent the order of autocorrelation. The BG test is a Lagrange multiplier test. Using the residuals from the OLS estimation of the original equation, the BG test regresses lagged residuals up to lag q and the original independent variables. The joint test is of the first q autocorrelations of the residual.

$$\epsilon_t = \rho_1\epsilon_{t-1} + \cdots + \rho_q\epsilon_{t-q} + \beta_1 x_t + u_t \tag{63}$$

The null hypothesis states no autocorrelated relationship exists and the rho coefficients equal zero. The alternative hypothesis states the presence of an AR(q) process. Drawbacks of BG test lie in the testing for joint significance and the choice of the appropriate lag to test. Distinguishing the important lagged residual may be difficult. The test is also only valid asymptotically.

White's General Test for Heteroscedasticity determines if the variance of the error terms depend on the regressors. If the variance of the error terms depends on the regressors and is not constant, heteroscedasticity is present. The OLS process assumes the variance of the error must have a consistent variance across any value of the regressors (Wooldridge 2015). If a model fails the assumption and contain heteroskedastic errors, the estimators remain consistent but not efficient. The interpretation of the coefficients is also not an issue in the presence of heteroscedasticity.

White's General Test can be used for nonlinear forms of heteroscedasticity and when the error terms may not be normally distributed. White's test regresses the original independent variables, the square of the independent variables and their cross products on the squared residuals from the initial estimation. As can be surmised from the list of regressors, when all of the regressors are used to test for the various types of heteroscedasticity, a large number of degrees of freedom are used. Due to the small number of explanatory variables used in the OLS and SUR models it is assumed that the number of degrees of freedom would be sufficient to avoid the loss of power of the test. Multiplying the r-squared from the regression by the number of observations determines the Lagrange Multiplier test statistic. The test statistics follows a chi-squared distribution with the degrees of freedom equaling the number of regressors in the test equation. A test statistic greater than the chi-squared critical value at the indicated level of significance, usually 5%, rejects the null hypothesis that the error terms are homoscedastic (Wooldridge 2015).

Finally, the variance inflation factor (VIF) determines the existence of multicollinearity between exogenous variables. OLS assumptions require uncorrelated explanatory variables. The VIF provides a statistical measure for each coefficient and can be calculated for coefficient j as follows:

$$VIF_j = \frac{1}{1 - R_j^2} \tag{64}$$

where R_j^2 represents the r-squared from regressing variable j on all the other independent variables and the intercept. The VIF can be explained as the increase in the variance of the coefficient due to the correlated nature of the variable with any of the other explanatory variables. No range of acceptable VIF measures exists to decisively indicate too much or an appropriate amount of multicollinearity existing in the model. Ultimately, the objective is to minimize the VIF measure. A VIF of 10 is used to indicate a general threshold of concern for modeling purposes.

Two years of ex-post forecasts are estimated for each dependent variable for the years of 2014 and 2015. 1975 to 2013 data is used as the in-sample forecast period and is used to calibrate the model. Two forecast evaluation measures evaluated the strength of the model and its ability to forecast the out-of-sample observations of the forecast objects. These evaluations primarily measure the ability to capture magnitude changes. The forecast evaluations weight each forecast observation equally with the objective to minimize the measures.

The root mean squared error (RMSE) is the average unit amount the forecast is incorrect over the entire forecast period. The equation for calculating the RMSE is as follows:

$$RMSE = \left[\frac{1}{M}\sum_{t=1}^{M}(F_t - A_t)^2\right]^{\frac{1}{2}} \tag{65}$$

where M measures the number of periods included in the forecast; F_t represents the forecasted value and A_t represents the actual value.

The second forecast evaluation used is the mean absolute percent error (MAPE). The MAPE considers the average percentage difference of the out-of-sample forecast and the actual observed values or the average percent forecast error. The following equation calculates the MAPE of a forecasted series:

$$MAPE = \frac{1}{M} \sum_{t=1}^{M} \left| \frac{F_t - A_t}{A_t} \right| * 100 \tag{66}$$

Capital Expenditure Data

The data used is sourced from the USDA Economic Research Service (ERS), Farm Income and Wealth Statistics (FIWS) and the USDA National Agricultural Statistics Service (NASS). The FIWS data source accumulates data observations on income and balance sheet measure for individual states and the United States as a whole. Data collection and publication takes place in February, August and November. Historical data included are national, annual averages spanning from 1974 to 2015 giving the model a total of 41 observations. The deflator used mimics the method implemented by USDA NASS, which uses the GDP chain-type price index published by FRED with 2009 as the base year.

Capital expenditures and ROI data are obtained from the USDA FIWS. The estimated equations are divided into four measures of capital expenditures— real estate capital expenditures, non-real estate capital expenditures, capital expenditures on tractors and capital expenditures on machinery and equipment. The various capital expenditure measures are from the “Gross Capital Expenditure” data release. The FIWS data series provides a breakdown of each of these expenditure measures. Real estate capital expenditures include expenditures on buildings, land improvements and include operator dwellings. Capital expenditures for the purchase of land, while desirable for the analysis, are excluded in the data provided by the USDA. Non-real estate capital expenditures include those on motor vehicles, tractors, machinery and equipment. Figure 4.27 presents the historical total capital expenditures from 1967 to 2016.

The return on investment explanatory variable is calculated as revenue divided by total operating cost plus capital consumption. The "Return to Operator" data from the USDA FIWS data file, "Gross Receipts of Farms" provides the data for the revenue measures. The total operating costs data comes from the "Farm Production Expenses" from the same source and includes capital consumption. Table 4.27 presents the descriptive statistics of the data used in the capital expenditure regressions.

Capital Expenditure Empirical Results

The regression results proved promising in terms of statistical significance as well as each model's ability to capture the dependent variables' variation. Table 4.29 shows the results for the in-sample OLS and SUR models.

In all models, the adjusted R^2 values are greater than 0.80 meaning the models explain at least 80% of the variation in the dependent variables. Additionally, all variables are statistically significant at least at the 10% level and most are significant at the 1% level. The SUR model, overall, performed better in terms of the adjusted R^2. The signs of the coefficients are also as expected for both the OLS and SUR output. As an investment becomes more profitable, or as the ROI increases, the amount of investment will increase, as expected. Therefore, the positive coefficients associated with ROI are as consistent with expectations.

Capital expenditures in the previous time period are expected to have some effect on the capital expenditure in the following period. As seen from the results, the positive and near one coefficient associated with the lagged dependent variables shows the expected relationship. A coefficient of a lagged dependent variable can be interpreted as the partial adjustment associated with that variable. The coefficient represents the portion of the dependent variable determined by its lag. Generally, a lagged variable greater than one indicates an issue and may imply over-adjustment.

Following the estimation of the models, robustness tests for multicollinearity, serial correlation and heteroscedasticity are performed. Each test shows no signs of any time-series related issues. The outcomes of the robustness tests can be seen in Table 4.30. The minimum threshold of issues with multicollinearity used is 10. All models have VIFs less than 2. The null hypothesis for the BG test is that there does not exist evidence of serial correlation. As the p-values in Table 4.30 show, all tests fail to reject the null hypothesis. Finally, White's General Test for Heteroscedasticity testing the null hypothesis of no evidence of heteroscedasticity fails to be rejected in all regressions.

A double log transformation of the dependent and independent variables yields elasticity measures for each of the calculated coefficients. The coefficients can be interpreted as the elasticity of the dependent variable with respect to the independent variable. The coefficients then infer the percent change in the dependent variable given a 1% change in the independent variable holding all other variables constant. These results can be seen in Table 4.31.

The total ROI measures in the OLS estimations, on average, have an effect on the independent variables by about 1.2%. The ROI has the largest effect on capital expenditures on machinery and equipment. When ROI increases by about 1%, capital expenditures on machinery and equipment increases by about 1.4%.

The lagged dependent variable has an average effect on the dependent variable of about 0.97% across OLS regressions. Again, the maximum percentage change occurs in the case of the lagged dependent variable for the capital expenditures on machinery and equipment at about 0.99%.

The elasticities for the SUR models are slightly lower. In the case of the total ROI measure, a 1% increase in total ROI increases the dependent variables between 0.83% and 1.1% across the SUR regressions. Real estate capital expenditures on buildings and improvements yields the minimum ROI elasticity whereas capital expenditures on machinery and equipment yields the largest. The elasticities for the lagged dependent variable for the SUR models range from 0.88% for non-real estate capital expenditures and 0.90% for real estate capital expenditures on buildings and improvements.

The forecast output from each model yield promising results based on the forecast evaluations measures. Table 4.32 shows the RMSE and MAPE of each forecast. In all cases except forecasting capital expenditures for tractors, the SUR model outperformed the individual OLS estimations. All MAPEs are less than 24% meaning that the models, on average, are incorrect by less than 24% on each forecast. The MAPEs associated with the total real estate capital expenditures on buildings and improvements are the lowest at 11.51% and 11.31% for the OLS and SUR models, respectively. The recent observations for the variable have far less variation compared to capital expenditures on non-real estate assets. Therefore, it is intuitive that the MAPE would be lower. See Figure 4.34 through Figure 4.37 for model outputs for the OLS forecasts. All SUR model output yield slightly smaller magnitudes than the OLS forecasts. Table 4.33 provides the margin of error for each of the forecasts. The margin of error indicates over or under estimation of the values estimated by the models. The calculation measures the margin of error as the forecast value divided by the actual observation. Therefore, the closer the value is to 100 the closer the forecast is to the actual observation. In both the OLS and SUR models, the forecasts underestimate the amount of capital expenditures in 2014 by about 93% and 92%, respectively. In 2015, both sets of models over estimate the amount of capital expenditures by about 130% and 128%, respectively. In the 2014 estimate, the OLS model performs better than the SUR model and vice versa for the 2015 forecast in terms of absolute magnitude differences.

The models provide estimated capital expenditures based on expected economic behavior. From the lender's standpoint, the model provides a more conservative perspective than the actions observed in the market. The past has shown serious overshooting in capital expenditures following negative signals from the market. The model shows an expected decrease in capital expenditures following a decrease in ROI. Intuitively, lenders should limit lending and producers should minimize expansions or modernizations of their operations when ROI falls.

Federal Reserve Survey Analysis

To gain a better understanding of the farm business sector business environment, we considered data available from the Chicago and Kansas City District Federal Reserve Banks. These data sets provide insight into the current market's strength and the borrowers and lenders sentiment about the market and their expectations for the future. Table 4.28 outlines several of the questions and possible responses asked by the Federal Reserve banks. Specifically, six questions outlining lenders' sentiment and current lending practices are used. Questions used to gauge the current status of the market are changes in the rate of loan repayment; renewals and extension of loans; and the percent of lenders' portfolios falling into repayment problems ranging from no significant repayment problems to severe repayment problems. Questions about the changes in the availability of funds, lender's collateral requirements, changes in overall credit standards, the expected repayment rates and percent of loan portfolio in severe stress determine lender sentiment. Analyzing these data series over time show how sentiment and actions either coincide or lead one another. The analysis of the series together provides intuition for understanding the supply of credit to the farm business sector.

Federal Reserve Survey Data

Data on the sentiment and actions of agricultural lenders comes from surveys given to regional bankers whose loan portfolios are predominately agricultural loans. The survey is sent out quarterly on the first of April, July, October and January. The Chicago Federal Reserve, 7th district, and the Kansas City Federal Reserve, 10th district, both have reasonably long historical data series and provide a significant amount of data on the questions asked to participants. The Chicago Federal Reserve covers banks in Illinois, Indiana, Iowa, Michigan and Wisconsin. The Kansas City Federal Reserve sends surveys to banks in Colorado, Kansas, Nebraska, Oklahoma, Wyoming, Northern New Mexico and Western Missouri. Both banks receive around 200 responses from bankers per quarter. The Chicago Federal Reserve's historical series span from 1992 to the first quarter of 2016. The Kansas City Federal Reserve spans from 1980 to the first quarter of 2016.

All 10th district data is on an indexed scale where 100 indicates no change. If the value of the index is greater than 100, than the question at hand has seen an increase compared to a quarter or year prior. For the 7th district, a couple of scales are used. In the case of the question concerning the percent of the bank's loan portfolio containing major or severe stress, answers are a percentage. The measure of change in credit standards of the bank ranges from 1 to 5. 1 indicates credit standards have eased considerably; 2, eased somewhat; 3, there is no change; 4, credit standards have tightened somewhat and 5, tightened considerably. Therefore, 3 represents the base-line of the index indicating no change. Any value above 3 implies credit standards overall have increased, and below 3, credit standards have eased. Once again, the question considers the change in the variable over the last three months when previously surveyed. Four questions ask about changes in loan variables and the comparison of those variables to their magnitude three months prior. The answers range from 1 to 3 with 1 indicating the variable has increased; 2, it has decreased and 3, there has been no change. For the sake of graphing and intuitively interpreting results, these values are converted to the following range: 1 indicates a decrease; 2, no change and 3, an increase. Table 4.28 outlines the questions asked and possible answers in detail.

Lender Analysis

Figure 4.38 shows the historical data of changes in loan repayment rates and renewal and extensions of current loans. Both series are indicative of the overall health of the borrower and therefore, agriculture credit market. The measure of loan renewals and extension index has a similar implication of a borrowers' ability to repay loans but also shows the current need to restructure debt due to cash flow inadequacies. The two series have a strong negative correlation. As loan repayment rates increase, or the bank's loan portfolio risk decreases, the demand for renewing or extending loans decreases. The data series shows a similar relationship in both direction and magnitude as was witnessed in the 1980s. The similarity suggests a cause for concern in today's market.

Figure 4.39 overlays collateral requirements and loan repayment rates. The collateral requirement graph shows the lender's response to the change in credit risk. The relationship of these two series answers the question of, "as lenders notice changes in the repayment rates, what actions do they take to manage potential risk?" The two series, in general, evolve as one would expect. As the market becomes riskier and repayment rates decrease, collateral requirements are likely to increase to hedge against that risk. Interestingly, the constant above 100 outcome for the change in collateral requirements indicate banker's requirements are always increasing. These series also fluctuations minimally overtime.

Today, Figure 4.39 shows the repayment rate has dropped to about 52% yet the collateral requirements have increased only slightly. A similar scenario was present in the 1990's. Repayment rates dropped to about 54% with little change in the collateral requirements. The level of collateral requirements is similar to that of 2009 when expected repayment rates were about 94%. The minimal change in collateral requirements despite the decrease in borrowers' ability to repay their loans shows a disconnect between the markets ability to pay and lenders' actions. Lenders do not seem to be tightening their lending standards. The lack of response indicates they are continuing to expand their risk positions. They are also not signaling to the farm business sector the change in risk they are witnessing in the decrease in repayment rates.

Figure 4.40 shows the demand for renewals and extensions with the regional bank's level of funds available for making loans. The comparison of these series shows the relationship of need for liquidity in the farm business sector and the lender's willingness to supply that liquidity. The graph also shows the action banks take in response to their feelings about the overall farm business sector. Largely, the two series move in opposite directions. As the credit market becomes riskier, the banks tighten the funds they are willing to loan. Barry and Robison (2001) show that the natural risk aversion response has negative repercussions that cause a market to become riskier. The short-term cash flow problems lead to overall liquidity problems and the need to restructure debt or carryover loans to the next period. As banks restrict access to funds, producers who may have positive long-term business prospects are put under stress and may not be able to sustain operations. The stress of these businesses who fail increases the overall risk in the market. As was seen in the 1970s and 1980s, as more businesses failed, cropland prices plummeted as much of the debt was collateralized by the land. As a result, governmental assistance and borrowing from FSA occurred.

Today, the demand for renewals and extensions is the greatest it has been in the last 28 years yet loan fund availability is only slightly lower at about 95. Lenders are not contracting loan creation very heavily. The lack of contraction in the loan funds available is positive from the perspective of Barry and Robison (2001). The availability of loan funds reduces the credit risk from not having access to loans. On the other hand, the lack of reduction of funds is another indication that lenders are continuing to expand their risk positions despite signals of stress in the farm business sector. They are also not signaling to the sector the increase in risk they are observing and possibly encouraging the farm business sector to take on more debt.

The data from the 7th district Federal Reserve Bank provides more intuition into stress in the portfolio of the banks and the collateral expenditures of the borrowers while also providing similar indicators as the 10th district in terms of overall market stress and lender's actions in response to those risks. In Figure 4.41, two series are considered—the percentage of the bank's portfolio with major or significant repayment problems and changes in bank credit standards. There are there time periods where major credit standard tightening occurred—in the early 2000s, the late 2000s and today. The recession in the greater macro economy and the issues of trade that resulted from it likely caused the contraction in the late 2000s. Today, a similar uptick in the level of credit standard tightening has occurred. Similar to the 10th district's collateral requirement levels, the change in credit standards above three at all times indicates credit standards are either tightening to some extent or not changing.[3] Major stress in loan portfolios reached a maximum in the late 1990s. Today, stress has increased but remains 44% below the maximum reached in the late 1990s. Today differs from the late 1990s in terms of the systematic issues present in the farm business sector today.

The two series show that the tightening of credit standards coincide with increases in the percentage of stress in the loan portfolio (2006-2008 and 2012-2013). Considering Figure 4.42, the tightening of credit standards starting in 2012 preceded the downturn in net farm income that began in 2014. Since 2013, net farm income has decreased, credit standards have increased and the amount of stress in the loan portfolios has increased. Figure 4.43 measures banker's expectations of the changes in various capital expenditures over the next year. The graph shows that indicators of stress tend to occur several years prior to changes in capital expenditures. Two time periods show bankers indicating increases in stress— either through increases in repayment problems or through tightening of credit standards. From 1998 to 2001, credit standards tightened but capital expenditures were expected to continue to increase until 2004. In 2008 and 2009, repayment issues increased yet, bankers indicated that they believed capital expenditures would continue to increase through 2011. These final graphs depict lender's sentiment about the market not aligning with their actions creating a riskier loan portfolio for themselves, and the market overall.

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[3] A response of 3 means no change and a response of 4 or 5 indicates some level of tightening of credit standards.

The most recent data shows the percent of “major” and “significant” stress in the loan portfolio has increased since 2012. The percent of the portfolio falling into these two categories doubled from 2.2% to 4.4% from 2014 to 2015. The increase in loan portfolio stress indicates the farm business sector is in stress. Lenders are expected capital expenditures in all categories to contract and have expected them to do so since 2013. These indexes are currently at their lowest value in the history of the data. The contraction in the capital expenditures is a signal of a contraction in the farm business sector. The two signals the graph is portraying—stress and sector contraction—compared to the change in credit standards show different conclusions. The index shows credit standards have increased only slightly with a value of 3.5. In comparison, 2008 saw a similar index value for change in credit standards yet repayment problems were at about 2.1% and lenders were expecting no changes to capital expenditures. Once again, lenders are not showing they are contracting loan origination despite signals of stress and sector contraction.

Conclusions

The timeline of events for the previous boom and bust cycles in agriculture are more alike than different. A predominant pattern is the failure to contract capital expenditures when the market signals the farm business sector may no longer be in a period of growth. The lack of risk aversion from the market creates several risks with the continued growth in capital expenditures. Continual use of debt to finance these capital expenditures adds risk to both market participants. The additional expansion into certain specialty equipment, i.e. cotton-picking machinery, hampers producers’ ability to adjust to more lucrative enterprises due to the asset fixity they have created. As the markets become tighter and cash flows diminish, producers are less able to service their increased debt positions and are less able to transition to alternative enterprises and manage cash flow. Through the development and forecasting of capital expenditures, the models for each type of capital expenditure show tightening a year prior to when it actually occurred in the market. The following year, the model shows a moderate increase in capital expenditures whereas the market in all types of capital expenditures contract substantially.

A deeper consideration into the debt positions of the aggregate market shows more similarities between the farm business sector's ability to cash flow its debt and the 1980s farm business sector than recently touted. Since that time period, the market has not seen the debt burden ratio grow substantially larger than the times interest earned until today. Data from the 7th and 10th District Federal Reserve Banks provides insight to better understand the changes in these debt positions. The data sets provide micro-level sentiment and action data from regional agriculture bankers.

The 10th district shows an overall negative correlation between the demand for liquidity through the measure of demand for renewals and extensions and the willingness to provide liquidity with the loan fund availability and collateral requirements measures. The negative correlation, although expected, poses additional risk to the market, if substantial. Many of 7th and 10th district data show that throughout history, regional bankers' negative outlook on the market, does not reduce their expectations of expansions in capital expenditures and therefore, expansion in debt and risk levels.

Looking solely at loan repayment rates and renewals and extensions, the graph shows a similar situation to that of the 1980s. Loan repayment rates have declined past levels seen in the late 1980s and demand for renewals and extensions are much greater than late 1980s levels.

Today, the lender surveys indicate the level of stress in their loan portfolios are increasing and they are expecting the farm business sector to contract. Yet, the lenders are not responding by reducing the loans funded to the sector nor are they increasing their standards of lending to reduce the risk in the loans they are originating. The lenders' actions are not matching their sentiment towards the strength of the farm business sector and therefore are also not signaling to the market an increase in stressful times.

The past and present farm business sector are showing similarities across debt ratios and actions between borrowers and lenders, similarities that have been noted through multiple boom-and-bust cycles. Understanding the pattern and how it has been repeated, lenders and borrowers have an ability to better manage their risk at both an earlier time and when in the midst of a contraction period.

CHAPTER V

CONCLUSIONS

Cropland markets, in general, prove difficult to empirically model. The nuances associated with the markets are numerous. The qualitative factors adding to the value placed on the land make quantifying the market price difficult. Two models have been proposed to value and better understand the pricing mechanisms associated with cropland. The results show the complexity of successfully doing so. The final chapter addresses the relationship between debt and cropland prices that has proven important in the overall stability of cropland markets as well as the farm business sector.

Two models have been applied to cropland models that have not been done in the past. The methodologies address varying intricacies of cropland that have previously been discussed in literature but not explicitly modeled. This paper served to address those holes in the research of cropland valuation. Additionally, the relationship between debt and cropland price stability is studied in more detail. The study overall shows a repeated pattern of behavior in the farm business sectors that creates a riskier environment that may be present in the rapid increases in cropland prices seen in the market today.

Addressing the Shortcomings of Previous Cropland Valuation Techniques

The model addresses two significant shortcomings in previous cropland valuation literature. Cropland is in an incomplete market structure carrying both hedgeable and unhedgeable risk. Previous models also required strict assumptions to state variables used in the estimation of cropland price. The use of the good-deal bound approach in a dynamic optimization framework addressed both of these limitations.

Despite both of these issues being addressed, the model severely underperformed pricing the market price of cropland. Several factors are likely the cause of the undervaluation. As noted above, many of the factors that are valued for a given piece of land are not related to the income yielded from the land nor are they quantifiable. These factors would also not be present in the capitalized valuation of land. The model output is also substantially lower than the capitalized value of land therefore there remains a margin of error unexplained by this argument.

Other factors may be that the price responses of rent are not symmetric as income increases and decreases. As shown in chapter III, asymmetric price transmissions are present in the relationship between rent and crop prices. As a result, the model may not be addressing the positive and negative price movements appropriately.

Finally, the idea of real options is that in reality people will price a good with the understanding that a certain amount of risk is hedgeable and therefore the price will not price for that risk. In many of the models, the hedgeable risk is assumed to be high with the magnitudes of the R^2 associated with the model outputs. Therefore, the substantial margin between the actual and modeled prices may have to do with the fact that in reality, people do not consider the hedgeability of an asset not directly traded on an exchange and therefore would not reduce the price of the asset accordingly.

While the model does not reflect the market price of cropland, it may provide insight on an inherent price of land and the possible overvaluation that is placed on the asset. The exercise, none-the-less reiterates the difficulty in empirically modeling cropland despite the number of nuances addressed by the approach in this paper.

Re-Addressing Sticky Rental Rates

As a direct extension of the previous chapter, the asymmetry of rent in response to changes in crop prices is empirically tested. While the topic of asymmetry in rents has been discussed in literature it has not, in practice, been tested. Using an error correction model, the results show the presence of asymmetry in both the short-run and long-run. The results show a consistent, positive asymmetry across crop estimations and in both the short and long-run.

The positive asymmetry present in the short-run dynamics indicate landowners likely have more power in the determination of rental rates. The positive asymmetry suggests that rent in the short-run will react more fully to increases in crop prices or that prices are also less likely to decrease as rapidly as crop prices decease and production becomes less profitable.

The positive asymmetry is present in the long-run effects of the models as well. The coefficients of the co-integrating variables also have the expected negative signs. The residuals represent an over or undervaluation of the rent term in the long-run and therefore act as corrective portions of the model. In both cases, the coefficients are expected to be negative to achieve the corrective mechanism.

Asymmetry was found in every model estimated and the type of asymmetry was consistent across all three models. The results are economically interesting and provide a basis for shaping future research on the relationship between income, rental rates and cropland values.

The Re-Emergence of Previous Boom and Bust Patterns in Today's Cropland Markets

Previous patterns of the boom and bust cycles in the farm business sector suggest a relationship between the use of debt for capital expansion and the busts of the cycles in the sector. Specifically, the farm business sector has repeatedly witnessed significant capital expansion occurring despite signals of a contraction in the market. Since debt is used to finance these expansions, the market participants become overleveraged and unable to service their debt once markets contract. The additional risk from the debt position further stresses the markets and causes instability overall.

From the analysis of the Federal Reserve Bank Surveys, agriculture markets may be in more similar of a situation to that of the 1970s and 1980s then recently believed. Stress is seen in the form of increased demand for renewals and extensions of loans and a decrease in the loan repayment rate. These surveys are showing levels similar to those witnessed in the 1980s. Additionally, while the overall debt-to-asset ratio is lower for the farm business sector overall, statistics used to measure the ability of an entity to service debt are not as robust. The times interest earned and the debt burden ratio, both measures of the ability to service debt, are similar to the relationship and magnitude that was seen in the 1980s.

The debt positions and actions of the borrowers and lenders are more similar to the previous boom and bust cycles than they are different. While the lower debt to asset ratio is continually touted in recent literature on the subject, one must consider the measures that tell about the farm business sector's ability to service debt.

Limitations and Suggestions for Future Research

As noted previously, the research in this paper does come with data and methodological limitations. The model could be improved with a more granular data set. As is, states are represented by a single crop price which in many cases only represents ten or less percent of the cash receipts from the state's agriculture. If county-level data was available, crop prices would better represent the income yielded from production.

Similarly, this study is looking only at crop production. In some cases, the states are predominantly livestock or specialty crop producers. Access to richer price data series would allow this study to be expanded to more than just crop production. The results in chapter III may also be improved by creating a stronger criterion for the grouping of states into crop price delineation. The criteria may be along the lines of a certain amount or percentage of the state's cash receipts must be from the crop to include it in that model.

The results from the model in chapter III may benefit the model specification in chapter II. A better understanding and modeling of the asymmetric price transmission relationship among the specific crop producing states may yield better results when applied in the model from chapter II.

The data from the Federal Reserve surveys have several limitations. The results represent only a subset of the United States therefore may not be generalizable. The questions asked in the surveys are also specific to the region the survey is distributed.

Therefore, some data may be available in one region of the United States but not another. The dates for which data are available are also not consistent and not considerably long. The historical observations are limited and unfortunately some data does not even go back to the 1970s. Therefore, comparisons made between the market today and previous cycles may be extremely limited.

REFERENCES

2003. "Direct and Counter-cyclical Payment Program." Fact Sheet, Farm Service Agency, United States Department of Agriculture, Washington D.C.

2008. "Direct and Counter-Cyclical Payment (DCP) Program." Fact Sheet, Farm Service Agency, United States Department of Agriculture, Washington D.C.

2014. "What's in the 2014 Farm Bill for Farm Service Agency Customers." 2014 Farm Bill Fact Sheet, Farm Service Agency, United States Department of Agriculture, Washington D.C.

2015. "Assets, Debt, and Wealth." *United States Department of Agriculture*. Accessed January 5, 2016. www.ers.usda.gov.

2016. *USDA ERS*. February. Accessed Febrauary 2016. https://www.ers.usda.gov/.

2016. *USDA NASS*. February. Accessed February 2016. https://www.nass.usda.gov/.

Adeyemi, Olutomi I., and Lester C. Hunt. 2007. "Modelling OECD industrial energy demand: Asymmetric price responses and energy-saving technical change." *Energy Economics* 29: 693-709.

Alston, Julian M. 1986. "An Analysis of Growth of US Farmland Prices 1963-82." *American Journal of Agricultural Economics* 68 (1): 1-9.

Archer, Wayne R., and David C. Ling. 1993. "Pricing Mortgage-Backed Securities: Integrating Optimal Call and Empirical Models of Prepayment." *Real Estate Economics* 21 (4): 373-404.

Azzam, Azzeddine M. 1999. "Asymmetry and Rigidity in Farm-Retail Price Transmission." *American Journal of Agricultural Economics* 81 (3): 525-533.

Bachmeier, Lance, and James M Griffin. 2003. "New Evidence on Asymmetric Gasoline Price Response." *Review of Economics and Statistics* .

Bailey, DeeVon, and B. Wade Brorsen. 1989. "Price Asymmetry in Spatial Fed Cattle Markets." *Western Journal of Agricultural Economics* 14 (2): 246-252.

Balke, Nathan S., and Thomas B. Fomby. 1997. "Threshold Cointegration." *International Economic Review* 38 (3): 627-645.

Balke, Nathan S., Stephen P. Brown, and Mine K Yucel. 1998. "Crude Oil and Gasoline Prices: An Asymmetric Relationship?" *Economic Review- Federal Reserve Bank of Dallas*, January 1: 2-11.

Ball, Laurence, and N. Gregory Mankiw. 1994. "Asymmetric Price Adjustment and Economic Fluctuation." *The Economic Journal* 104: 247-261.

Barnard, Charles H., Gerald Whittaker, David Westenbarger, and Mary Ahearn. 1997. "Evidence of Capitalization of Direct Government Payments into U.S. Cropland Values." *American Journal of Agricultural Economics* (Oxford University Press) 79 (5): 1642-1650.

Barry, Peter J. 1978. "Rural banks and farm loan participation." *American Journal of Agricultural Economics* 60 (2): 214-224.

Barry, Peter J., and Lindon J. Robison. 2001. *Agricultural finance: Credit, credit constraints, and consequences*. Vol. 1. Handbook of Agricultural Economics.

Barry, Peter J., and Warren F. Lee. 1983. "Financial Stress in Agriculture: Implications for Agricultural Lenders." *American Journal of Agricultural Economics* 65 (5): 945-952.

Barry, Peter J., Charles B. Baker, and Luis R. Sanint. 1981. "Farmers' Credit Risk and Liquidity Management." *American Journal of Agricultural Economics* 63 (2): 216-227.

Bartholomew, Lynn, Jonathan Berk, and Richard Roll. 1988. "Mortgage Securities Research Adjustable Rate Mortgages: Prepayment Behavior." *Housing Finance Review* 7 (1): 31-46.

Black, Fischer. 1976. "The Pricing of Commodity Contracts." *Journal of Financial Economics* (Noth-Holland Publishing Company) 167-179.

Blinder, Alan. S. 1982. "Inventories and Sticky Prices: More on the Microfoundation of Macroeconomics." *The American Economic Review* 72 (3): 334-348.

Borenstein, Severin, A. Colin Cameron, and Richard Gilbert. 1997. "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?" *The Quarterly Journal of Economics* 112 (1): 305-330.

Boyd, Milton S., and B. Wade Brorsen. 1988. "Price Asymmetry in the U.S. Pork Marketing Channel." *Applied Economic Perspectives and Policy* 10 (1): 103-109.

Briggeman, Brian C. 2010. "Debt, income and farm financial stress." *Main Street Economist*.

Briggeman, Brian C. 2011. "The Role of Debt in Farmland Ownership." *Choices* 26 (2).

Briggeman, Brian C., and Christopher Zakrzewicz. 2009. "Can the Ag Credit Survey Predict National Credit Conditions?" *Economic Review - Federal Reserve Bank of Kansas City* 93-110.

Buckle, Robert A., and John A. Carlson. 2000. "Inflation and Asymmetric Price Adjustment." *Review of Economics and Statistics* 82 (1): 157-160.

Burt, Oscar R. 1986. "Econometric Modeling of the Capitalization Formula of Farmland Prices." *American Journal of Agricultural Economics* 68 (1): 10-26.

Chen, Li-Hsueh, Miles Finney, and Kon S. Lai. 2005. "A threshold cointegration analysis of asymmetric price transmission from crude oil to gasoline prices." *Economic Letters* 89: 233-239.

Chinloy, Peter. 1989. "The Probability of Prepayment." *The Journal of Real Estate Finance and Economics* 2 (4): 267-283.

Clark, J. Stephen, Murray Fulton, and John T. Scott. 1993. "The Inconsistency of Land Values, Land Rents and Capitalization Formula." *American Journal of Agricultural Economics* 75 (1): 147-155.

Cochrane, John H. 2005. *Asset Pricing*. Princeton: Princeton University Press.

Cochrane, John H., and Christopher L. Culp. 2003. "Equilibrium Asset Pricing and Discount Factors: Overview and Implications for Derivatives Valuation and Risk Management." In *Modern Risk Management: A History*, by Peter Field, 57-92.

Cochrane, John H., and Jesus Saa-Requejo. 2000. "Beyond Arbitrage: Good-Deal Asset Price Bound in Incomplete Markets." *Journal of Political Economy* 108 (1): 79-119.

Damania, Richard, and Bill Z. Yang. 1998. "Price Rigidity and Asymmetric Price Adjustment in a repeated Oligopoly." *Journal of Institutional and Thoeretical Economics* 154: 659-679.

Deng, Yongheng, John M. Quigley, and Robert Van Order. 2000. "Mortgage Terminations, Heterogeneity and the Exercise of Mortgage Options." *Econometrics* 68 (2): 275-307.

Dixit, Avinash K., and Robert S. Pindyck. 1994. *Investment Under Uncertainty*. Princeton University Press.

Doye, Damona. 2016. "Farm Finance Theme Overview: Are the Good Times Really Over?" *Choices* 31 (1).

Du, Xiaodong, and David A. Hennessy. 2012. "The Panting Real Option in Cash Rent Valuation." *Applied Economics* 44 (6): 765-776.

Du, Xiaodong, and David A. Hennessy. 2008. "The Planting Real Option in Cash Rent Valuation." Department of Economics, Iowa State University, Center for Agricultural and Rural Developme.

Ellinger, Paul, Allen Featherstone, and Michael Boehlje. 2016. "Leverage of U.S. Farmers: A Deeper Perspective." *Choices* 31 (1).

Enders, Walter, and C. W. J. Granger. 1998. "Unit-Root Tests and Asymmetric Adjustment With an Example Using the Term Structure of Interest Rates." *Journal of Business and Economic Statistics* 16 (3): 2939-2955.

Enders, Walter, and Pierre L Siklos. 2001. "Cointegration and Threshold Adjustments." *Journal of Business and Economic Statistics* 19 (2): 166-176.

Falk, Barry. 1991. "Formally Testing the Present Value Model of Farmland Prices." *American Journal of Agricultural Economics* 73 (1): 1-10.

Falk, Barry, and Bong-Soo Lee. 1998. "Fads Versus Fundamentals in Farmland Prices." *American Journal of Agricultural Economics* 80 (4): 696-707.

Featherstone, Allen M., and Charles B. Moss. 2003. "Capital Markets, Land Values, and Boom-Bust Cycles." *Government Policy and Farmland Markets: The Maintenace of Farmer Wealth* 159-78.

Featherstone, Allen M., and Timothy G. Baker. 1988. "Effects of Reduced Price and Income Supports on Farmland Rent and Value." *North Central Journal of Agricultural Economics* (Oxford University Press) 10 (2): 177-189.

Featherstone, Allen M., and Timothy G. Baker. 1988. "Effects of Reduced Price and Income Supports on Farmland Rent and Value." *North Central Journal of Agricultural Economics* 10 (2): 177-189.

Featherstone, Allen, Laura M. Roessler, and Peter J. Barry. 2006. "Determining the probability of default and risk-rating class for loans in the seventh farm credit district portfolio." *Review of Agricultural Economics* 4-23.

Floroiu, Oana, and Antoon Pelsser. 2013. "Closed-Form Solutions for Options in Incompelte Markets." *Netspar Discussion Paper*. Tilburg.

Follian, James R., Louis O. Scott, and TL Tyler Yang. 1992. "Microfoundations of a Mortgage Prepayment Function." *The Journal of Real Estate Finance and Economics* 5 (2): 197-217.

Gardner, Bruce L. 1975. "The Farm-Retail Price Spread in a Competitive Food Industry." *American Journal of Agricultural Economics* 75 (3): 399-409.

Gloy, Brent, Michael D. Boehlje, Craig L. Dobins, Christopher Hurt, and Timothy G. Baker. 2011. "Are economic fundamentals driving farmland values?" *Choices* 2.

Goodwin, Barry K., and Matthew T. Holt. 1999. "Price Transmission and Asymmetric Adjustment in the U.S. Beef Sector." *American Journal of Agricultural Economics* 81 (3): 630-637.

Goodwin, Barry K., and Nicholas E. Piggott. 2001. "Spatial Market Integration in the Presence of Threshold Effects." *American Journal of Agricultural Economics* 83 (2): 302-317.

Harris, J. Michael, Robert Williams, Robert Dubman, and John Dillard. 2009. "Debt Landscape for US Farms Has Shifted." *Amber Wave* 7 (no. 4): 14.

Heien, Dale M. 1980. "Markup Pricing in a Dynamic Model of Food Industry." *American Journal of Agricultural Economics* 62 (1): 10-18.

Hendershott, Patric H., and Robert Van Order. 1987. "Pricing Mortgages: An Interpretation of the Models and Results." *Journal of Financial Services* 1 (1): 19-55.

Henderson, Jason, and Nathan Kaufman. 2013. "Farm Investment and Leverage Cycles: Will This Time Be Different?" *Economic Review- Federal Reserve Bank of Kansas City* 89.

Henderson, Jason, Brent Gloy, and Michael Boehlje. 2011. "Agriculture's boom-bust cycles: is this time different?" *Economic Review-Federal Reserve Bank of Kansas City* 83.

Herdt, Robert W., and Williard W. Cochrane. 1966. "Farm Land Prices and Farm Technological Advance." *Journal of Farm Economics* 48 (2): 243-263.

Hull, John C. 2006. *Options, Futures, and Other Derivatives*. Upper Saddle River: Pearson Education.

Ibendahl, Gregory, and Terry Griffin. 2013. "The Connection between Cash Rents and Land Values." *Journal of ASFMRA* 239-247.

Ibendahl, Gregory, and Terry Griffin. 2013. "The Connection Between Cash Rents and Land Values." *Journal of ASFMRA* 239-247.

Jason, Henderson. 2008. "Will Farmland Values Keep Booming?" *Choices* 93 (2): 81-104.

Just, Richard E., and John A. Miranowski. 1993. "Understanding Farmland Price Changes." *American Journal of Agricultural Economics* 75 (1): 156-168.

Kau, James B., and Donald C. Keenan. 1995. "An Overview of the Option-Theoretic Pricing of Mortgages." *Journal of Housing Research* 6 (2.): 217.

Kau, James B., and Thomas M. Springer. 1992. "The Prepayment Option on Mortgage Securities: A Random Coefficient Approach." *Review of Quantitative Finance and Accounting* 2 (1): 33-45.

Kau, James B., Donald C. Keenan, and Taewon Kim. 1994. "Default Probabilities for Mortgages." *Journal of Urban Economics* 35 (3): 278-296.

Kau, James B., Donald C. Keenan, and Walter J. Muller. 1993. "An Option-Based Pricing Model of Pricate Mortgage Insurance." *Journal of Risk and Insurance* 288-299.

Kaufman, Henry. 1986. "Debt: The Threat to Economic and Financial Stability ." *Economic Review* 3-11.

Kaufman, Nathan. 2013. "Financing Young and Beginning Farmers." *Main Street Economist*.

Kilian, Lutz, and Robert J. Vigfusson. 2011. "Are the Responses of the U.S. Asymmetric in Energy Price Increase and Decreases." *Quantitative Economics* 2 (3): 419-453.

Kinnucan, Henry W., and Olan D. Forker. 1987. "Asymmetry in Farm-Retail Price Transmission for Major Dairy Products." *American Journal of Agricultural Economics* 69 (2): 285-292.

Klinefelter, Danny A. 1973. "Facotrs Affecting Farmland Values Farmland Values in Illinois." *Illinois Agricultural Economics* 27-33.

Lence, Sergio H. 2014. "Farmland Prices: Is This Time Different?" *Applied Economic Perspectives and Policy* 36 (4): 577-603.

Levin, Andrew, Chien-Fu Lin, and Chia-Shang James Chu. 2002. "Unit root tests in panel data: asymptotic and finite-sample properties." *Journal of Econometrics* 108: 1-24.

Lloyd, Tim. 1994. "Practitioners' Corner: Testing a Present Value Model of Agricultural Land Values." *Oxford Bulletin of Economics and Statistics* 56 (2): 209-223.

Melichar, Emanuel. 1979. "Capital Gains versus Current Income in the Farming Sector." *American Journal of Agricultural Economics* 61 (5): 1085-1092.

Miller, Douglas J., and Marvin L. Hayenga. 2001. "Price Cycles and Asymmetric Price Transmission in the U.S. Pork Market." *American Journal of Agricultural Economics* 83 (3): 551-562.

Moreno, Manuel, Javier F. Navas, and Federico Todeschini. 2009. "Land Valuation Using a Real Option Approach." *RACSAM-Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales. Serie A. Matematicas* 103 (2): 405-420.

Moss, Charles B. 1997. "Returns, Interest Rates, and Inflation: How They Explain Changes in Farmland Values." *American Journal of Agricutlural Economics* 79 (4): 1311-1318.

Neumark, David, and Steven A. Sharpe. 1992. "Market Structure and the Nature of Price Rigidity: Evidence from the Market for consumer Deposits." *Quarterly Journal of Economics* 107: 657-680.

Peltzman, Sam. 2000. "Prices Rise Fast than They Fall." *Journal of Political Economy* 108 (3): 466-502.

Penson, Jr., John B. 1987. "Evaluating Financial Trends in Agriculture." *Agricultural Finance Review* 14-20.

Penson, Jr., John B., Dean W. Hughes, and Glenn L. Nelson. 1977. "Measurement of capacity depreciation based on engineering data." *American Journal of Agricultural Economics* 59 (2): 321-329.

Penson, Jr., John B., Robert F. Romain, and Dean W. Hughes. 1981. "Net Investment in Farm Tractors: An Econometric Analysis." *American Journal of Agricultural Economics* 63 (4): 629-635.

Peters, May, Suchada Langley, and Paul Westcott. 2009. "Agricultural Commodity Price Spikes in the 1970s and 1990s: Valuable Lessons for Today." *Amber Waves*, March 01.

Phipps, Tim T. 1984. "Land Prices and Farm-Based Returns." *American Journal of Agricultural Economics* 422-429.

Pope, III, Arden C. 1985. "Agricultural Productive and Consumptive Use Components of Rural Land Values in Texas." *Americal Journal of Agricultural Economics* 81-86.

Pope, Rulon D., Randall A. Kramer, Richard D. Green, and B. Delworth Gardner. 1979. "An Evaluation of Econometric Models of US Farmland Prices." *Western Journal of Agricultural Economics* 107-119.

Radchenko, Stanislav. 2005. "Oil price volatility nd the asymmetric response of gasoline prices to oil price increases and decreases." *Energy Economics* 27: 708-730.

Reagan, Patricia B., and Martin L. Weitzman. 1982. "Asymmetries in PRice and Quantity Adjustments by the Competitive Firm." *Journal of Economic Theory* 27: 410-420.

Reynolds , John Everett, and John Francis Timmons. 1969. "Factors Affecting Farmland Values in the United States." *Iowa State University Experimental Station Res.Bull.*

Roberts, Michael J., Barrett Kirwan, and Jeffrey Hopkins. 2003. "The Evidence of Government Program Payments on Agricultral Land Rents: The Challenges of Identification." *American Journal of Agricultural Economics* 85 (3): 762-769.

Robison, Lindon J., David A. Lins, and Ravi VenKataraman. 1985. "Cash Rents and Land Values in US Agriculture." *American Journal of Agricultural Economics* 67 (4): 794-805.

Schmitz, Andrew. 1995. "Boom/Bust Cycles and Ricardian Rent." *American Journal of Agricultural Economics* 77 (5): 1110-1125.

Scholnick, Barry. 1996. "Asymmetric Adjustment of Commercial Bank Interest Rates: Evidence from Malaysia and Singapore." *Journal of International Money and Finance* 15 (3): 485-496.

Shaik, Saleem, Glenn A. Helmers, and Joseph A. Atwood. 2005. "The Evolution of Farm Programs and Their Contribution to Agricultural Land Values." *American Journal of Agricultural Ecnomics* 87: 1190-1197.

Shalit, Haim, and Andrew Scmitz. 1982. "Farmland Accumulation and Prices." *American Journal of Agricultural Economics* 64 (4): 710-719.

Tong, H. 1983. "Threshold Models in Non-Linear Time Series Analysis." (Springer).

Tsay, Ruey S. 1989. "Testing and Modeling Threshold Autoregressive Processes." *Journal of the American Statistical Association* 84 (405): 231-240.

Tweeten, Luther G., and C. Leroy Quance. 1969. "Positivistic MEasure of Aggregate Supply Elasticities: Some New Approaches." *American Journal of Agricultural Economics* 51: 342-352.

Tweeten, Luther G., and James E. Martin. 1966. "A Methodology for Predicting U.S. Farm Real Estate Price Variation." *Journal of Farm Economics* 48 (2): 378-393.

V. Cramon-Taubadel, Stephan. 1998. "Correction Representation: An Application to the German Pork Market ." *European Review of Agricultural Economics* 25 (1): 1-18.

V. Cramon-Taubadel, Stephan, and Jens-Peter Loy. 1996. "Price Asymmetry in the International Wheat Market: Comment." *Canadian Journal of Agricultural Economics* 44: 311-317.

Vantreese, Valerie L., Jerry R. Skees, and Michael R. Reed. 1986. "Using Capitalization Theory to Model Farmland Prices." *North Central Journal of Agricultural Economics* 135-142.

Ward, Ronald W. 1982. "Asymmetry in Retail, Wholesale, and Shipping Point Pricing for Fresh Vegetables." *American Journal of Agricultural Economics* 64 (2): 205-212.

Wolffram, Rudolf. 1971. "Positivistic Measures of Aggregate Supply Elasticities: Some New Approaches: Some Critical Notes." *American Journal of Agricultural Economics* 53 (2): 365-359.

Wooldridge, Jeffrey M. 2015. *Introductory econometrics: A modern approach*. Nelson Education.

Xiaodong, Du, and David A. Hennessy. 2008. "The Planting Real Option in Cash Rent Valuation." Department of Economics, Center for Agricultural and Rural Development.

Young, Edwin, and Dennis A. Shields. 1996. "1996 FAIR Act Frames Farm Policy for 7 Years." Agricultural Outlook Supplement, Economic Research Service, United States Department of Agriculture, Washington D.C.

Zwilling, Bradley, Brandy Krapf, and Dwight Raab. 2016. "Working Capital and the Age of the Farm Operator." *Farmdoc Daily*.

APPENDIX A

TABLES

Table 2.1. 1996 Farm Bill crop support percentages

Crop	Percentage (%)
Corn	46.2
Wheat	26..3
Upland Cotton	11.6
Rice	8.5
Other Feed Grains	7.4

Table 2.2. 2002 Farm Bill direct payment rates and counter cyclical target prices

		Direct Payment Rate ($)	Counter-Cyclical Payment Target Prices	
Commodity	Unit	2002-2007	2002-2003	2004-2007
Barley	per bushel	0.24	2.21	2.24
Corn	per bushel	0.28	2.60	2.63
Grain Sorghum	per bushel	0.35	2.54	2.57
Oats	per bushel	0.02	1.40	1.44
Other Oilseeds	per hundredweight	0.80	9.80	10.10
Peanuts	per ton	36.00	495.00	495.00
Rice	per hundredweight	2.35	10.50	10.50
Soybeans	per bushel	0.44	5.80	5.80
Upland Cotton	per pound	0.07	0.72	0.72
Wheat	per bushel	0.52	3.86	3.92

Table 2.3. 2008 Farm Bill direct payment rate and counter-cyclical payment target prices

		Direct Payment Rate ($)	Counter-Cyclical Payment Target Prices ($)		
Commodity	Unit	2008 -2012	2008	2009	2010-2012
Barley	per bushel	0.24	2.24	2.24	2.63
Chickpeas, large (Garbanzo bean, Kabuli)	per hundredweight	0.28	Not available	12.81	12.81
Chickpeas, small (Garbanzo bean, Desi)	per hundredweight	0.35	Not available	10.36	10.36
Corn	per bushel	0.02	2.63	2.63	2.63
Dry Peas	Per hundredweight	0.80	Not Available	8.32	8.32
Grain Sorghum	per bushel	36.00	2.57	2.57	2.63
Lentils	per hundredweight	0.44	Not available	12.81	12.81
Oats	per bushel	0.07	1.44	1.44	1.79
Other Oilseeds	per hundredweight	0.52	10.10	10.10	12.68
Peanuts	per ton	2.35	495.00	495.00	495.00
Rice, long grain	per hundredweight	2.35	10.50	10.50	10.50
Rice, medium/short grain	per hundredweight	0.24	10.50	10.50	10.50
Soybeans	per bushel	0.28	5.80	5.80	6.00
Upland Cotton	per bound	0.35	0.71	0.71	0.71
Wheat	per bushel	0.02	3.92	3.92	3.92

Table 2.4. Crop futures contract specifications

Crop	Contract	Exchange	Historical Observations
Corn	December	CBOT	1969-2017
Soybeans	November	CBOT	1964-2017
Chicago Wheat	September	CME	1965-2017
Kansas City Wheat	July	CME	1977-2017

Table 2.5. Summary statistics of crop futures prices

	Mean	Standard Deviation	Min	Max	No. of Observations	Earliest Observation
Corn	473.85	198.89	268.41	1187.41	45	1973
Soybeans	1131.69	411.86	547.88	2456.04	54	1964
Chicago Wheat	761.75	311.70	414.74	1720.98	33	1965
KC Wheat	594.47	202.29	388.11	1099.42	41	1977

Table 2.6. Summary statistics of real rent data

	Mean	Standard Deviation	Min	Max	No. of Observations
Alabama	55.65	13.73	37.03	78.69	50
Arkansas	87.70	10.37	67.96	108.14	50
Delaware	89.56	17.05	65.20	121.87	50
Georgia	69.50	18.35	40.40	102.12	50
Illinois	173.53	35.68	132.24	252.78	50
Indiana	153.39	36.18	117.07	247.10	50
Iowa	176.50	38.77	132.11	255.62	50
Kansas	55.77	9.62	44.57	79.86	50
Kentucky	103.26	22.18	70.03	140.59	50
Louisiana	82.60	13.01	60.90	113.76	50
Maryland	80.49	24.40	51.54	225.74	50
Michigan	84.21	16.04	61.94	114.28	50
Minnesota	110.48	25.30	79.75	171.12	50
Mississippi	83.13	17.07	50.57	122.54	50
Missouri	101.96	19.49	72.78	149.96	50
Nebraska	160.39	42.11	105.07	250.79	46
New York	54.84	13.33	33.29	78.11	50
North Carolina	72.66	19.76	44.57	121.53	50
North Dakota	51.17	9.72	37.70	75.40	50
Ohio	117.78	28.73	89.00	188.28	50
Oklahoma	43.63	13.54	28.55	72.99	50
South Dakota	60.92	17.17	42.18	114.69	50
Tennessee	87.54	19.51	57.03	126.57	50
Wisconsin	91.16	17.96	61.28	124.20	50

Table 2.7. Summary statistics for real cropland prices

	Mean	Standard Deviation	Min	Max	No. of Observations
Alabama	2,246.60	404.78	1,536.73	2,670.89	20
Arkansas	1,731.78	384.41	1,239.63	2,438.50	20
Delaware	6,647.51	2,386.37	3,201.52	10,547.19	20
Georgia	2,843.20	878.53	1,357.44	4,575.78	20
Illinois	4,367.10	1,557.34	2,650.86	7,084.11	20
Indiana	4,034.14	1,382.82	2,433.15	6,486.10	20
Iowa	4,189.94	2,012.44	2,177.03	8,050.12	20
Kansas	1,146.85	439.76	772.01	2,079.23	20
Kentucky	2,749.21	465.63	1,920.91	3,392.30	20
Louisiana	1,713.20	327.30	1,342.88	2,357.51	20
Maryland	5,961.16	1,500.66	3,905.85	8,648.69	20
Michigan	3,026.20	717.67	1,741.62	4,141.41	20
Minnesota	2,571.45	1,028.92	1,395.86	4,480.47	20
Mississippi	1,688.13	453.21	1,051.38	2,411.50	20
Missouri	2,316.62	700.30	1,331.83	3,505.25	20
Nebraska	2,393.62	1,268.64	1,306.22	4,765.67	20
New York	1,908.58	410.73	1,306.22	2,471.01	20
North Carolina	3,400.91	450.43	2,407.54	3,880.34	20
North Dakota	905.87	488.29	529.16	1,947.83	20
Ohio	3,776.29	845.87	2,548.41	5,324.67	20
Oklahoma	1,003.95	254.78	708.18	1,475.70	20
South Dakota	1,464.20	913.06	583.96	3,395.04	20
Tennessee	2,929.62	312.96	2,343.51	3,426.80	20
Wisconsin	2,998.04	925.40	1,331.83	4,409.09	20

Table 2.8. Recovered rho and R^2 for the maximum likelihood estimations for each state

State	Recovered rho	R^2
Alabama	0.947	0.818
Arkansas	0.934	0.905
Delaware	0.892	0.913
Georgia	0.954	0.819
Illinois	0.944	0.929
Indiana	0.909	0.952
Iowa	0.828	0.958
Kansas	0.670	0.941
Kentucky	0.790	0.845
Louisiana	0.918	0.787
Maryland	0.989	0.129
Michigan	0.610	0.580
Minnesota	0.821	0.910
Mississippi	0.818	0.866
Missouri	0.876	0.866
Nebraska	0.667	0.934
New York	0.570	0.862
North Carolina	0.686	0.792
North Dakota	0.899	0.890
Ohio	0.965	0.823
Oklahoma	0.595	0.509
South Dakota	0.968	0.644
Tennessee	0.541	0.907
Wisconsin	0.957	0.894

Table 2.9. Model evaluation measures

	Model			Capitalized Value		
State	MAPE	RMSE	Mean Error	MAPE	RMSE	Mean Error
Alabama	84.10	1,933.56	-1,896.63	48.45	1,165.93	-1,115.75
Arkansas	54.66	1,023.55	-970.05	27.73	493.39	389.86
Delaware	89.54	6,488.71	-6,041.37	67.55	5,329.19	-4,778.05
Georgia	78.29	2,418.42	-2,266.00	31.19	1,324.93	-1,012.93
Illinois	64.91	3,163.69	-2,906.91	19.39	962.57	-291.76
Indiana	67.69	2,988.43	-2,779.43	16.98	1,018.74	-572.67
Iowa	60.88	3,168.31	-2,703.71	27.41	1,132.63	77.45
Kansas	50.35	733.72	-619.32	29.34	335.95	94.42
Kentucky	71.64	2,011.19	-1,975.44	13.80	508.26	-297.32
Louisiana	65.78	1,185.77	-1,143.94	18.02	329.15	134.38
Maryland	91.21	5,669.10	-5,467.62	68.85	4,476.56	-4,214.11
Michigan	75.69	2,378.15	-2,303.89	29.80	1,062.10	-946.73
Minnesota	59.65	1,802.04	-1,605.81	23.53	533.87	327.68
Mississippi	60.75	1,116.01	-1,052.30	29.31	478.00	397.73
Missouri	63.88	1,624.08	-1,517.80	18.70	405.83	50.42
Nebraska	50.50	1,710.98	-1,360.35	60.28	1,112.22	932.89
New York	81.86	1,617.73	-1,572.17	40.76	880.67	-813.63
North Carolina	85.45	2,938.51	-2,909.70	53.99	1,890.99	-1,851.97
North Dakota	49.10	662.18	-509.38	60.51	423.85	293.06
Ohio	74.39	2,892.89	-2,816.28	30.45	1,297.83	-1,200.20
Oklahoma	72.22	791.86	-745.02	26.77	366.50	-207.77
South Dakota	49.25	1,163.01	-866.90	65.15	638.48	415.05
Tennessee	78.64	2,326.46	-2,308.17	33.89	1,053.10	-1,008.18
Wisconsin	72.01	2,364.39	-2,187.69	27.60	985.85	-752.02

Table 3.1. State and associated beginning date

State	Initial historical date
Alabama	1968
Arkansas	1968
Delaware	1974
Georgia	1974
Illinois	1974
Indiana	1974
Iowa	1974
Kansas	1974
Kentucky	1968
Louisiana	1968
Maryland	1974
Michigan	1974
Minnesota	1974
Mississippi	1968
Missouri	1968
Nebraska	1974
New York	1974
North Carolina	1968
North Dakota	1968
Ohio	1978
Oklahoma	1978
South Dakota	1974
Tennessee	1968
Wisconsin	1974

Table 3.2. State delineation based on crop production

Corn	Soybeans	Wheat
Delaware	Alabama	North Dakota
Georgia	Kentucky	Oklahoma
Illinois	Louisiana	
Indiana	Mississippi	
Iowa	Missouri	
Kansas	North Carolina	
Maryland	Ohio	
Michigan	Tennessee	
Maine		
Nebraska		
New York		
South Dakota		
Wisconsin		

Table 3.3. Model parameterization for each model

	Step	ΔRent Lags	Crop Price Lags	Positive & Negative Crop Price Series Lags	AIC	BIC
	Step 1	1, 2	0, 1, 2, 3		3,994.42	4,024.20
Corn	Step 2	1		0, 1, 2, 3	3,981.47	4,024.1
Estimation	Step 3	1		0, 1, 2, 3	3.947.84	3,998.88
	Step 1	1, 2, 3	0, 1, 2, 3		2,762.14	2793.34
Soybean	Step 2	1, 2, 3		0, 1, 2, 3	2,755.72	2,804.03
Estimation	Step 3	1		0, 1, 2, 3	2,729.34	2,777.65
	Step 1	1	0, 1, 2, 3		326.63	340.29
Wheat	Step 2	1		0, 1, 2 ,3	330.44	353.21
Estimation	Step 3	1		0, 1, 2, 3	330.39	357.71

0 represents the contemporaneous observation

Table 3.4. Corn long-run level relationship regression output

	Long-run effects
	Coefficient (standard error)
Georgia	-21.134*** (4.8125)
Illinois	87.2459*** (4.8125)
Indiana	66.0793*** (4.8125)
Iowa	90.7063*** (4.8125)
Kansas	-33.9516*** (4.8125)
Maryland	-7.2023 (4.8125)
Michigan	-3.9562 (4.8125)
Minnesota	25.5612*** (4.8125)
Nebraska	71.4395*** (4.8125)
New York	-35.8175*** (4.8125)
South Dakota	-24.9599*** (4.8125)
Wisconsin	2.9908 (4.8125)
Corn Price	0.0807*** (4.8125)
R^2	0.823
Adjusted-R^2	0.819
No. of Observations	559

*** Significant at the 1% critical level
** Significant at the 5% critical level
* Significant at the 10% level

Table 3.5. Levin-Lin-Chu unit-root test for the residuals recovered from the corn long-run level relationship regression output

H_0: Panels contain unit roots		Number of panels: 13
H_a: Panels are stationary		Number of periods: 43
ADF regressions: 1 lag		
	Statistic	P-value
Unadjusted t	-8.7394	
Adjusted t	-3.6941	0.0001

Table 3.6. Long-run coefficient stability test for the corn model

	Positive Residual	Negative Residual
t-statistic	1.2523	-0.2354

H_0: The coefficients are not statistically different for sub-groups of states
T-statistics rejection region threshold with > 100 observations
1% significance level: 2.640
5% significance level: 1.660
10% significance level: 1.290

Table 3.7. Corn error correction output

	Coefficient (standard error)				
		t	t-1	t-2	t-3
ΔRent			-0.0184*** (0.0433)		
Positive corn price		0.0681*** (0.0176)	0.0509*** (0.0184)	-0.0042 (0.0141)	0.0706*** (0.0140)
Negative corn price		0.0715*** (0.0133)	0.0023 (0.0106)	0.0282*** (0.0100)	0.0084 (0.0080)
Positive residual series			-0.2286*** (0.0374)		
Negative residual series			0.0520 (0.0523)		
Intercept	1.1253 (1.0215)				
R^2	0.2874				
Adjusted-R^2	0.2719				
No. of Observations	520				

*** Significant at the 1% critical level
** Significant at the 5% critical level
* Significant at the 10% level

Table 3.8. Corn price coefficient asymmetry t-test

	$\delta_t^+ = \delta_t^-$	$\delta_{t-1}^+ = \delta_{t-1}^-$	$\delta_{t-2}^+ = \delta_{t-2}^-$	$\delta_{t-3}^+ = \delta_{t-3}^-$	$\alpha^+ = \alpha^-$
t-statistic	-0.1483	***2.2823***	***-1.8790***	***3.8668***	***-4.3615***

H_0: $\beta_i^+ = \beta_i^-$
T-statistics rejection region threshold with > 100 observations
1% significance level: 2.640
5% significance level: 1.660
10% significance level: 1.290

Table 3.9. Soybean long-run level relationship regression output

	Long-run effects
	Coefficient (standard error)
Arkansas	32.1512*** (2.6604)
Kentucky	47.4102*** (2.6604)
Louisiana	27.0110*** (2.6604)
Mississippi	27.1233*** (2.6604)
Missouri	46.8680*** (2.6604)
North Carolina	16.4581*** (2.6604)
Ohio	62.6025*** (2.6604)
Tennessee	31.5396*** (2.6604)
Soybean Price	0.0317*** (0.0014)
Intercept	19.8872*** (2.5073)
R^2	0.739
Adjusted-R^2	0.734
No. of Observations	441

*** Significant at the 1% critical level
** Significant at the 5% critical level
* Significant at the 10% level

Table 3.10. Levin-Lin-Chu unit-root test for the residuals recovered from the soybean long-run level relationship regression output

H_0: Panels contain unit roots		Number of panels: 9
H_a: Panels are stationary		Number of periods: 49
ADF regressions: 1 lag		
	Statistic	P-value
Unadjusted t	-7.8464	
Adjusted t	-2.8999	0.0019

Table 3.11. Long-run coefficient stability test for the soybean model

	Positive Residual	Negative Residual
t-statistic	-0.5698	0.0432

H_0: The coefficients are not statistically different for sub-groups of states
T-statistics rejection region threshold with > 100 observations
1% significance level: 2.640
5% significance level: 1.660
10% significance level: 1.290

Table 3.12. Soybean error correction output

	Coefficient (standard error)			
	t	t-1	t-2	t-3
ΔRent (t-1)		-0.0433 (0.0492)		
Positive soybean price (t)	0.0130*** (0.0024)	-0.0067** (0.0026)	0.0100*** (0.0033)	0.0126*** (0.0033)
Negative soybean price (t)	0.01490*** (0.0029)	0.0094*** (0.0031)	0.0048** (0.0024)	0.0014 (0.0023)
Positive residual series		-0.1000** (0.0438)		
Negative residual series		-0.2495*** (0.0606)		
Intercept	-0.6790 (0.6291)			
R^2	0.2737			
Adjusted-R^2	0.2538			
No. of Observations	414			

*** Significant at the 1% critical level
** Significant at the 5% critical level
* Significant at the 10% level

Table 3.13. Soybean crop price coefficient asymmetry t-test

	$\delta_t^+ = \delta_t^-$	$\delta_{t-1}^+ = \delta_{t-1}^-$	$\delta_{t-2}^+ = \delta_{t-2}^-$	$\delta_{t-3}^+ = \delta_{t-3}^-$	$\alpha^+ = \alpha^-$
t-statistic	-0.5003	***-3.9486***	***1.2988***	***2.7833***	***1.9998***

H_0: $\beta_i^+ = \beta_i^-$
T-statistics rejection region threshold with > 100 observations
1% significance level: 2.640
5% significance level: 1.660
10% significance level: 1.290

Table 3.14. Wheat long-run level relationship regression output

	Long-run effects
	Coefficient (standard error)
North Dakota	10.7859*** (1.773)
Wheat Price	0.0343*** (0.005)
Intercept	19.154*** (2.921)
R^2	0.5579
Adjusted-R^2	0.546
No. of Observations	78

*** Significant at the 1% critical level
** Significant at the 5% critical level
* Significant at the 10% level

Table 3.15. Levin-Lin-Chu unit-root test for the residuals recovered from the wheat long-run level relationship regression output

H_0: Panels contain unit roots — Number of panels: 2
H_a: Panels are stationary — Number of periods: 39
ADF regressions: 1 lag

	Statistic	P-value
Unadjusted t	-3.7035	
Adjusted t	-1.7885	0.0368

Table 3.16. Wheat error correction model output

		Coefficient (standard error)			
		t	t-1	t-2	t-3
ΔRent			0.0896 (0.1100)		
Positive wheat price		0.0037 (0.0053)	0.0010 (0.0050)	0.0065 (0.0048)	0.0053 (0.0052)
Negative wheat price		0.0082 (0.0051)	0.0089* (0.0049)	-0.0037 (0.0046)	0.0012 (0.0038)
Positive residual series			-0.1634 (0.1101)		
Negative residual series			-0.0337 (0.0794)		
Intercept	-0.1933 (0.5158)				
R^2	0.3228				
Adjusted-R^2	0.1986				
No. of Observations	72				

*** Significant at the 1% critical level
** Significant at the 5% critical level
* Significant at the 10% level

Table 3.17. Wheat price coefficient asymmetry t-test

	$\delta_t^+ = \delta_t^-$	$\delta_{t-1}^+ = \delta_{t-1}^-$	$\delta_{t-2}^+ = \delta_{t-2}^-$	$\delta_{t-3}^+ = \delta_{t-3}^-$	$\alpha^+ = \alpha^-$
t-statistic	-0.6112	-1.1347	***1.5497***	0.6327	-0.9556

H_0: $\beta_i^+ = \beta_i^-$
T-statistics rejection region threshold with > 70 observations
1% significance level: 2.390
5% significance level: 1.671
10% significance level: 1.296

Table 4.1. Descriptive statistics of capital expenditure regression data

	Capital expenditures on tractors	Capital expenditures on machinery	Non-real estate capital expenditures	Real estate capital expenditures on buildings and improvements	Total capital expenditures	Total ROI
Mean	5,729,719.94	10,227,698.17	20,418,525.01	9,838,942.24	30,257,467.25	1.27
Min	2,586,454.00	5,288,642.00	10,804,382.63	4,873,636.00	15,678,018.63	1.06
Max	10,675,121.00	19,617,553.00	35,023,289.99	18,439,490.47	52,247,874.26	1.53
Standard deviation	1,961,023.61	3,806,937.15	5,929,148.59	3,183,526.13	8,870,474.29	0.08
Observations	52.00	52.00	52.00	52.00	52.00	52.00

Table 4.2. Regional bank questions

Question	Categories of answer	Possible responses
7th District		
How will capital expenditures by producers in the year ahead compare to the expenditures of the past year?	Land purchases or improvements, buildings and facilities, machinery and equipment, trucks and autos	Higher, lower or the same
How have your credit standards for approving agricultural loans during the past three months changed relative to a year earlier?		Tightened considerably, tightened somewhat, remained basically unchanged, eased somewhat, and eased considerably
Please indicate the percentage of the dollar amount of your bank's farm loan portfolio that currently falls within each of the following repayment classifications	Major repayment problems requiring more collateral and/or long-term workouts and severe repayment problems which will likely result in loan losses and/or require forced sales of borrower's real assets	Percent value

Table 4.2. Regional bank questions (cont.t)

10th District		
What changes occurred in non-real estate farm loans at your bank in the past three months relative to a year earlier?	Rate of loan repayment	Higher, lower or the same
What changes occurred in non-real estate farm loans at your bank in the past three months relative to a year earlier?	Renewals and extensions	Higher, lower or the same
What changes occurred in non-real estate farm loans at your bank in the past three months relative to a year earlier?	Amount of collateral required	Higher, lower or the same
What changes occurred in non-real estate farm loans at your bank in the past three months relative to a year earlier?	Loan fund availability	Higher, lower or the same

Table 4.3. Regression output

Regression output		Adjusted R^2	Coefficients (standard errors) ROI	Lagged dependent variable
OLS	Total real estate capital expenditures on buildings and improvements	0.8473	8,708,679** (3,821,131)	0.9788*** (0.9788)
	Total non-real estate capital expenditures	0.8094	20,400,000*** (7,426,051)	0.9689*** (0.0779)
	Capital expenditures on tractors	0.7985	5,147,986** (2,469,922)	0.9362*** (0.0760)
	Capital expenditures on machinery & equipment	0.8530	13,000,000*** (4,065,427)	1.0015*** (0.0708)
SUR	Total real estate capital expenditures on buildings and improvements	0.8524	6,894,255* (3,595,429)	0.917*** (0.0655)
	Total non-real estate capital expenditures	0.8159	17,500,000*** (6,680,363)	0.918*** (0.0498)
	Capital expenditures on tractors	0.8075	4,738,772** (2,307,539)	0.899*** (0.0518)
	Capital expenditures on machinery & equipment	0.8554	10,400,000*** (3,611,661)	0.918*** (0.0481)

*** Significant at the 1% critical level
** Significant at the 5% critical level
* Significant at the 10% level

Table 4.4. Robustness tests

Robustness test outcomes of OLS estimation	Real estate capital expenditures on buildings and improvements	Total non-real estate capital expenditures	Capital expenditures on tractors	Capital expenditures on machinery & equipment
Mean VIF	1.46	1.29	1.13	1.41
BG p-value	0.616	0.724	0.824	0.483
White test p-value	0.223	0.142	0.249	0.169

Table 4.5. Elasticity measures

Model		Real estate capital expenditures on buildings and improvements	Total non-real estate capital expenditures	Capital expenditures on tractors	Capital expenditures on machinery & equipment
OLS	Total ROI	1.077	1.173	1.062	1.444
	Lagged dependent variable	0.964	0.966	0.948	0.987
SUR	Total ROI	0.828	0.955	0.930	1.106
	Lagged dependent variable	0.895	0.881	0.892	0.892

Table 4.6. Forecast evaluations

Model		RMSE	MAPE
OLS	Total real estate capital expenditures on buildings and improvements	1,314,248.04	11.51
	Total non-real estate capital expenditures	5,893,161.89	23.11
	Capital expenditures on tractors	1,743,965.22	18.72
	Capital expenditures on machinery & equipment	2,548,531.66	20.12
SUR	Total real estate capital expenditures on buildings and improvements	1,302,411.80	11.31
	Total non-real estate capital expenditures	1,666,054.72	18.46
	Capital expenditures on tractors	2,419,511.19	20.10
	Capital expenditures on machinery & equipment	5,655,034.40	22.65

Table 4.7. Margin of error measurement of forecast models and actual observations

Margin of error	OLS		SUR	
	2014	2015	2014	2015
Capital expenditures on tractors	95.34	132.78	93.81	130.73
Capital expenditures on machinery	99.72	139.95	97.55	137.75
Non-real estate capital expenditures	91.64	137.86	89.98	135.27
Real estate capital expenditures on buildings and improvements	86.20	109.21	86.15	108.77

APPENDIX B

FIGURES

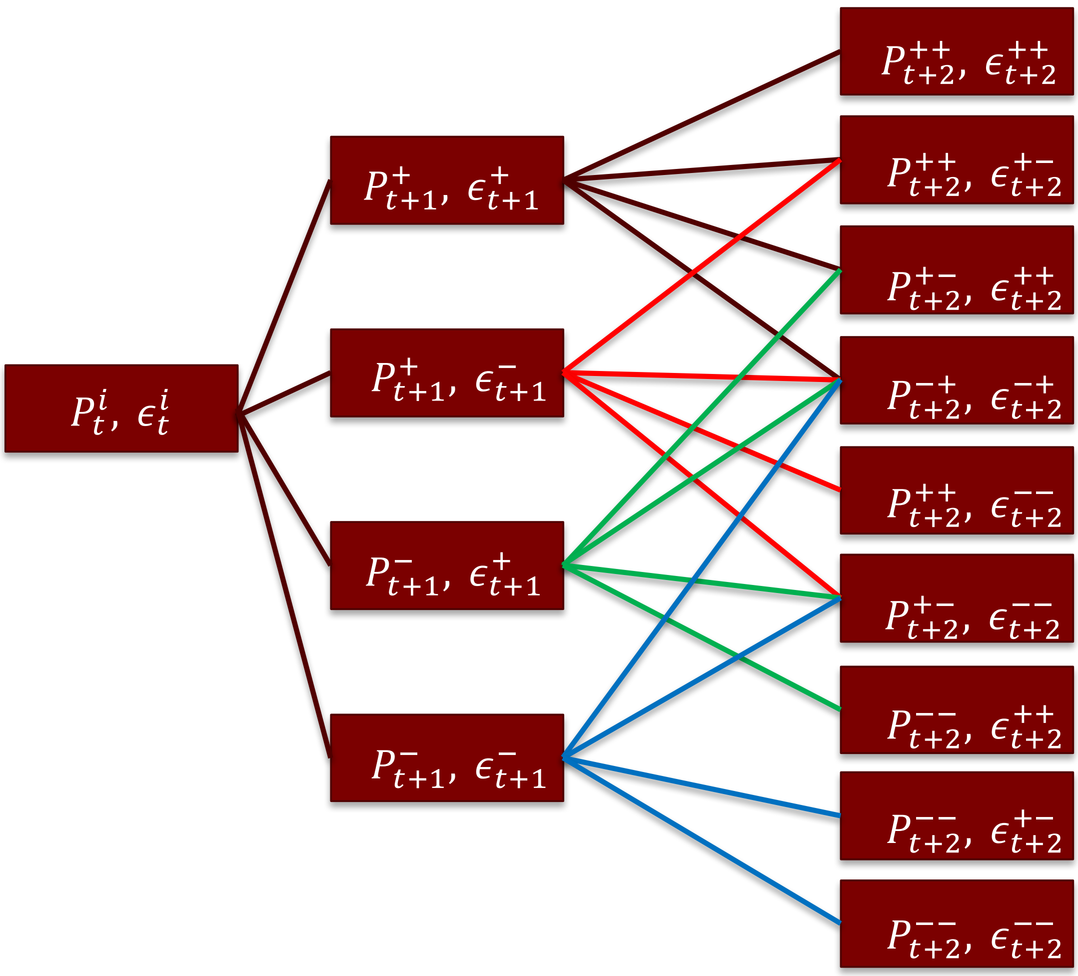

Figure 2.1. Two-step dynamic optimization example

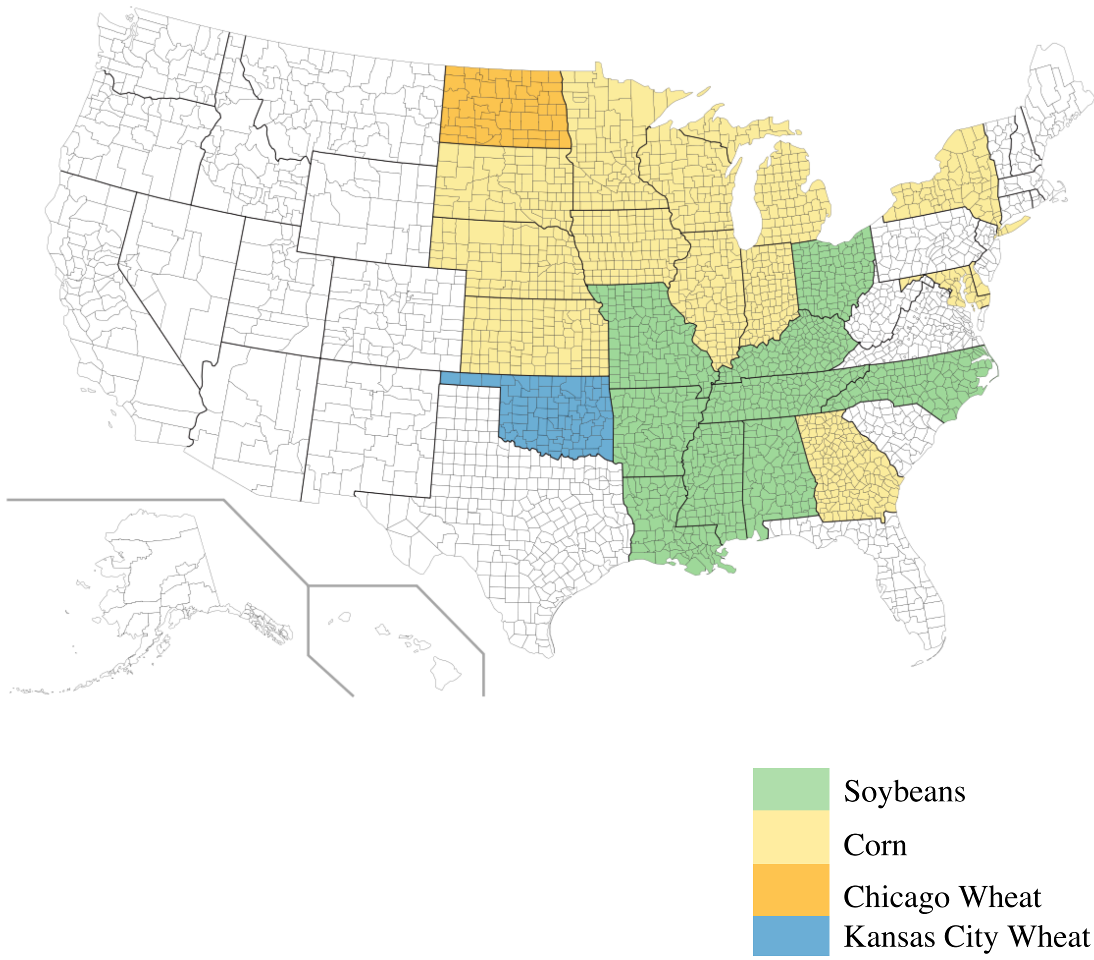

Figure 2.2. Map of states tested and associated crop

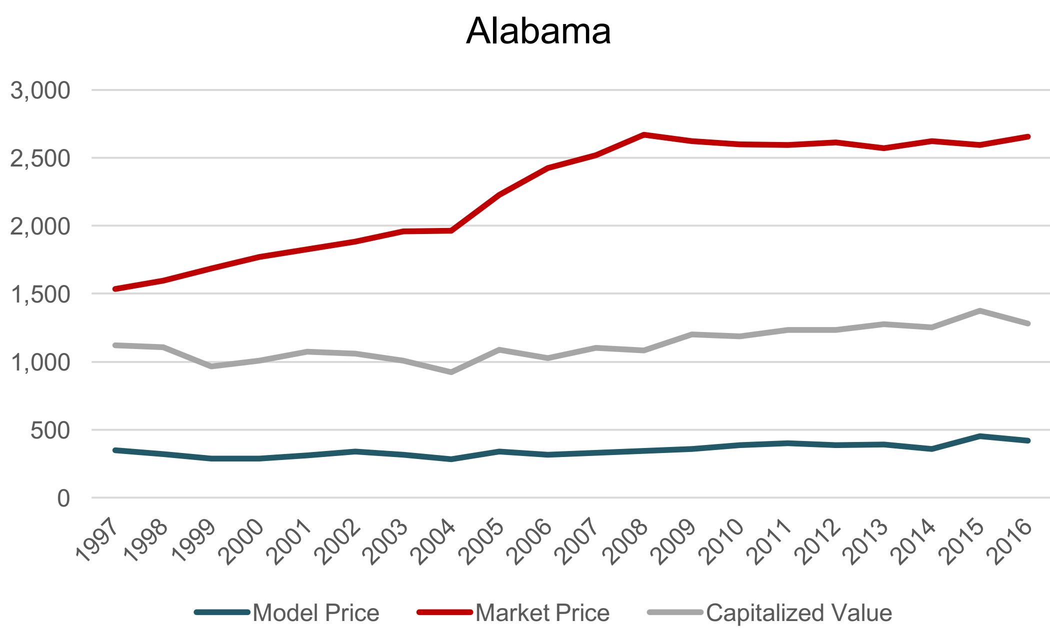

Figure 2.3. Alabama cropland prices, modeled and actual

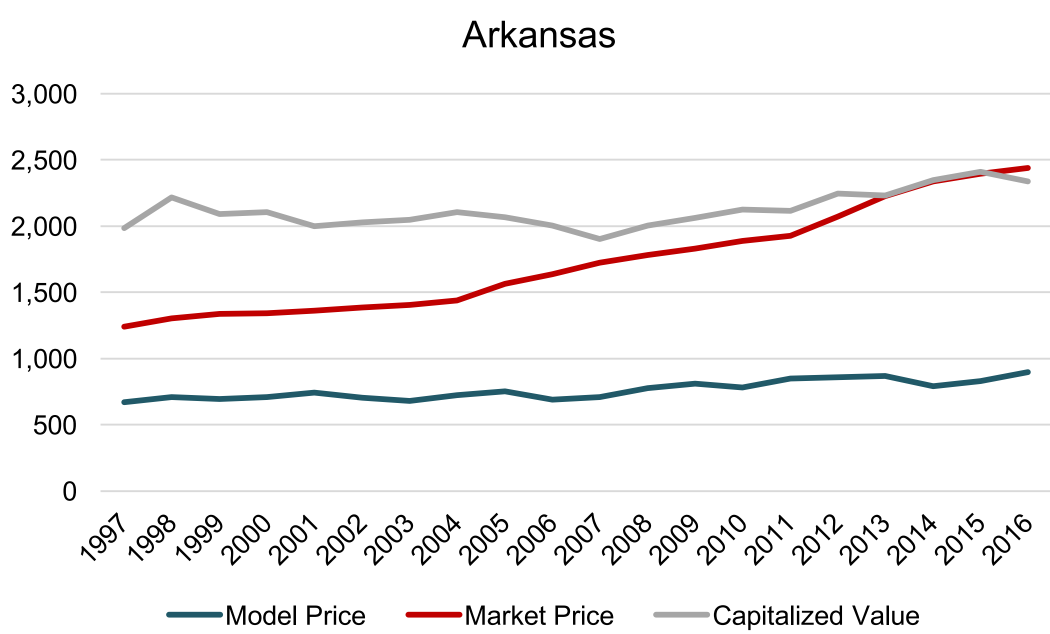

Figure 2.4. Arkansas cropland prices, modeled and actual

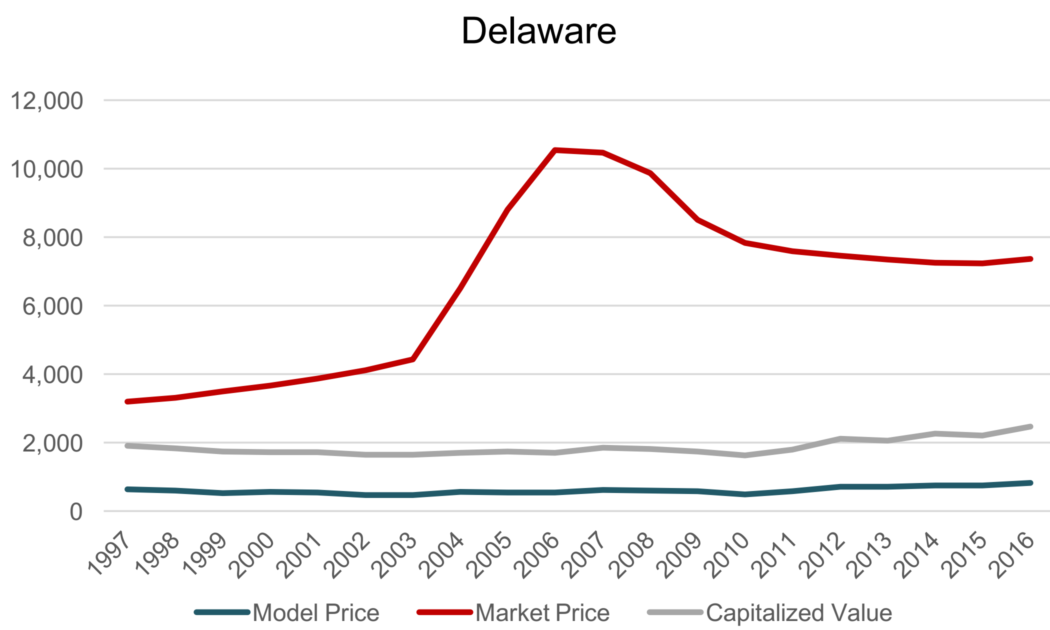

Figure 2.5. Delaware cropland prices, modeled and actual

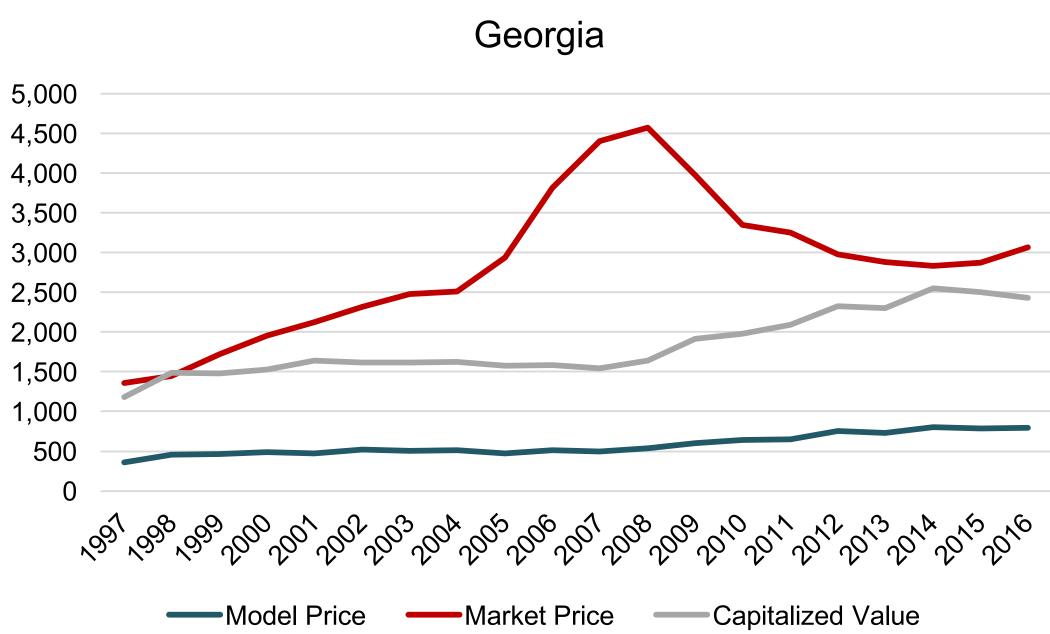

Figure 2.6. Georgia cropland prices, modeled and actual

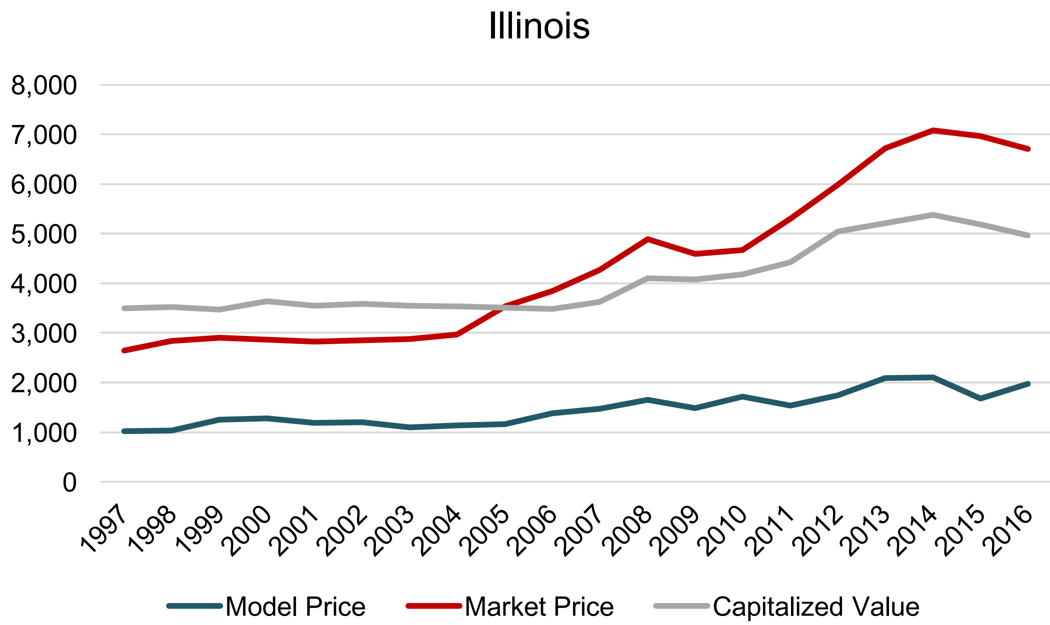

Figure 2.7. Illinois cropland prices, modeled and actual

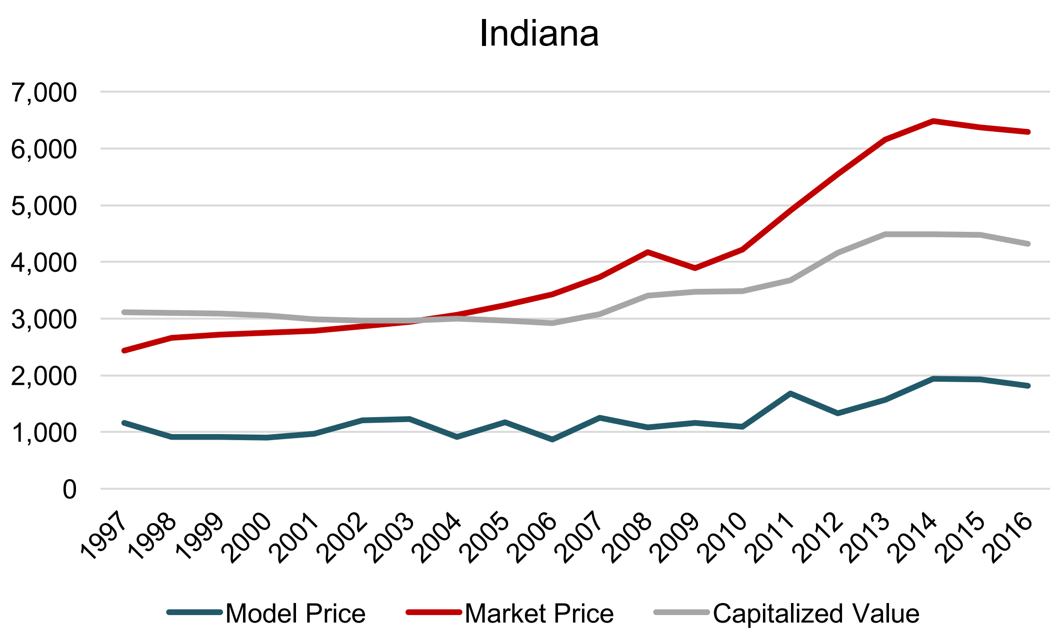

Figure 2.8. Indiana cropland prices, modeled and actual

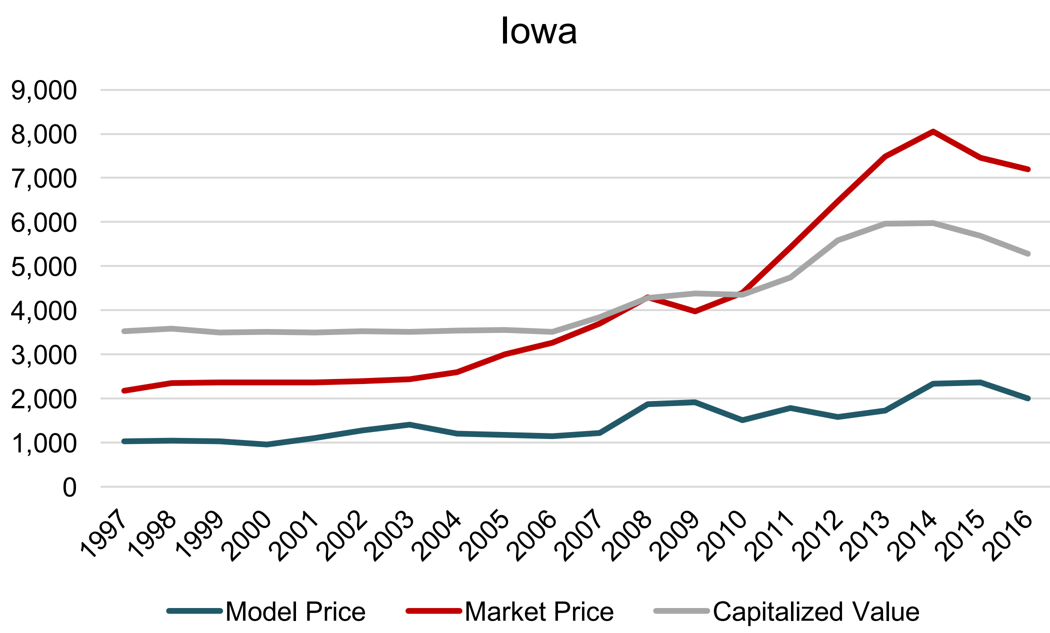

Figure 2.9. Iowa cropland prices, modeled and actual

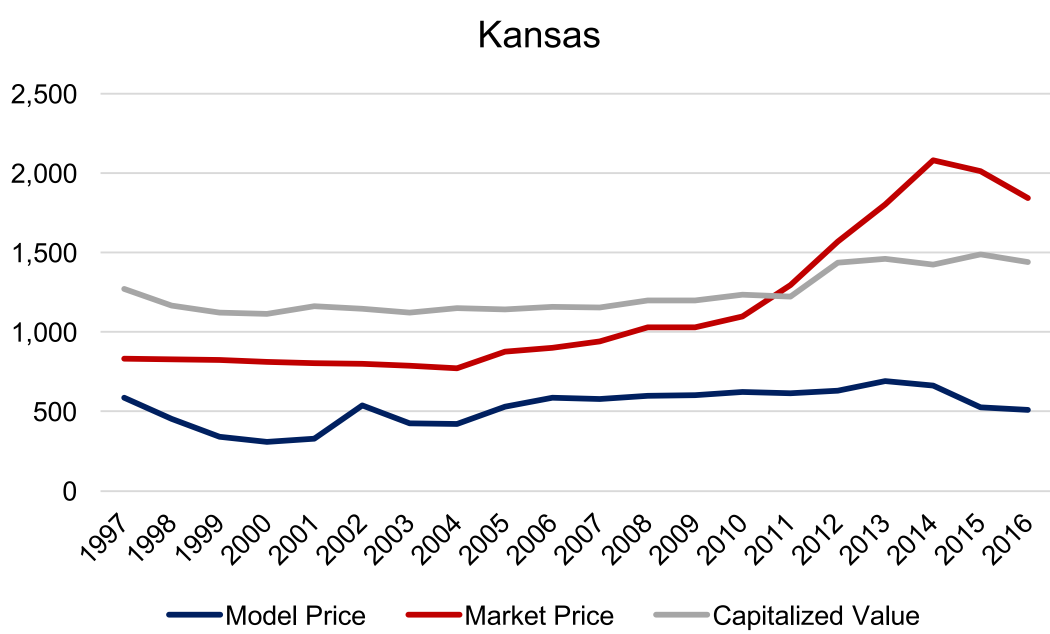

Figure 2.10. Kansas cropland prices, modeled and actual

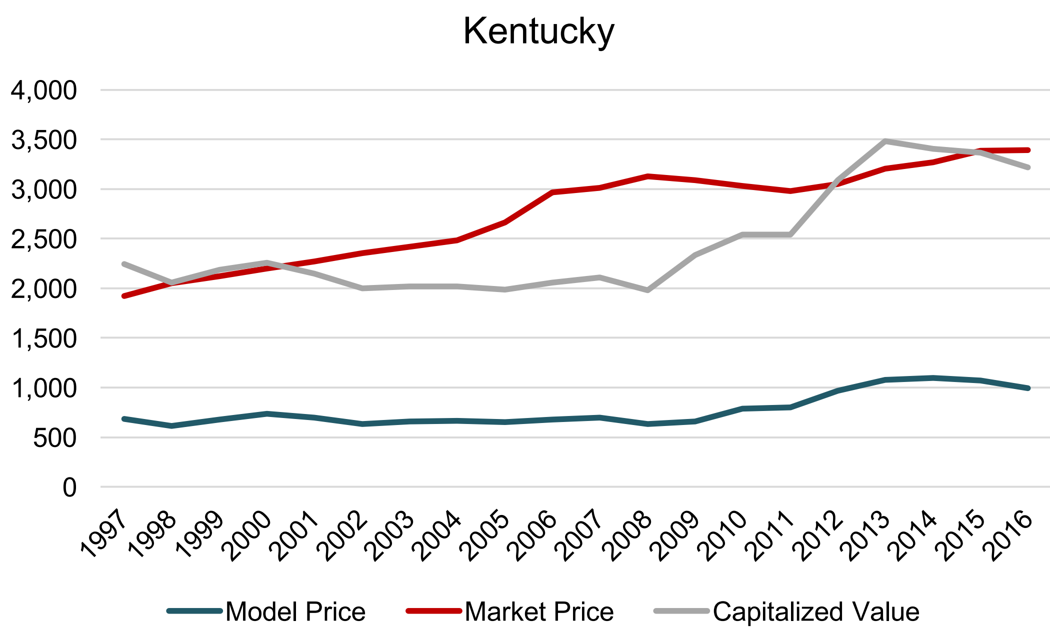

Figure 2.11. Kentucky cropland prices, modeled and actual

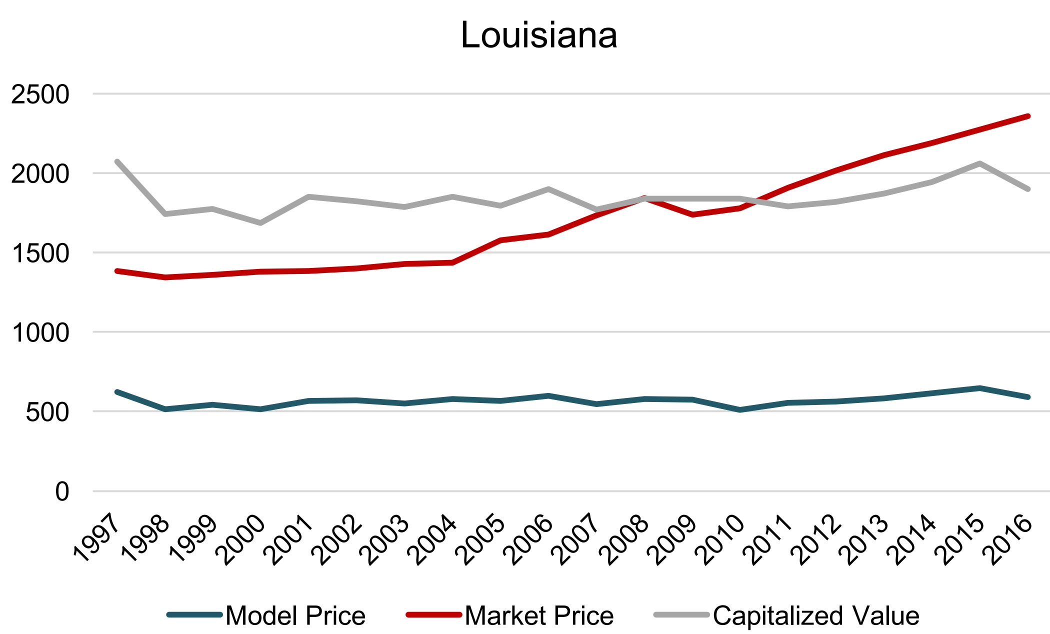

Figure 2.12. Louisiana cropland prices, modeled and actual

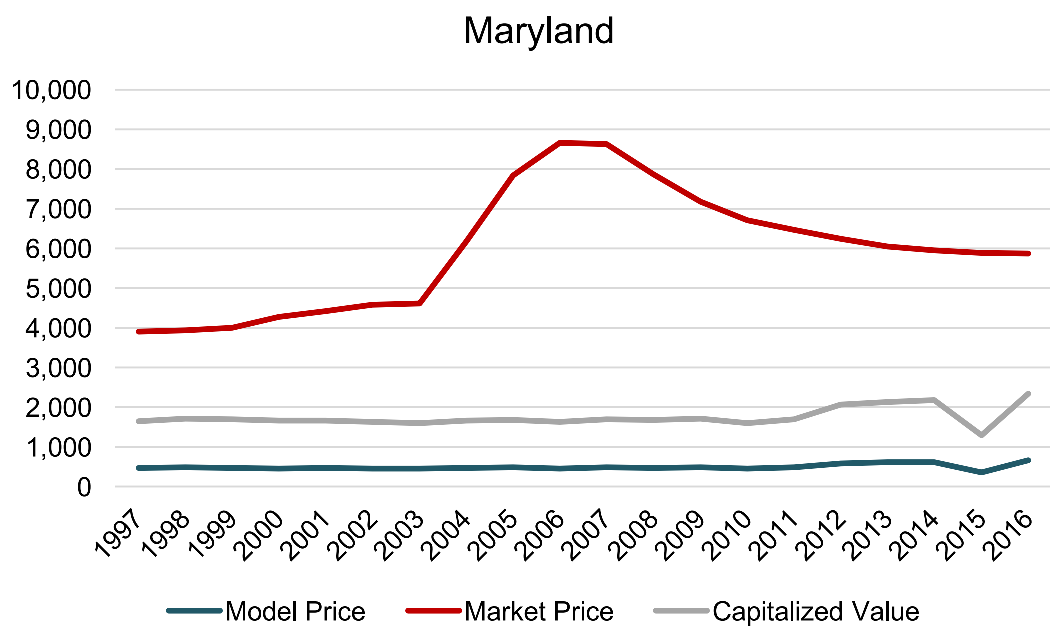

Figure 2.13. Maryland cropland prices, modeled and actual

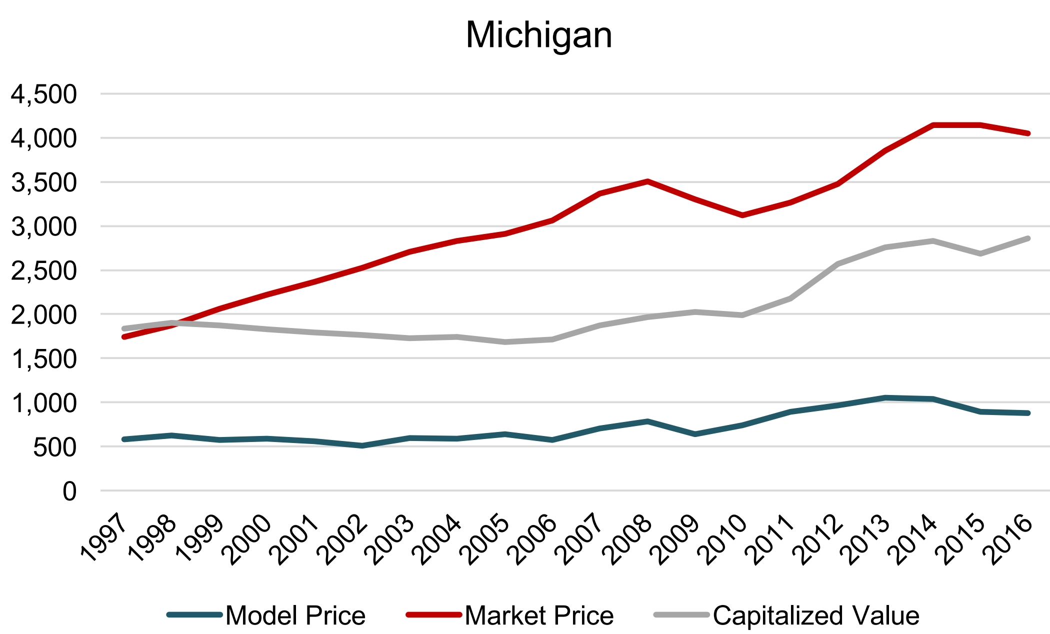

Figure 2.14. Michigan cropland prices, modeled and actual

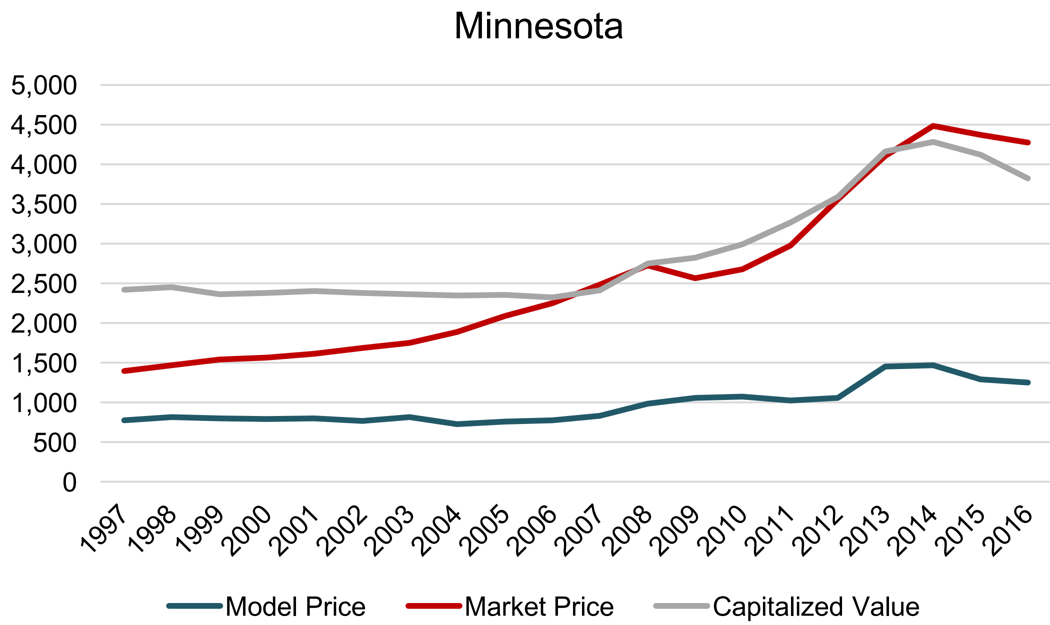

Figure 2.15. Minnesota cropland prices, modeled and actual

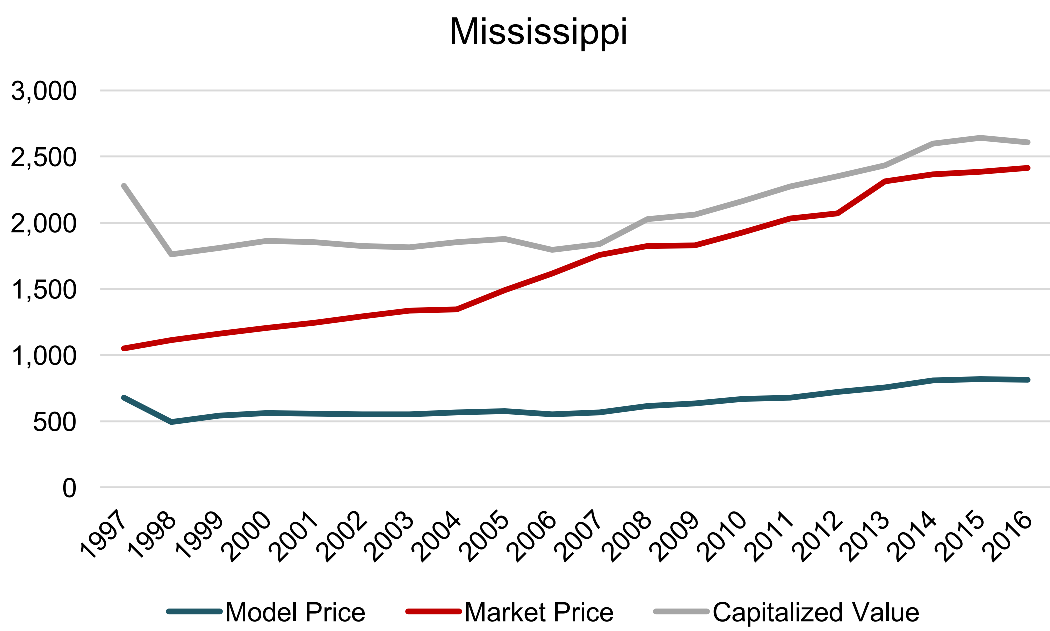

Figure 2.16. Mississippi cropland prices, modeled and actual

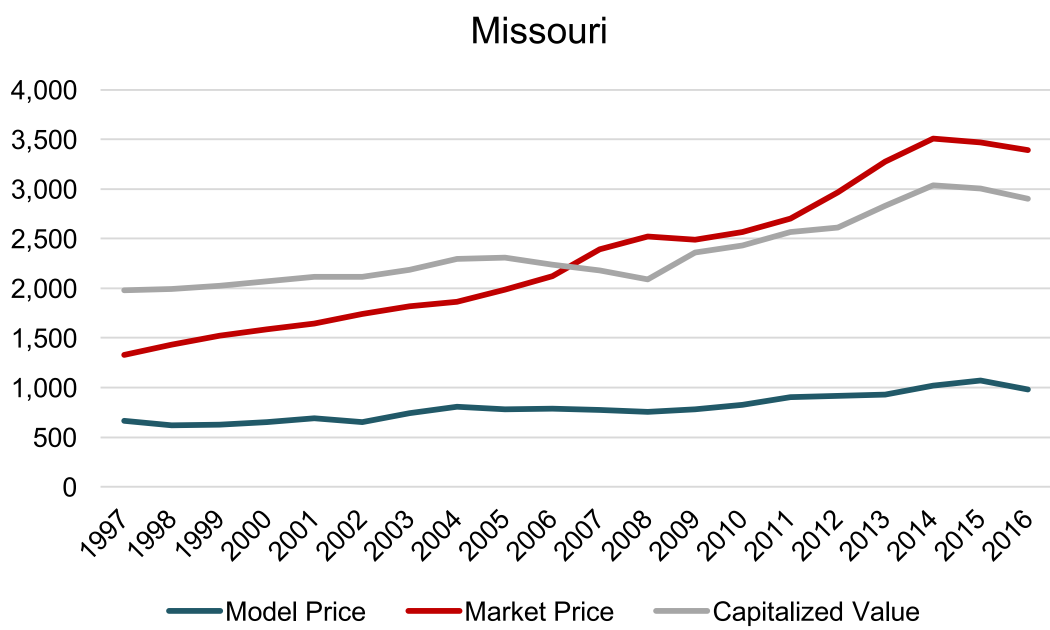

Figure 2.17. Missouri cropland prices, modeled and actual

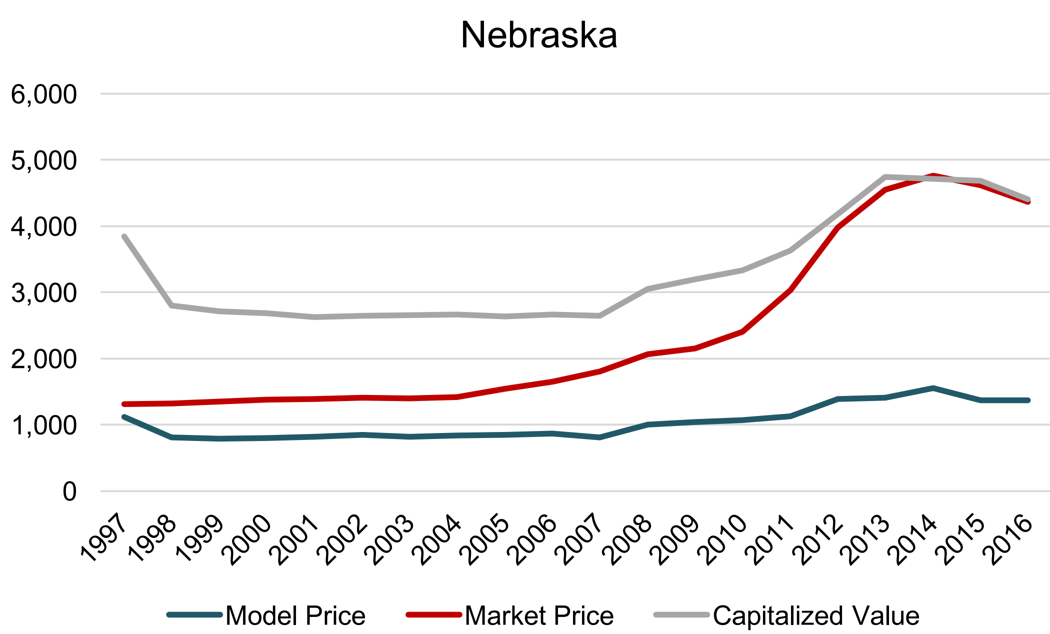

Figure 2.18. Nebraska cropland prices, modeled and actual

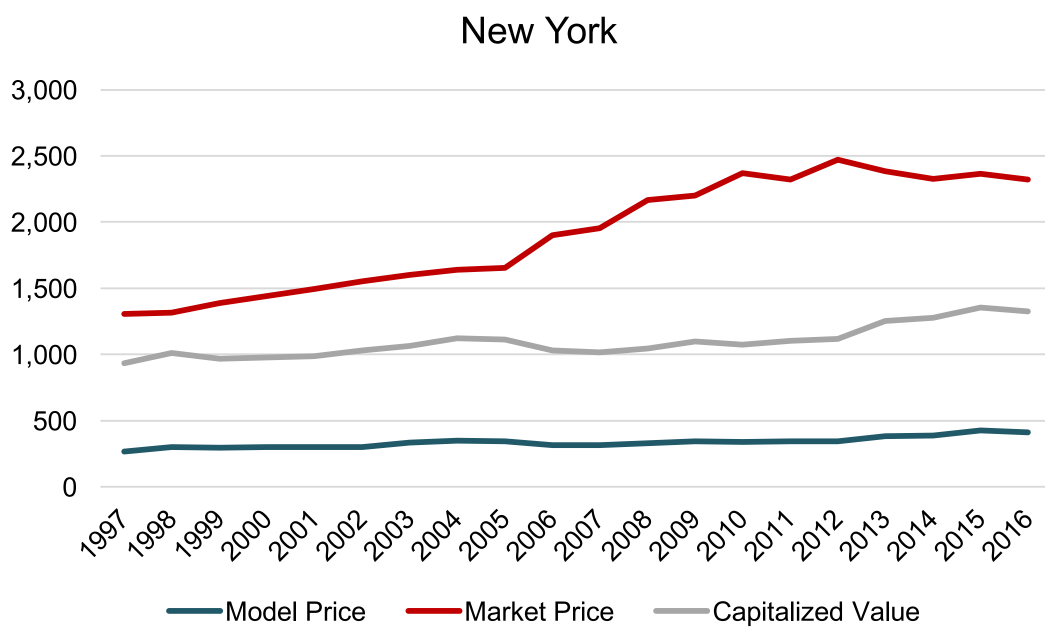

Figure 2.19. New York cropland prices, modeled and actual

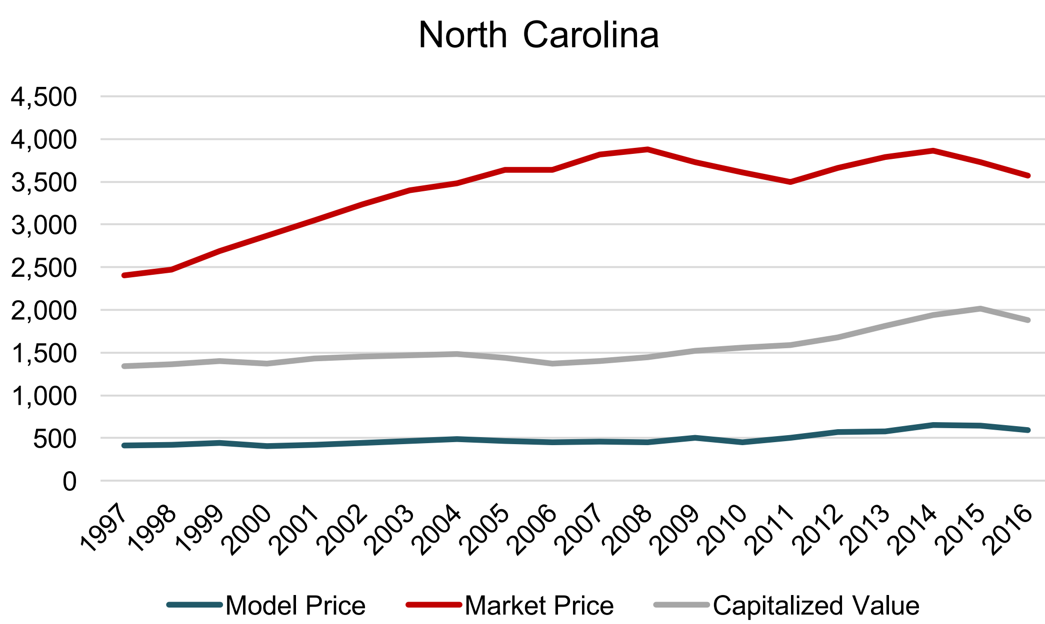

Figure 2.20. North Carolina cropland prices, modeled and actual

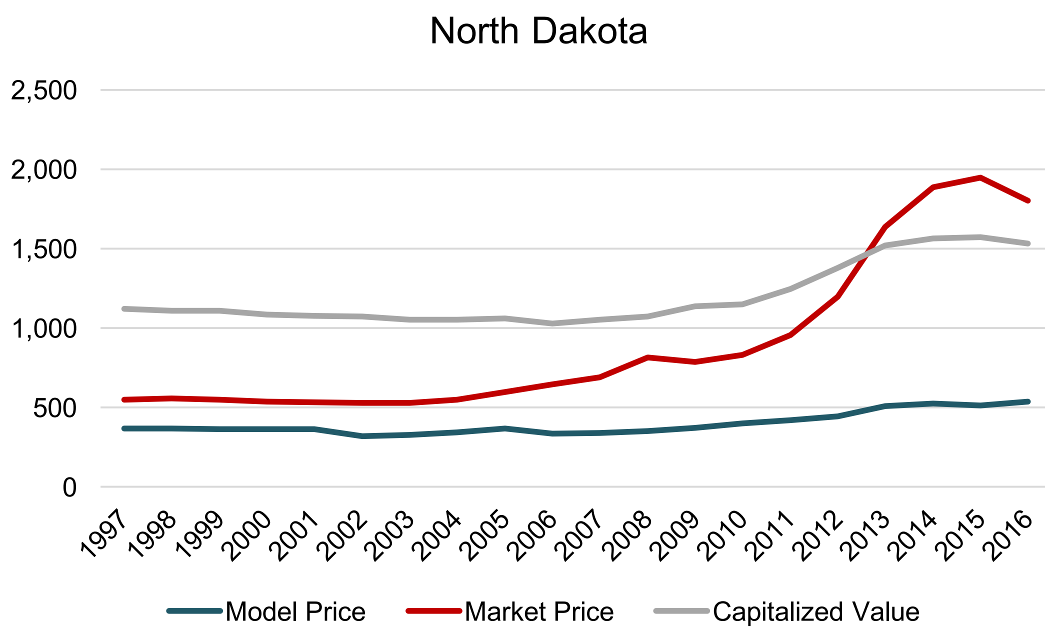

Figure 2.21. North Dakota cropland prices, modeled and actual

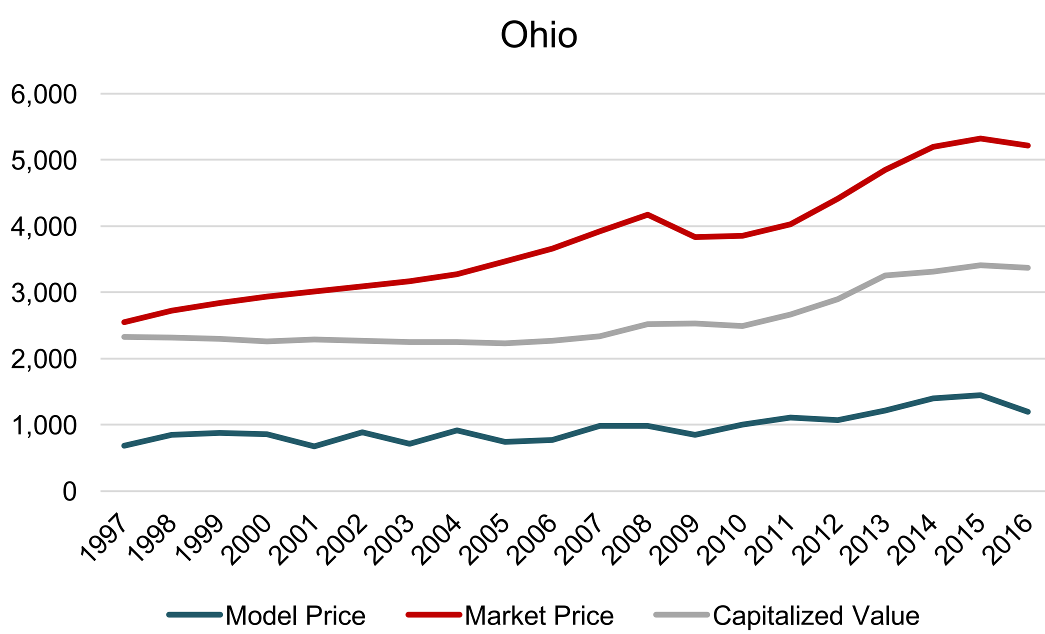

Figure 2.22. Ohio cropland prices, modeled and actual

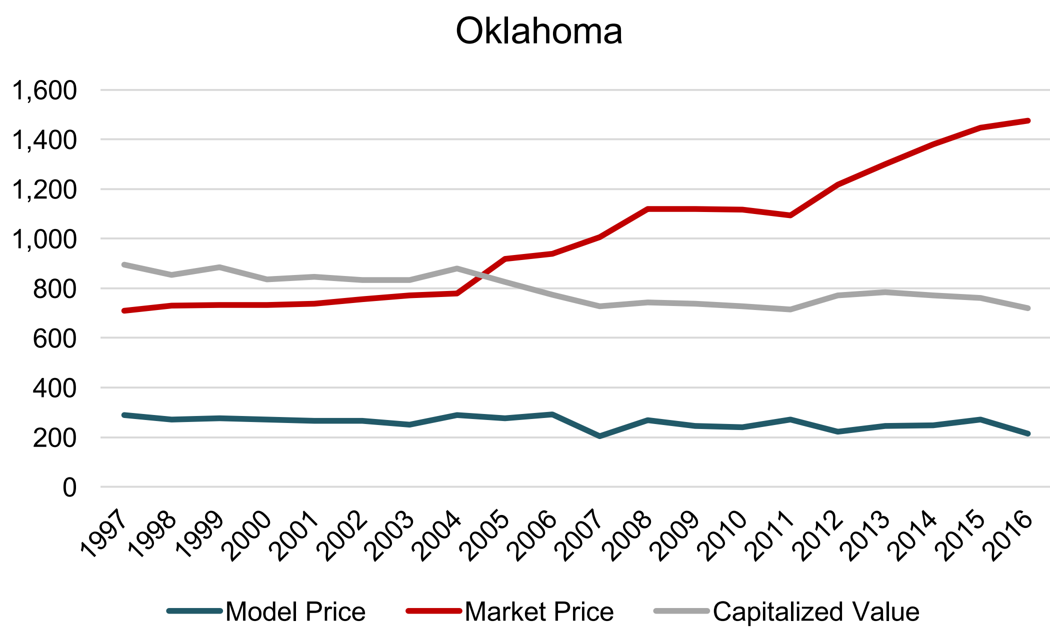

Figure 2.23. Oklahoma cropland prices, modeled and actual

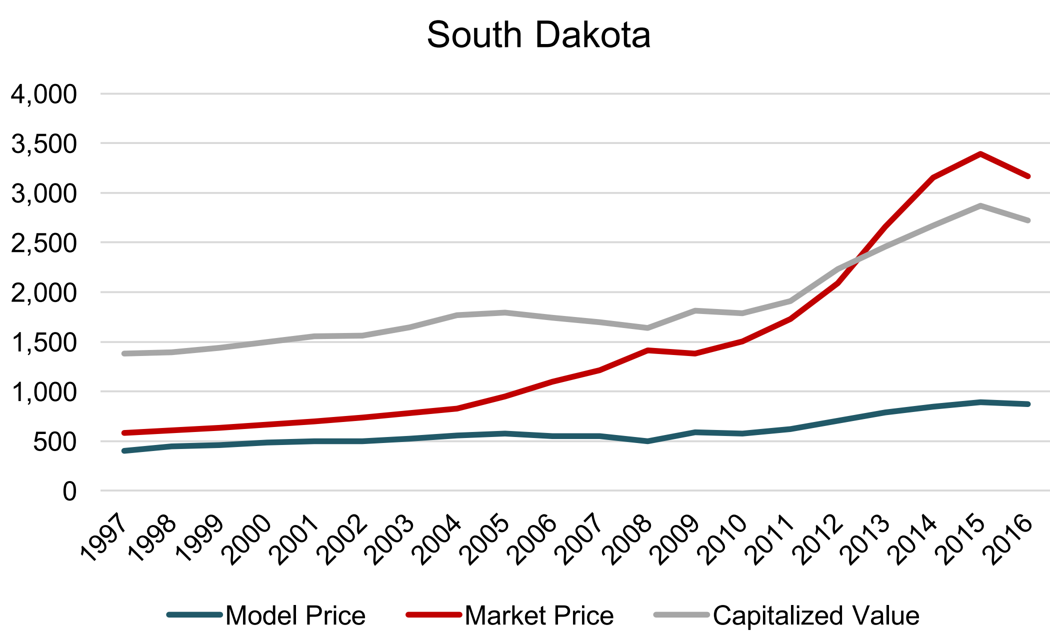

Figure 2.24. South Dakota cropland prices, modeled and actual

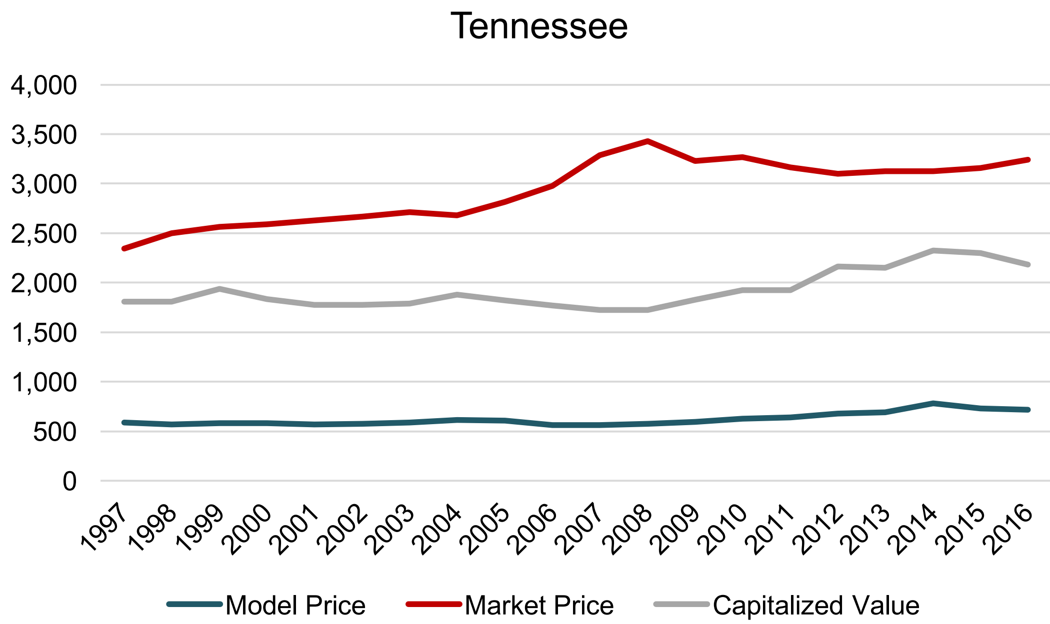

Figure 2.25. Tennessee cropland prices, modeled and actual

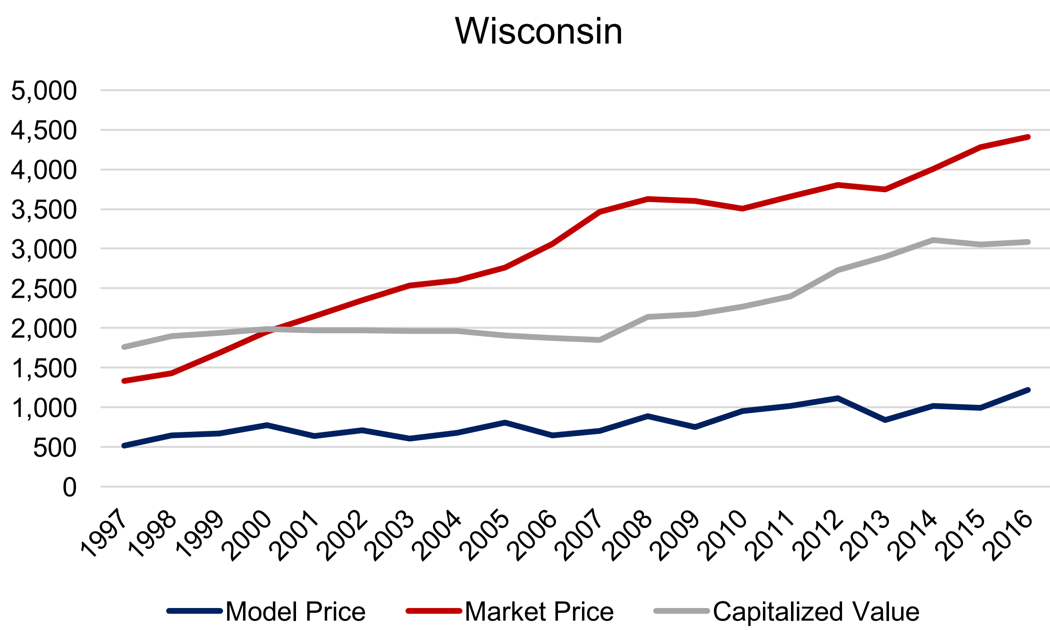

Figure 2.26. Wisconsin cropland prices, modeled and actual

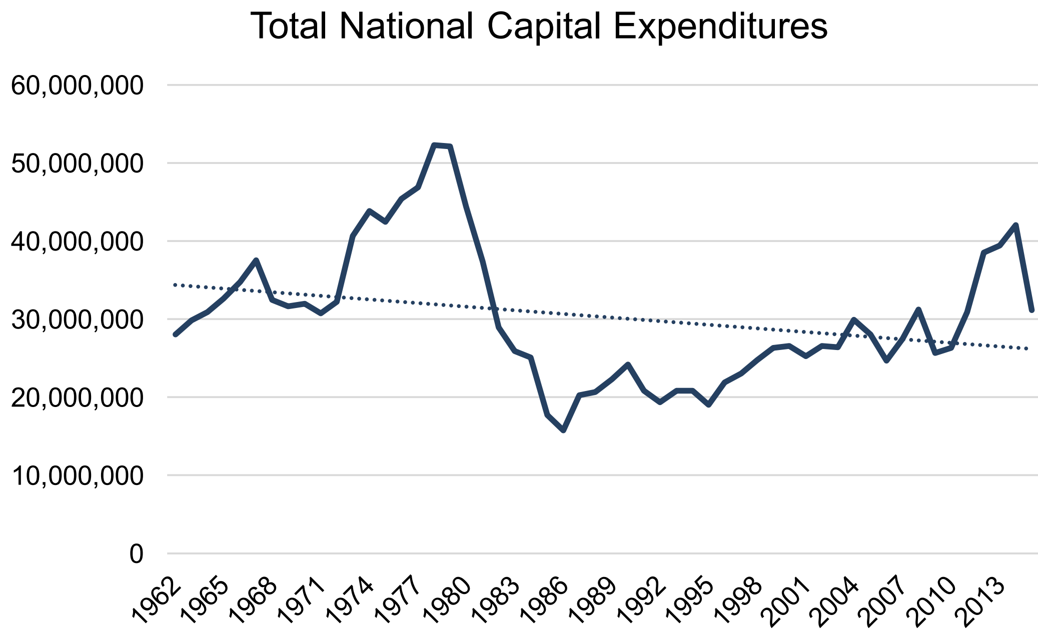

Figure 4.1. Total national capital expenditures (USDA ERS 2016)

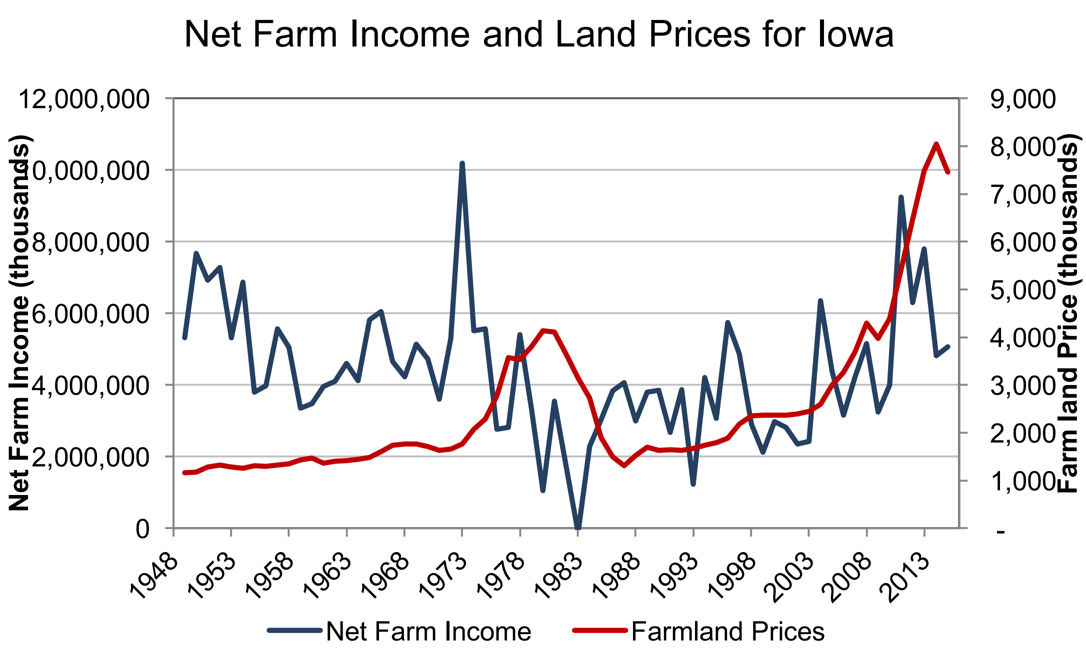

Figure 4.2. Net farm income and land prices for Iowa (USDA ERS 2016)

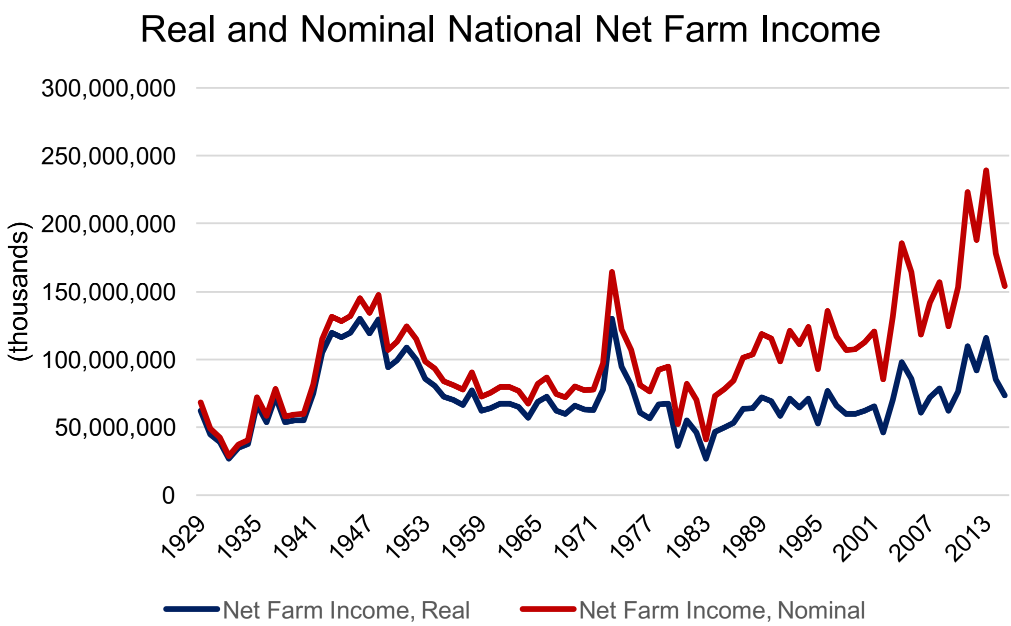

Figure 4.3. Real and nominal national net farm income (USDA ERS 2016)

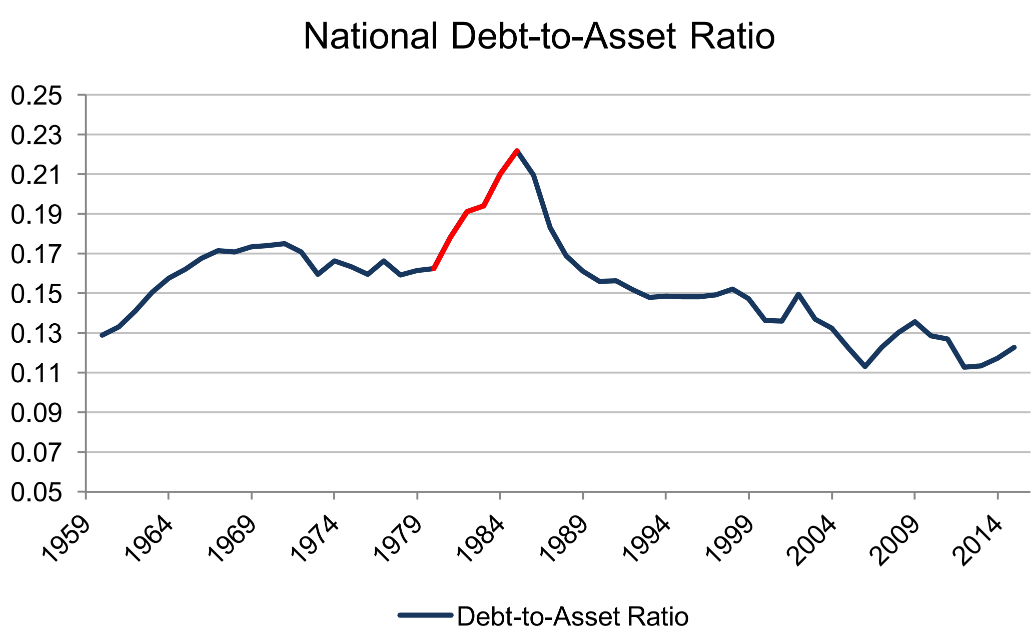

Figure 4.4. National debt-to-asset ratio (USDA ERS 2016)

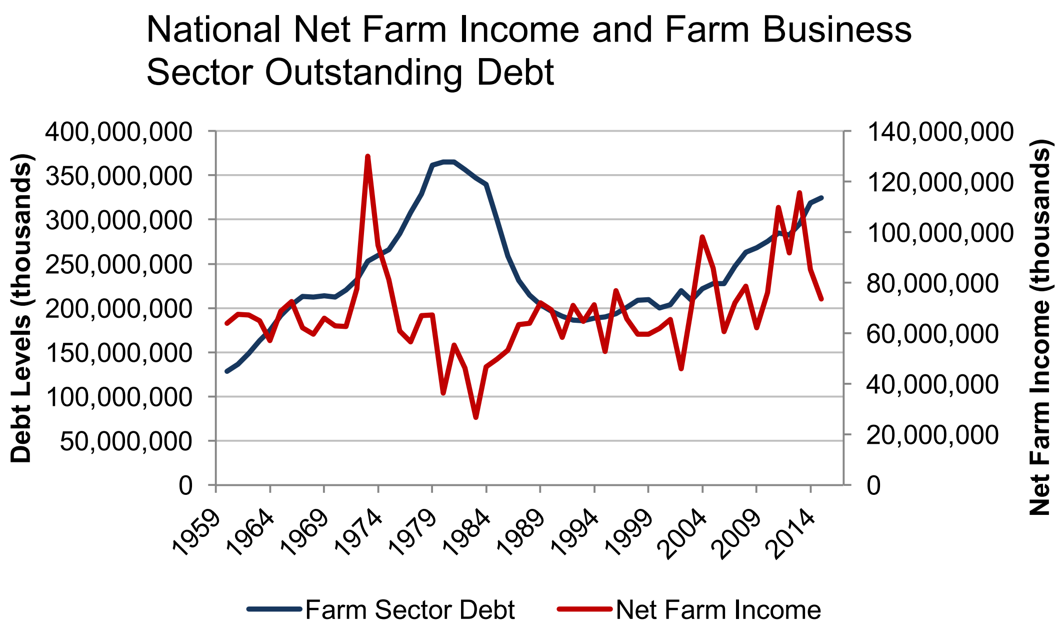

Figure 4.5. National net farm income and farm business sector outstanding debt (USDA ERS 2016)

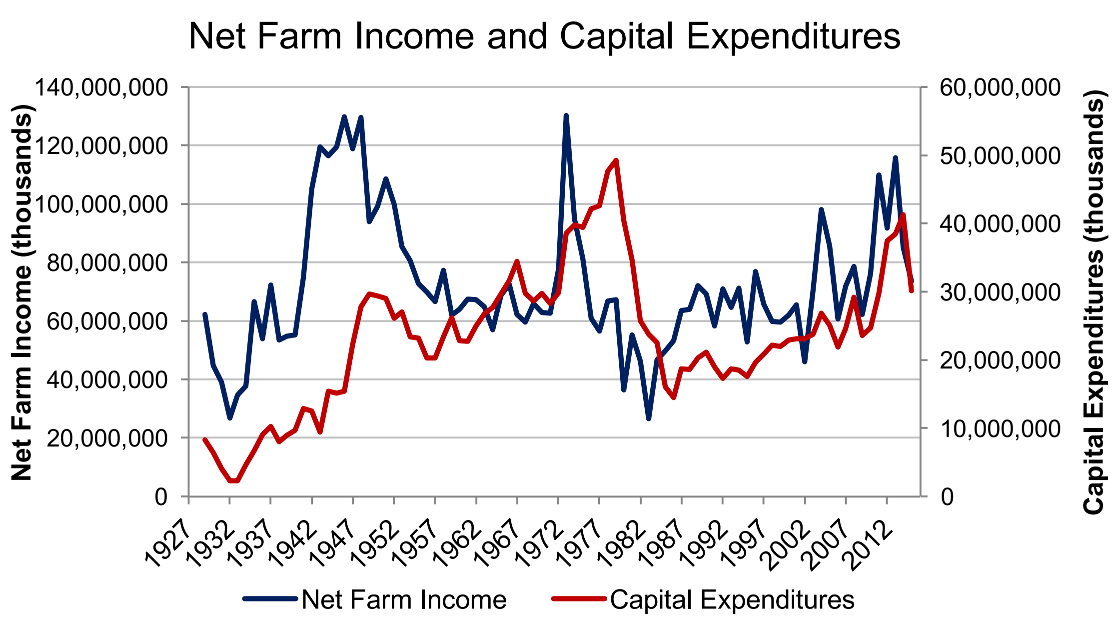

Figure 4.6. National net farm income and capital expenditures (USDA ERS 2016)

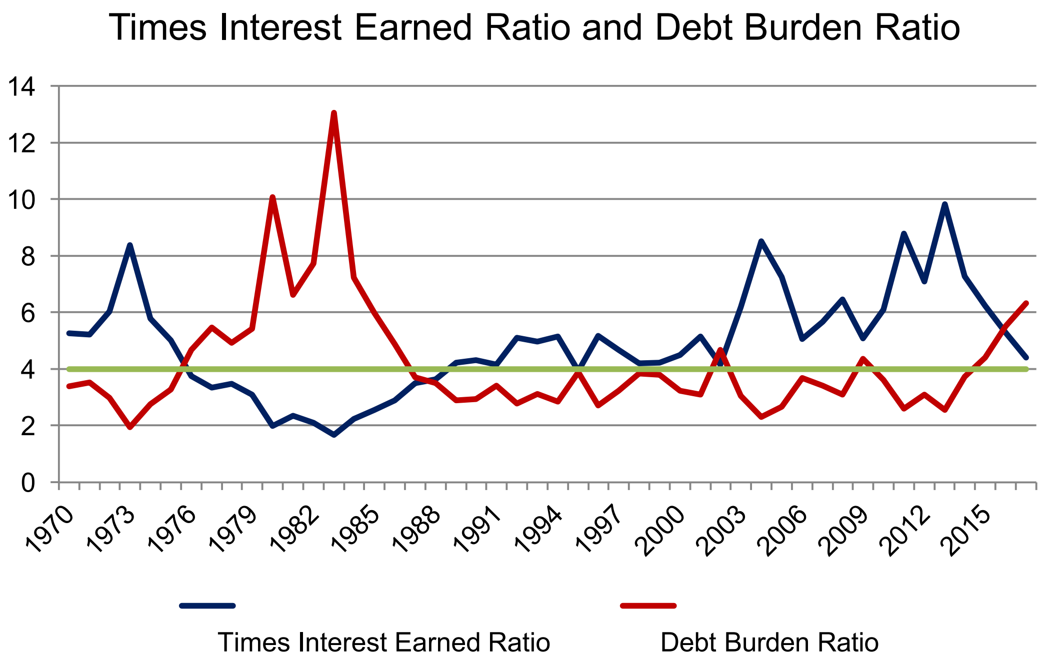

Figure 4.7. Times interest earned and debt burden ratio for the United States (USDA ERS 2016)

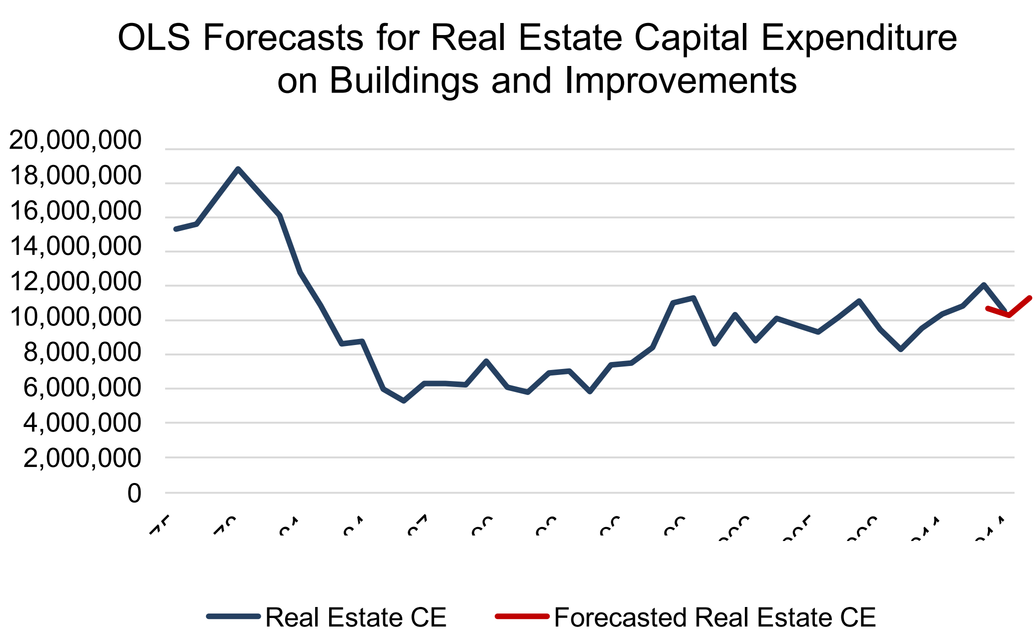

Figure 4.8. National real estate capital expenditure forecasts

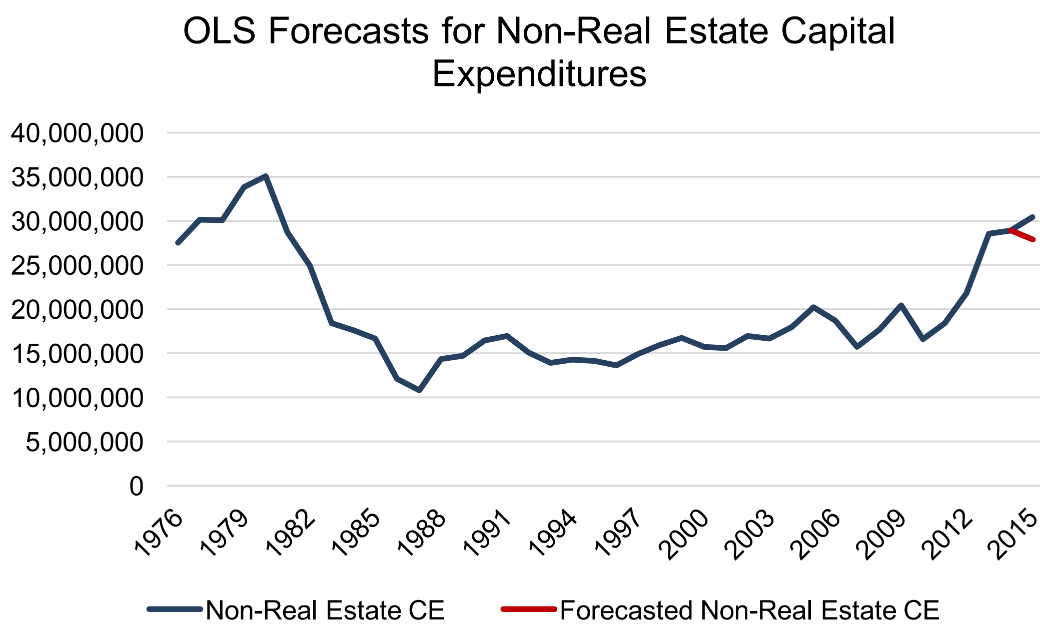

Figure 4.9. National non-real estate capital expenditure forecasts

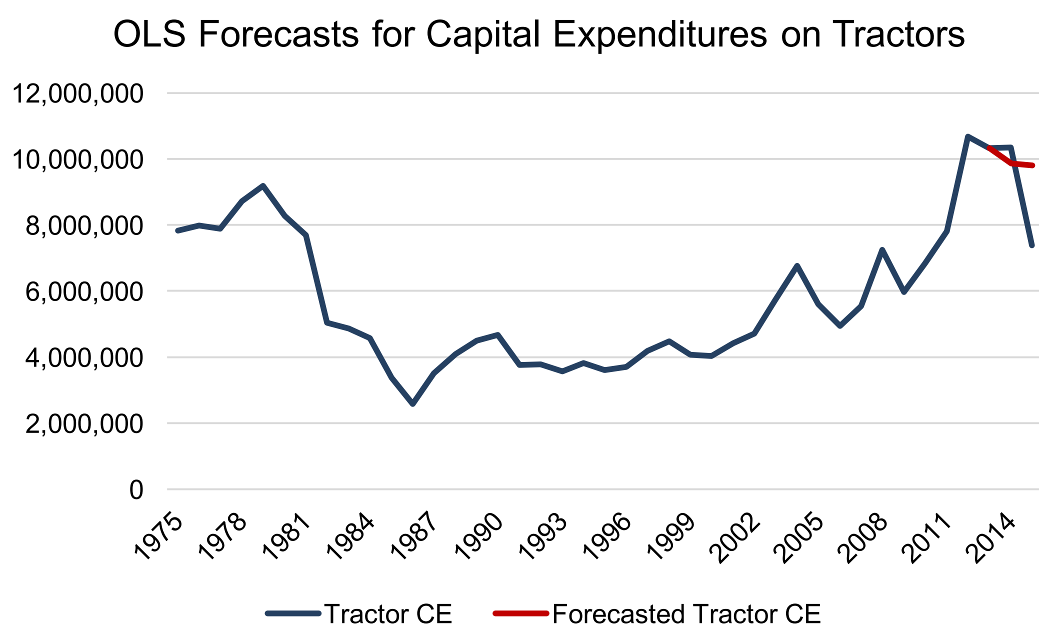

Figure 4.10. National capital expenditure on tractors forecasts

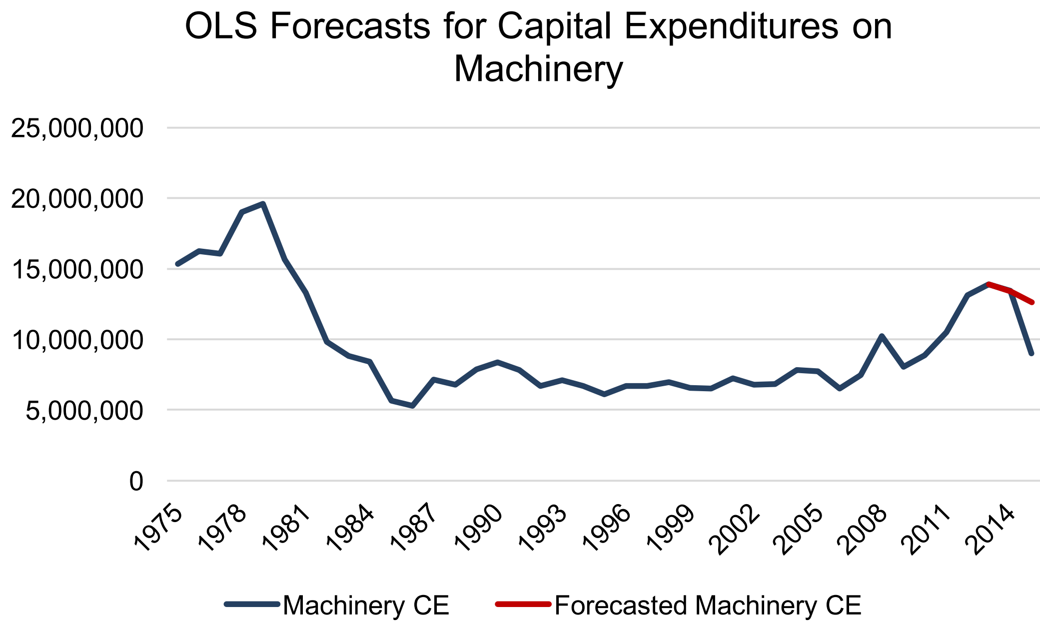

Figure 4.11. National capital expenditure on machinery forecasts

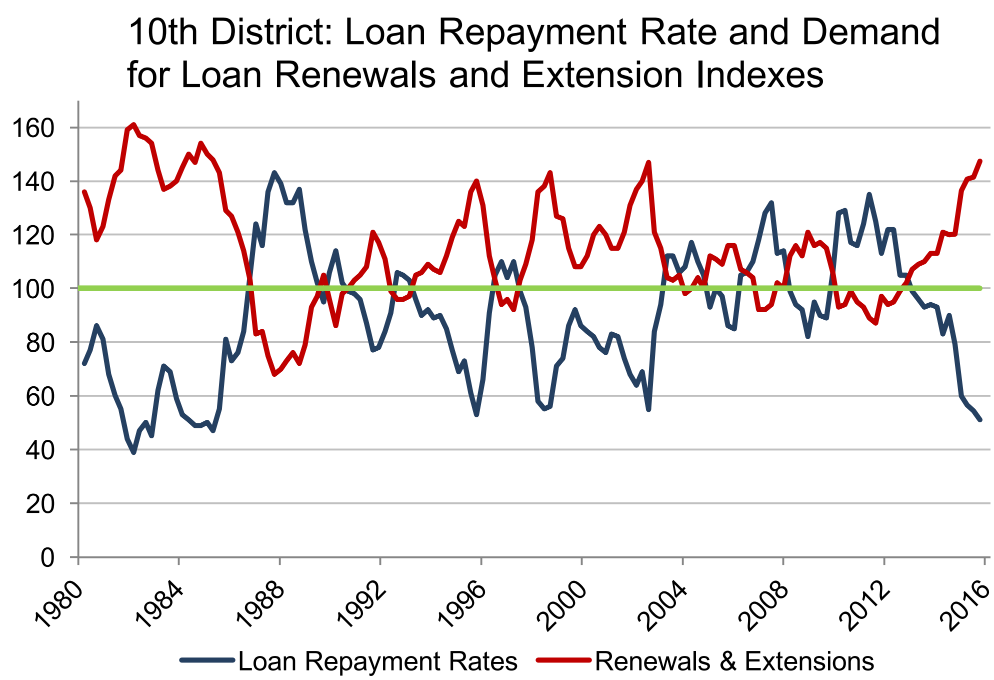

Figure 4.12. Loan repayment rate and loan renewals and extensions for the 10th District Federal Reserve Bank

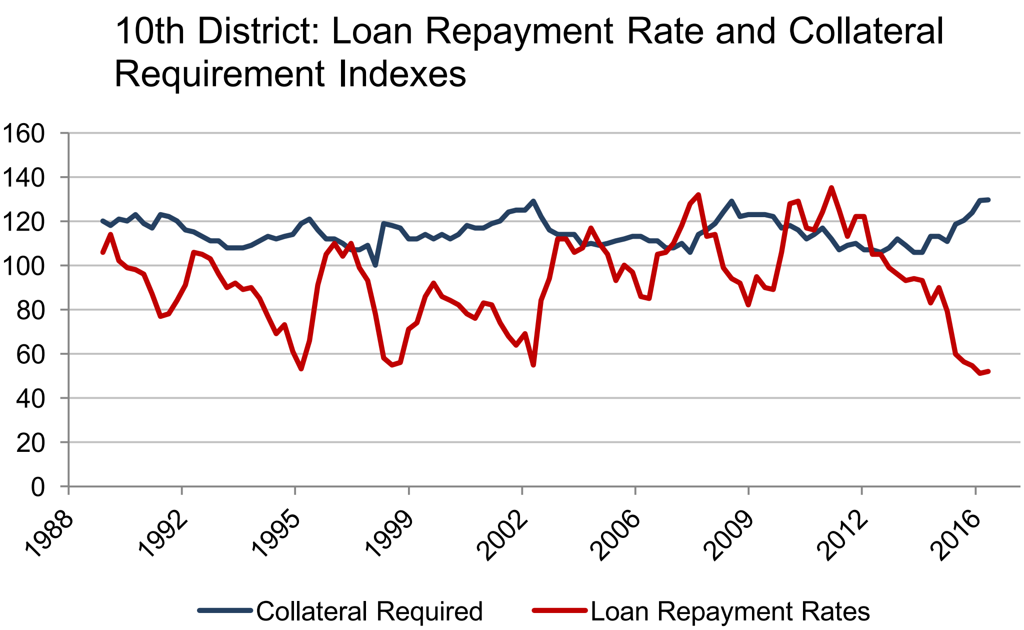

Figure 4.13. Loan repayment rate and collateral requirement indexes for the 10th District Federal Reserve Bank

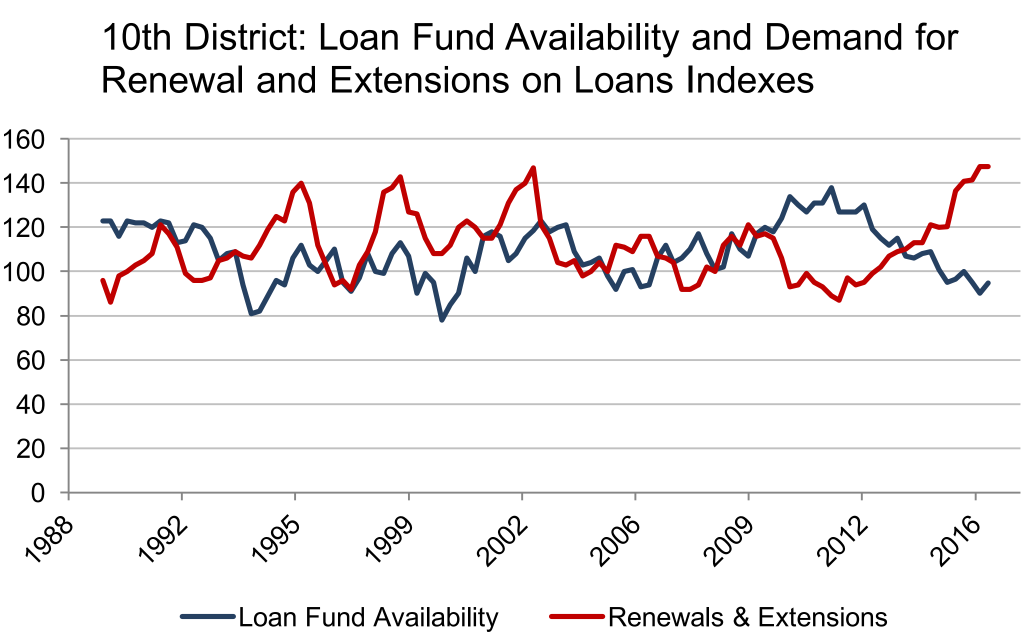

Figure 4.14. Loan fund availability and demand for renewals and extensions for the 7th District Federal Reserve Bank

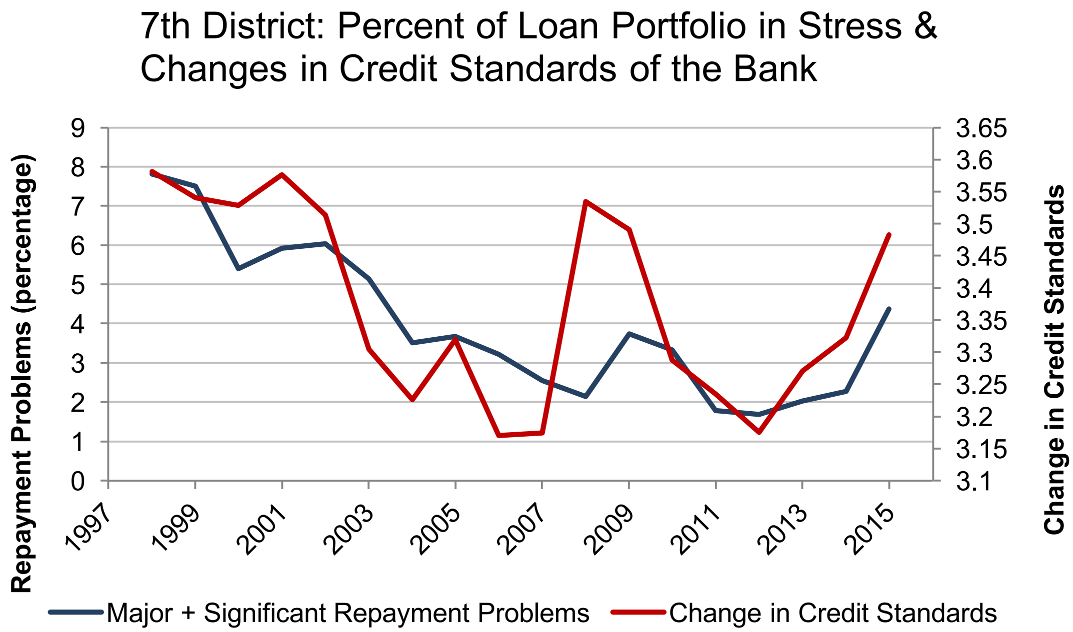

Figure 4.15. Percent of loan portfolio in stress & changes in credit standards for the bank for the 7th District Federal Reserve Bank

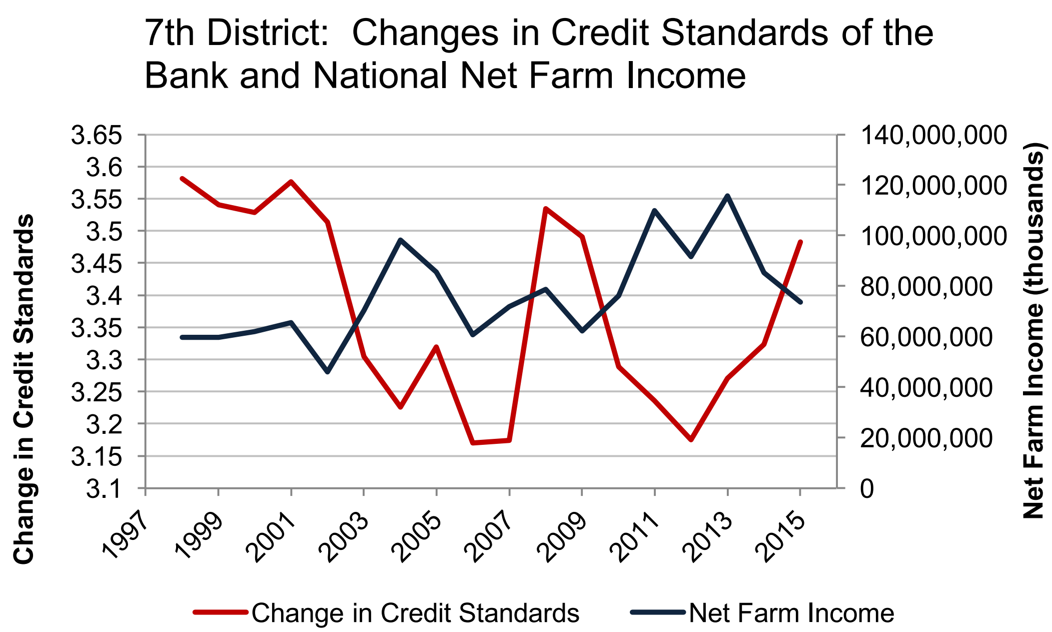

Figure 4.16. Change in credit standards and net farm income for the 7th District Federal Reserve Bank

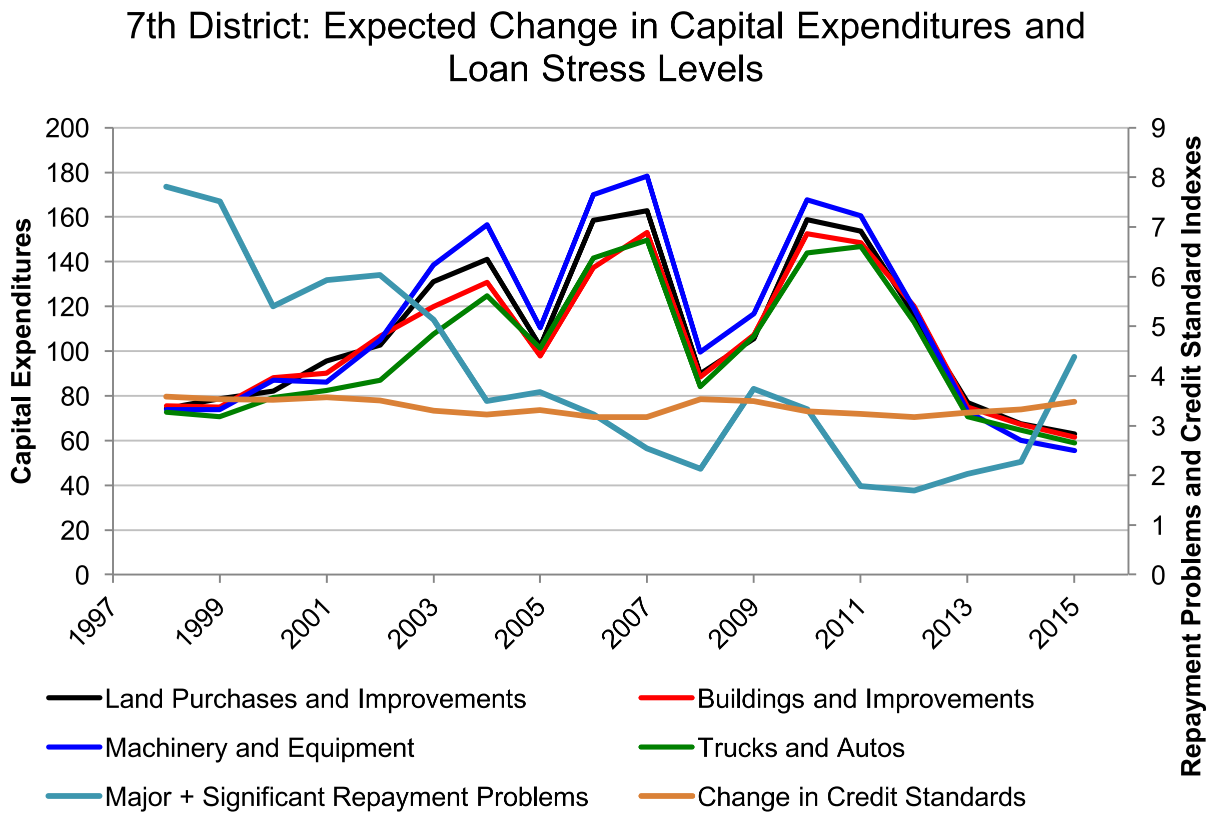

Figure 4.17. Expected change in capital expenditures and loan stress levels for the 7th District Federal Reserve Bank

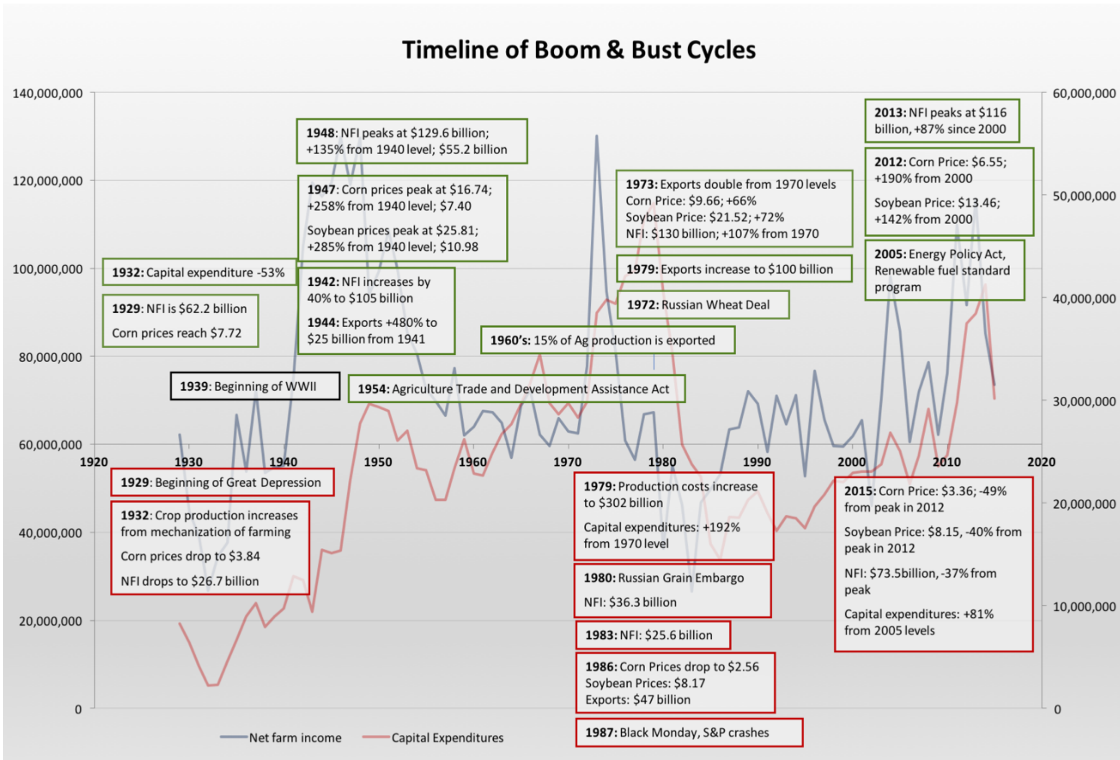

Figure 4.18. Timeline of boom-and-bust cycles in the farm business sector