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Agricultural Commodity Futures and Farmland Investment: A Regional Analysis

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Agricultural Commodity Futures and Farmland Investment: A Regional Analysis

BY

John Sherwood Clements III

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree
of
Doctor of Philosophy
in the Robinson College of Business
of
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GEORGIA STATE UNIVERSITY
ROBINSON COLLEGE OF BUSINESS
July 23, 2010

ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor in Philosophy in Business Administration in the Robinson College of Business of Georgia State University.

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ABSTRACT

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By

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July 23, 2010

Committee Chair: Dr. Alan J. Ziobrowski

Major Department: Real Estate

Using seventeen years of data from 1991 to 2008, I derive a pricing model for farmland values. This valuation model is the first using agricultural commodity futures as a proxy for "ex ante" income projections for the crops grown or livestock grazed on United States farmland. While not all inclusive, the model is tested regionally including the Corn Belt, Delta States, Lake States, Mountain, Pacific Northwest, Pacific West and Southeast Regions. Additionally, I test whether interest rate futures contracts have a relationship with farmland values as interest rates have been proven to be a reliable predictor in past research. Farmland capitalization rates and anticipated inflation have hypothesized relationships, but are mainly used as control variables in the study.

In general, agricultural commodity futures contracts are a poor predictor of changes in farmland market values. When examining relationships with quarterly percentage change regression models of the included variables, I find the Mountain region provides the most reliable pricing model where both live cattle and Minnesota wheat futures contracts has a positive statistically significant relationships with farmland market values. Also, wheat

futures prices have a significant relationship with farmland values in the Corn Belt region. Interest rate futures contracts, farmland capitalization rates and anticipated inflation are not statistically significant in the majority of the regions.

As a robustness check, I model the price levels of the variables using Johansen's cointegration procedure. This time-series econometric methodology provides results in regards to long-run equilibrium relationships between the variables. The results are only slightly better. Corn, orange juice and sugar futures contracts have positive statistically significant relationships with farmland market values in multiple regions. Again, wheat has a statistically significant positive relationship with farmland values in the Corn Belt region. The Mountain region and interest rate futures contracts are not applicable for the cointegration tests as they are not integrated to the order of one.

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Chapter One

Introduction

Agricultural commodity production has increased in efficiency in recent years due to advances in technology in harvesting, equipment, and processes. Farmland has provided record returns, including appreciation (depreciation), income (losses) and realized capital gains, over the past 5 years outperforming other asset classes such as stocks, bonds, offices, and apartments (Newell and Eves, 2007). Yet, farmland is arguably one of the least transparent real estate investment classes, thus utilization by institutional investors is lacking compared to other assets. Pricing models and the valuation of farmland have been the topics of numerous studies in past research and one central theme is the differing choice of variables used in these studies. My research integrates the futures market into the process of pricing this unique asset class of our economy.

Farmland makes up a significant portion of the real estate asset market in the United States. As of 2007, the number of farms in the United States totaled 2,204,792 and with an estimated value of $1,744,295,252,000 (USDA, 2007). According to the USDA, the value of farmland increased approximately 50% from 2002-2007. The average price per acre increased from approximately $1200 an acre to nearly $1900 an acre during this timeframe. In the United States, approximately 29,000 farms are held by institutional investors and/or corporations with 10 or more or stockholders.

Investment in farmland has also increased as a result of the enactment of the Employment Retirement Income Security Act in 1974. This law required pension funds to diversity their portfolios. Investments like timberland and farmland that were often overlooked in favor of stocks and bonds became attractive options for these institutions. Large institutional investors such as Hancock Agricultural Resource Group, UBS Agrivest, and even the Mormon Church are among the most prominent large scale investors in farm assets. Farmland investment by institutional investors, corporations, partnerships, and others is 13.5% of the total farmland economy with approximately 348,000,000 acres (USDA, 2007).

Asset Valuation

The fundamental value of any financial asset is the present value of expected future cash flows (Brigham and Daves, 2004). An asset is valued by forecasting the expected cash flows and discounting these flows over the holding period by a required rate of return (Discounted Cash Flow model or DCF). This model can be used for stocks, bonds and even real estate. Real estate and other financial assets may also be valued with relative value models. These are data-based approaches where historic transactions of similar assets in the same market are examined to derive a market value estimate (Knight, Sirmans, and Turnbull, 1998). A third valuation model of financial assets including real estate is the option pricing model. Theoretically, a call option can be placed on assets that provide an owner the right, without obligation, to obtain an asset upon payment of an exercise price (Geltner, 1989). In this model, land value increases with uncertainty for

future development or change of use, but the chance of immediate development decreases with this greater uncertainty.

For the purposes of this study, I consider the valuation model for farmland to be a present value model. The model is not DCF, but uses similar finance theory as farmland value is based upon the expectations of income produced by farm commodity products. These expectations are taken from the futures markets, which provide daily trading of futures contracts used for speculation of commodity prices to hedge downside risk.

Farmland Pricing Model

Pricing models for various investments such as stocks, bonds, commodities and farmland have been examined extensively in prior research. Consistent with finance theory, Falk (1991) notes that when markets have rational expectations and constant discount rates, the present value of expected current and future real net rents produced by a tract of farmland at the end of a given time period should be equal to the real farmland prices at the beginning of that time period. However, Shiller demonstrates, using other assets, this relationship is inconsistent with the observations of real markets. Shiller (1979) shows that bond yield volatility is too large when based only on changes in the term structure of interest rates. Similar, Shiller (1981) evaluates the classic valuation model for stocks and finds that stock price volatility is too large to be explained solely by the present value of future dividends. Further, Case and Shiller (1989) find evidence that is consistent with the notion that real estate is inefficient as well. They find that predictable movements in the real interest rates do not match a change in the real housing prices in the housing

markets of Atlanta, Chicago, Dallas, and San Francisco. The authors add that rents cannot truly be measured by differences in the quality of construction of rental and owner occupied housing, so the question of market efficiency is not definitively answered in their study.

Shiller (1984) argues that social dynamics he calls "fads and fashions" are important in assessing the movements of speculative asset prices. He shows, for example, that stock prices consistently overreact to new information on dividends. Thus asset prices cannot be forecast strictly on the basis of present value of future cash flows. Different types of assets may be "fashionable" (intrinsically more valuable) at some times and "unfashionable" at other times. Falk (1991) provides other arguments after testing the Efficient Market Hypothesis (EMH) on farmland prices. The null hypothesis of market efficiency is rejected for Iowa farmland data and he proposes that farmland may have rational bubbles.

Farmland present value models have been tested extensively and most have rejected the model because of excess volatility in the real estate values as compared to income measures such as cash rents (see Burt (1986), Falk (1991, 1992), Featherstone and Baker (1987), Tegene and Kuchler (1991, 1993), Hanson and Myers (1995), Engsted (1998), Lence and Miller (1999) and De Fontnouville and Lence (2002)). Conversely, using state and national data, De Fontnouville and Lence (2002) received mixed results after including 3% transaction costs (sales commissions and closing costs). They failed to

reject to the PVM on all tests using 6% transaction costs and the authors considered this percentage to be more realistic for farmland.

Prior research does not include agricultural commodity futures as an explanatory variable in their present value models and has provided a gap in the present farmland valuation literature. The dissertation's main purpose is to bridge this gap in the literature. This is important as futures have provided farmers with the opportunity to hedge downside risk since March 13, 1851 when the 1st recorded forward contract was introduced in Chicago, Illinois (Kline, 2000). In 1865, the 1st standardized futures contract was written by the Chicago Board of Trade (Barrie, 2001).

Agricultural Commodity Futures

Real estate research using futures contracts in pricing models is very limited (See Hinkelman and Swidler (2008), Bertus, Hollins, and Swidler (2006), Clements, Ziobrowski and Holder (2010), Liang, Seiler, and Chatrath (1998) and Jensen, Johnson and Mercer (2000). These studies test the usefulness of futures contracts as a hedging mechanism for such items as house price risk or REIT price returns, test the relationship between lumber futures and timberland market values or test whether futures contracts can be held as a portion of an optimally diversified portfolio. Futures prices have been found to be credible predictors of some asset prices, but these were financial assets, not real estate (Martikainen, Perttunen, and Puttonen, 1985).

For the purposes of this study, agricultural commodity futures are used as expectation of future income from the real estate asset farmland. Commodities used include annual row crops, permanent trees, and livestock grazing on the land. Nationally, agriculture sales are split as crops and trees accumulated 48% with livestock adding the remaining 52% (USDA, 2007). The five individual commodity leaders were: Cattle (21%), Corn (13%), Poultry (12%), Dairy Cattle (11%) and Soybeans (7%). It should be noted that not all commodities produced on farms are sold on the futures exchanges. Poultry, for example, is not a commodity available for trading. Futures provide expectations of prices, while the spot prices are actual current prices on these commodities. Consistent with expectations, as these futures prices rise the value of the land that produces these commodities should increase in the region that the crop is produced. I hypothesize that commodity futures should be positively related with farmland values in study.

Rationale and Scope of the Study

Farmland market values are the focus of the study and are derived from index data provided by the National Council of Real Estate Investment Fiduciaries (NCREIF). NCREIF is the largest agriculture index in the United States as it contains approximately 208 properties as of January, 2009 presently valued at over 1.1 billion dollars. NCREIF derives a nationally quarterly return index as well as geographic regions similar to the annual Census of Agriculture published by the United States Department of Agriculture. My other focus, agricultural commodity futures are traded on the United States futures exchanges such as the Chicago Mercantile Exchange, Intercontinental Exchange, Kansas City Board of Trade and the Minneapolis Grain Exchange. This data is provided by R &

C Research, Inc., a data mining company and includes all intra-day and end of day for most commodity futures available.

The sample period for the study is 1991 to 2008. I test ordinary least-squares regression analysis on the percentage change in farmland market values as compared to the percentage change in the prices for agricultural commodity futures over the time period. In view of the rejection of the PVM, our models test additional variables such as capitalization rates, interest rate futures, and anticipated inflation. Variables included in previous studies are interest rates, government payments, transaction costs, property taxes, ex-post land and building returns, soil characteristics, commodity transportation costs, inflation and debt payments. Because of small sample size, I do not include all of the above mentioned variables in the model. Other methodologies such as regression analysis on price levels and Johansen's cointegration technique are used. I find support for my hypothesis if the futures prices and anticipated inflation have positive signs and statistically significant with respect to farmland market values. Interest rate futures and farmland capitalization rates would be expected to have an inverse relationship with farmland market values.

Location is one of the most important factors in valuing real estate assets. Farmland is no different as many agricultural commodities are location specific varying by climate and temperatures. I test farm products used in the study by region. The regions are the Pacific West, Pacific Northwest, Corn Belt, Delta States, Southeast, Mountain, Southern Plains, and Lake States (NCREIF, 2009). As an example, oranges are grown in Florida

and California; therefore we expect orange juice futures to have a significant positive relationship with farmland values in the Southeast and Pacific West regions. Similarly, rough rice is grown in the Delta States region including Arkansas and Louisiana and we expect those futures prices to have a significant positive relationship with land values in this region. National indexes are provided by NCREIF and I test each agricultural commodity future's relationship with this index as well.

My study extends the current literature in several ways. First, the study uses agricultural commodity futures as an "ex-ante" component of the income produced from farmland. This research provides a theoretical link to the expected income from crops growing and livestock grazing on the land. Phipps (1984) observes that returns in prior research are based upon income from operations using "ex-post" data and lagged to set up "ex-ante" expectations relationship. I do not expect "ex-ante" futures values to be related to "ex-post" spot prices for the commodities, so our study extends the literature as it is forward looking. Commodities are volatile and should be based upon future expectations per finance theory. I do not know if investors look at futures with regards to farmland investing and the study tests the hypotheses as to whether short-term futures prices do indicate long-term trends as indicated by changes in farmland values.

Secondly, while farmlands have been studied on a regional basis as shown by studies by Moss (1997), Livanis, Moss, Breneman and Nehring (2006) and Mishra, Moss and Erickson (2008), they have not provided "ex-ante" income components attributable to their location in such a specific manner as the individual commodity futures prices

provide. Examples were given for orange juice and rough rice futures, but even futures such as live cattle that are found in all regions can be tested to see if commodity futures prices are significant with respect to the location where they are grown or grazed. Third, prior research on farmland has shown interest rates to be a credible explanatory variable, but have not used interest rate futures as an explanatory variable. Interest rate futures provide expectations of the change in interest rates over the short-term, similar to the agricultural commodity futures that provide expectations of the change in spot prices of the commodity.

Lastly, past research using futures and real estate aimed at hedging risk. This study provides information for use with speculation and price discovery, which are two other typical reasons for entering and trading in the futures market. Theoretically, owners of farmland in specific locations can examine prices for agricultural commodity futures and speculate on rising land values. The information provided by the futures may help with decisions on land expansion, lease-purchase conversions, or sales of excess land.

The results of the study are intended to provide conclusions for “large farms” similar to the farms located in the NCREIF index. NCREIF (2009) readily admits their portfolios represent a single asset class and may not represent the total agriculture market in the United States. I am not implying this study is a pricing model for small “family farms” that are common around the country. Conclusions are expected to provide insight into the possible behavior of the farmland investor, not the small private farmer.

Findings and Organization of Dissertation

In general, I find a weak relationship between agricultural commodities futures prices and farmland value. But in almost all regions of the United States, I find at least one commodity whose price is significantly related to farmland value. In the quarterly regression models, the Mountain region had the most accurate pricing model, with, live cattle, Minnesota wheat and cotton futures being significant. In the long-run cointegration models, sugar, corn and orange juice are significant in several regions. In the Corn Belt, wheat is a significant predictor of future changes in farmland prices in both the cointegration and regression models. Overall, capitalization rates are negatively related to farmland market values as expected and contrary to expectations anticipated inflation has a similar negative relationship. Interest rate futures contracts, based on the 10-year Treasury bond, are not significant in the regression models and are inappropriate for cointegration models because they follow a random walk.

While this chapter has introduced the study, the remainder of the study is organized in the following way. Chapter II presents a review of the relevant literature on the necessary topics and the theory behind the pricing model. Chapter III provides the data construction and the methodology employed in testing the model. The empirical results and discussion follow in Chapter IV and the final section, Chapter V, presents conclusions and possible future research needed on the topic area.

Chapter Two

Literature Review

The review of the relevant literature is separated into the following sections: Farmland valuation studies, agricultural commodity futures markets in the real estate literature studies and inflation in the real estate literature studies. The theoretical foundation and hypotheses for the study is shown following the relevant literature.

Farmland Valuation Literature

The real estate and economics literature has provided a long history of farmland valuation research. Herdt and Cochrane (1966) examine farmland prices theoretically and empirically to show that expectations of increases in future income are bid into land prices. They argue that rising demand for farmland occurs for the following 3 reasons: urbanization, farm technological advances and government allotments for price-supported commodities. The study's focus is placed on technological advances and the methodology is a 2-stage least squares regression on a multivariate model. The study covers 1913 to 1962 and includes many explanatory variables including interest rates, unemployment, total farm acreage, the United States Department of Agriculture (USDA) productivity index, and wholesale price levels. The results suggest that technological advances in agriculture benefit the farmland owner through bid up land prices and are not beneficial to the manager or operator who has a relatively constant income over time.

Present value models (PVM) are a central theme in farmland value research. The differences in the literature stem from the choices of explanatory variables and the types of methodology employed. Reinsel and Reinsel (1979) model farmland value using ratios of the difference in farmland value and farmland income (rents). Using annual USDA data over the time period of 1940 to 1979, their results suggest that farmland rents have increased over time, but farmland prices increased at an even faster rate. The authors theorize that population growth and inflation cause variation in land values as land is a scarce product and dense populations and rising commodity prices amplify the effects of scarcity.

Similarly, Melichar (1973) examines farmland capital flows (farm expenditures and debt capital) between 1950 and 1972 to help explain the difference in farmland rents and market values. He finds that an increase in farm debt will be necessary to sustain the current increase in farmland prices He surmises that real estate is approximately two-thirds of farm assets and real estate related capital inflows and outflows are two-fifths of the total capital flows. In other words, real estate is the largest portion of farm assets, but real estate purchases are less than half of farm expenditures. The external capital flow of debt allows for real estate land transfers and makes up for any shortfall in the other necessary components of farm production. These farm production components are farm machinery purchases, building and land improvements and crop and livestock inventories on a farm. Furthering his research, Melichar (1979) examined the market value of farmland assets for capital gains using similar USDA data. He suggests that "net farm income is not the appropriate measure of either land or production assets." He reasons

that capital gains should be subtracted from net income since not all real estate (operator's dwellings) is necessarily part of the farm's production. Also, he notes that future studies should consider lease income for passive investors and interest paid on farmland debt. His results indicate that farmland capital gains are fully explained by appreciation in the value of the individual farm assets.

Castle and Hoch (1978) hypothesize that market values for farmland are explained by a real capital gains component in addition to the customary expected farm earnings component as shown by the traditional PVM. The capital gains component accounts for all real changes in value including building and land appreciation, changes in debt, inflation, taxes and other variables. Using national annual average values per acre on United States Department of Agriculture (USDA) data from 1920 to 1978, the authors find that expected farm earnings accounts for approximately half of the real estate values. The remainder is explained by capitalization of the capital gains.

Alston (1986), using annual data from 8 states, shows that increases in net rental income to the land is the primary factor in explaining increases in farmland values. The states included in the study were Iowa, Illinois, Indiana, Missouri, North Dakota, South Dakota, Ohio and Minnesota and the time period covered 1963 to 1982. Additionally, Alston (1986) tested the Feldstein hypothesis (1980, 1980), that is, land prices should increase with the inflation rate. On the contrary, he finds anticipated inflation has a negative relationship with rising farmland prices, but the impact of inflation is small when compared to the impact of net rental income on farmland values. He also compared the

growth of the United States farmland price index with those of Canada, Argentina and New Zealand. Despite difference in capital gains tax regulations, income tax rates and rates of inflation, there was little difference in inflation's effects on land prices.

Little attention has been given to the use of future income for determining farmland values. Phipps (1984) admits that prior studies use "ex-post" returns as a proxy for expected returns to set up the expectations model for testing farmland market values. Using USDA annual data from a sample period of 1940 to 1979, he finds that farmland returns "Granger cause" farmland prices. Granger causality does not imply that one variable causes another, but that one variable may be used to predict changes in another variable. The econometric methodology also reduced serial correlation issues present in earlier farmland value research.

Using Agriculture Finance Datebook returns from 1910 to 1985, Featherstone and Baker (1987) do similar Granger causality tests to show that not only do farmland returns cause farmland values, but farmland values cause farmland values which suggests speculative bubbles in the farmland real estate market. Speculative price bubbles occur when actual market prices deviate significantly from the expected prices shown by market fundamentals. Tirole (1985) notes that price bubbles are caused by three necessary conditions: durability, scarcity, and common beliefs. Farmland is considered durable as the land is indestructible and like other real estate is a scarce resource. Featherstone and Baker (1987) observe that farmers hold common beliefs because they obtain information from the same sources such as the USDA and receive market signals provided by

interrelated commodity markets. Further, Featherstone and Baker (1987) use VAR econometric methodology with variance decompositions and impulse response functions to show that farmland values overreact to changes in net returns and changes in interest rates.

The first test of the Efficient Market Hypothesis (EMH) with a farmland PVM was performed by Falk (1991). Following the work of Campbell and Shiller (1987), Falk tests the PVM with a constant discount rate using annual Iowa farmland values and returns between 1921 and 1986. He rejects the null hypothesis finding that farmland markets are not efficient. Similarly, Falk (1992) tests the EMH with a time-varying discount rate using VAR methodology and once again rejects the null hypothesis. He suggests that fundamental changes in the market such as changes in the tax codes are causing the lack of efficiency in farmland markets.

Later, Falk and Lee (1998) decompose changes in farmland prices into three uncorrelated components, a permanent fundamental component, a temporary fundamental component, and a non-fundamental component, in order to study differences in explanations of farmland prices. Fundamental components are defined as shocks that influence the time path of rents and the time paths of interest rates. Examples of these shocks are government policy, weather and technology breakthroughs and the shocks can be permanent or temporary. Non-fundamental components are shocks that influence the farmland prices, but not the paths of the rent or the interest rates. These shocks are overreactions by the market not associated with any known fundamental changes (i.e. fads

as presented by Shiller (1984)). Shiller (1984) argues that social dynamics he calls "fads and fashions" are important in assessing the movements of speculative asset prices. He shows, for example, that stock prices consistently "overreact" to new information on dividends. Thus asset prices cannot be forecast strictly on the basis of present value of future cash flows. Different types of assets may be "fashionable" (intrinsically more valuable) at some times and "unfashionable" at other times. Falk and Lee (1998) find that farmland values are inefficient due to a combination of temporary fundamental factors and non-fundamental factors.

Tegene and Kuchler (1991) test the EMH on annual farmland data from the Lake States, the Corn Belt and the Northern Plains regions of the United States. They test not only a rational expectations model (forward looking), but an adaptive expectations model (backwards looking). Adaptive expectations use the past time period's results to predict the future results of the model, while rational expectations use all readily available public information to predict future results of the model. Rational expectations assume that prices will tend toward equilibrium otherwise there would be arbitrage opportunities in the market. In their research, the rational expectations model rejects the null hypothesis for market efficiency, while the adaptive expectations model accepts it. This result can be explained by policy changes that do not affect prices instantaneously in adaptive expectations markets as they do in rational markets. Tegene and Kuchler (1993) later find that speculative bubbles do not occur in farmland markets. Using cointegration, the authors accept the notion that market fundamentals are a determinant in the movement of farmland values similar to Falk (1991).

De Fontnouville and Lence (2002) include transaction costs in a test of the present value model with a constant discount rate using kernel regression. They test annual farmland values and returns in 20 states and conclude farmland prices are efficient when including transaction costs such as sales commissions and other fees in the price. They also test for market efficiency in farmland prices using national data and find an inefficient market similar to the previous research of Falk (1991) and Tegene and Kuchler (1993). Additionally, the authors test the PVM with a constant discount rate without transaction costs and find the market to be inefficient as well.

Engsted (1998) contradicts Tegene and Kuchler's (1993) research and argues that cointegration is not useful when examining discount rates and expectations in the PVM. He notes that cointegration tests do not provide evidence whether expectations are "backward looking" or "forward looking" nor evidence whether the discount rate is constant or time-varying. He uses the same data, but differing VAR methodology in performing the tests. He rejects the null hypothesis of market efficiency. He notes that PVMs should be tested with time-varying discount rates as suggested by Falk (1992).

Time-varying risk premiums in the returns for farmland are tested by Hanson and Myers (1995). They argue that commodity price booms are important "economic conditions that could lead to changes in risk premiums which would have important implications for the present value models for farmland." The authors test annual USDA returns data for the lower 48 states from 1910 to 1990 using first-order ARCH models. The methodology

uses lagged dependent variables to account for autocorrelation. The results do not suggest a time-varying risk premium in farmland values as excess returns to farmland are uncorrelated with the time-varying conditional variance. The PVM and Capital Asset Pricing Model (CAPM) of farmland returns are both rejected as the autocorrelation cannot be explained by the time-varying risk premium.

Inflation is a subject of some debate in farmland pricing. As noted earlier, Alston (1986) finds little significance when examining inflation's effects on farmland values. However, Moss (1997) examines Florida state data from 1960 to 1994 to find that inflation is the best predictor of changes in Florida farmland values. He also finds that agricultural returns are a significant predictor of farmland values. Moss (1997) extends the study to an inland 48 state analysis and finds that inflation is the most significant predictor of farmland values as compared to other explanatory variables: cost of capital and farm income. Regionally, the study provides similar results to the state level except in the Northeast region where the cost of debt capital was the most significant explanatory factor. Also, in the Northeast and Southern regions inflation has less total explanatory power when compared to other regions. In most regions, inflation accounted for 80% of the explanatory power.

Just and Miranowski (1993) examine Iowa, Kansas and Georgia data to find that inflation, the direct opportunity cost of each dollar invested in farmland and farmland returns are the primary explanatory variables in farmland pricing models. They use Seemingly Unrelated Regression (SUR) to counter high autocorrelation among the states

in the data set. The time period of the study was from 1963 to 1986. Just and Miranowski (1993) note that inflation has a multi-level effect as it leads to capital erosion, savings-return erosion and real debt reduction. Other results show that government payments and the availability of credit have little effect on the change in farm prices.

Weersink, Clark, Turvey and Sarker (1999) use Non-Linear Seemingly Unrelated Regression to test Ontario, Canada data from 1947 to 1993 and finds that the long-run response of farmland values to government payments is highly elastic. In the short-run, the government payments are inelastic, so landowners generally price government payments into the farmland values when the payments are perceived to be permanent. Moss, Shonkwiler and Reynolds (1989) find negative statistical significance between government payments and farmland asset values in the short-run. Using Bayesian vector autoregression on annual USDA data from 1945 to 1986, they find the relationship between government assistance and farmland values is transitory and values cannot be controlled reliably in the long-run by government price support payments. The authors suggest that a better approach to increasing farmland values is by decreasing the real interest rate. A large portion in the decline in market values over the 1980s can be attributed to increases in the real interest rate by the Federal Reserve Board.

New York State's Agricultural District Program has no significant relationship with farmland values (Vitaliano and Hill, 1994). This program features an agricultural-use tax exemption for landowners. Ordinarily this may not be important, but this is an example

of a farm “preservation” program or tax abatement program that is not enhancing farmland values. New York state real estate sales data from 1981 to 1986 is tested with weighted least squares regression to show that nonfarm “influence” variables were a significant predictor in this study. These variables show the influence of real estate development on farmland prices as they are distance measures to nearby commercial real estate such as retail shopping. Other significant variables include a climate measure known as growing degree days, poor drainage, school enrollment, percent of tillable soil, soil rating, distance to New York City and property tax rates.

Goodwin, Mishra, and Ortalo-Magne (2003) test USDA-National Agriculture Service (NASS) Agricultural Resource Management Survey (ARMS) data from 1998 to 2001 and find that price supports raise farmland values $6.55 per acre for every dollar invested while disaster payments raise values somewhat less at $4.69 per acre per dollar. Agriculture Transmission Market Payments from the 1996 Fair Act raised land values $4.94 for every dollar they provided to the farmer. When examining individual regions, the impact of price supports on farmland prices was uneven.

Mishra, Moss and Erickson (2008) use multivariate panel cointegration to examine the relationship among farmland returns (gross revenues per acre less expenditures), average farmland interest rates on farm business debt, debt to asset ratios and government payments. They pool annual USDA data on a national level as well as look at various regions. The results indicate that farmland prices are positively and significantly related to farmland returns in 9 out of 10 regions. Interest rates are negatively and significantly

related to farmland prices in all regions. Government payments are negatively and significantly related to farmland prices in all regions except the Northeast and Lake States. The debt-to-asset ratio is also negatively and significantly related to farmland prices in 7 of 10 regions.

Shalit and Schmitz (1982) use national farmland price data from the United States Department of Agriculture (USDA) Economic Research Service to find that farm savings (farm income minus farm consumption) and accumulated real estate debt are determinants of farmland prices. The time period of the study covers 1950 to 1978. The results suggest that credit liquidity by the banking sector directly impacts the speed at which farm values rise or fall. Additionally, the number of farms increases as the total debt per acre decreases.

Urban sprawl's affects on farmland values has been the topic of several studies. Shi, Phipps, and Colyer (1997) use gravity models to examine the influence of urbanization on farmland value in West Virginia. The study uses net income to farmland per acre, real capital gains to farmland per acre, the index of the ratio of population to the squared distance to the three closest metropolitan areas and the real interest rate as explanatory variables for the price per acre of farmland. All variables with the exception of the real interest rate are significant and have the appropriate signs. Shi, Phipps, and Colyer (1997) find that a 1 % increase in the urban influence index variable (population size/distance) results in a $132.60 increase in market values of farmland. Net income and real capital gains have lesser positive influences on farmland values.

Hardie, Naranyan and Gardner (2001) find that, in addition to farm revenue, non-farm factors also play a significant role in establishing farmland value. Results indicate that an increase of farm revenue of $1.00 per acre changes the value per acre of farmland by $2.95. A $1.00 increase in farm expenditures per acre reduces the value of farmland by $4.82 per acre. Non-farm factors also had significant effects. An increase in nearby housing prices or an increase in local population leads to an increase in farmland values. The study includes 3 cross-sections of county level data from the Mid-Atlantic states in the years, 1982, 1987 and 1992.

Following Von Thunen’s (1826) economic model, Livanis, Moss, Breneman and Nehring (2006) examine 3 effects of urban sprawl on farmland values: the impact of farmland conversion to urban uses, the effect of urbanization on agricultural returns and the speculative effects of conversion risk. The authors use generalized 3 stage least squares regression on county level data between 1987 and 1997 to find that on average a $1 increase in net farm income will increase farmland values $4.16 an acre. For urbanization effects, the results indicate that for every $1000 increase in median house prices, there is an $11.60 per acre increase in farmland value. As for speculative effects, a 1% increase in their accessibility index (population in an urban center/ distance to urban center) leads to a $3.09 per acre increase in farmland value. Livanis, et al (2006) find that the impact of agricultural income on farmland value is small. The effect of urban sprawl is strongest in the northeastern United States and is not unexpected.

Platinga, Lubowski, and Stavins (2002) use a spatial city model to find that option values associated with irreversible and uncertain development are capitalized into current farmland values. The test includes a cross section of 3000 counties across the United States and results are estimated for the average county in 1997. They find that potential future rents from development account for approximately 10% of farmland value. Increases in population density and highway density increase the value of farmland significantly.

Recently, Guiling, Brorsen and Doye (2009) estimate the effects of urban proximity on Oklahoma farmland tracts between 1971 and 2005. The authors use data from 12 of the state's cities and the size and distance effects of urban proximity from these cities are allowed to vary across time. They find that population and income explain the effects of urban proximity on agricultural land values. Researchers have theorized "flight from blight", but preferences for living further from the city center have not evolved over time except that resulting from increasing population and income.

Little research on the differences in farmland soil quality has been studied even though crops are grown and livestock is grazed on this soil. Miranowski and Hammes (2001) use Iowa transaction data covering the time period 1974 to 1979 to test if soil characteristics affect farmland values. Ordinary least squares regression models find that increased topsoil depth and PH (soil acidity) have a positive relationship on farmland values. Erosion from rainfall intensity and steepness and length of slopes has a negative impact on farmland values.

Agricultural Commodity Futures in the Real Estate Literature

A financial derivative is a financial instrument or security whose payoffs depend on another financial instrument or security (Kolb, 2003). Examples of these include options, swaps, forward contracts and futures contracts. Forward contracts on commodities and other assets are derived at a particular time, but delivery of these underlying assets and execution of the trade occurs at a later date. Futures contracts are very similar to forward contracts, but futures are traded on an organized exchange and are regulated by governmental agencies such as the Commodity Futures Trading Commission (CFTC). The United States has several of these exchanges including the Chicago Mercantile Exchange Group, New York Board of Trade, New York Mercantile Exchange, Kansas City Board of Trade and Minneapolis Grain Exchange. Additionally, futures contracts are guaranteed by a clearinghouse (financial institution) that insures the integrity of the transaction. Another difference is that purchasers of futures contracts must post a margin to be allowed to trade at the exchange. The margin is a form of insurance which provides financial assurance against sudden negative turns in the market that may induce a buyer to default. Lastly, that futures contracts show exact specifications for the assets involved in the transaction. Commodity specifications include size, quantity, tick size, delivery dates and delivery mechanisms.

Research on the effects of agricultural commodity futures upon real estate is somewhat sparse. Hinkelmann and Swidler (2008) used futures contracts to hedge national residential housing price risk. A total of 31 futures contracts are used in the study. The

time period for the study is 1983 to 2005 and the methodology is regression analysis on the change (return) in the futures price. Results indicate that futures are a poor hedge of house price risk. Many of the agricultural commodity futures prices such as corn, live cattle, sugar and coffee have inverse relationships with the Office of Federal Housing Enterprise Oversight (OFHEO) Index, a proxy for home prices. As a robustness check, the authors use the Bureau of the Census Index as another proxy for home prices to test the effectiveness of using these futures contracts as a hedge for house price risk. The results are similar with numerous negative relationships between futures prices and the index.

Similar research is performed on a local level by Bertus, Hollans, and Swidler (2008). They test one of the Chicago Mercantile Exchange's city futures contracts, Las Vegas, as a hedge for house price risk in Las Vegas. They consider the perspective of investment groups, mortgage portfolio investors, local real estate developers and the individual homeowners from 1994 to 2006. Regressions on changes in the futures prices show that investment groups and mortgage holders could have reduced house price risk by 88%. Developers would not have been able to hedge the house price risk of new homes in the city of Las Vegas, but existing home sales showed that the individual homeowner would be more successful in hedging risk with futures contracts.

Liang, Seiler, and Chatrath (1998) use interest rate futures, stock index futures, commodity futures and precious metal futures to test for their hedging potential against real estate investment trust (REIT) returns. This study extending from 1982 to 1994 uses

regression analysis to test the change in futures prices versus the change in three REIT indexes (Equity, Mortgage and All REITs). Rolling hedge and naïve hedge ratios are examined and none of the hedging strategies proved effective. The authors suggest that a REIT specific futures contract should be developed to benefit investors. Oppenheimer (1996) also tests the ability to hedge REIT returns with interest rate futures. Treasury futures contracts provided the best hedging results in this study.

Commodity futures diversification benefits are examined by Jensen, Johnson and Mercer (2000). The study tests the role of commodity futures in portfolios with stocks, bonds, T-bills and real estate. The comparison with the commodity futures and real estate is between the National Association of Real Estate Investment Trust (NAREIT) Index and the Goldman Sachs commodity total return (GSCI) index. The GSCI index includes agricultural commodity futures such as wheat, corn, soybeans, cotton, coffee, cocoa and sugar. Commodity futures are a poor individual investment. In the portfolio context using Markowitz optimization, the authors find that heavily weighting commodities will maximize returns in periods of restrictive monetary policy. However, in time periods of expansive monetary policy, commodity futures provide little benefit. In a study of diversification benefits including just commodity futures, Jensen, Johnson and Mercer (2002) find that agricultural crop futures contracts provide high returns during restrictive monetary policy, but are less effective during expansive monetary policy. Livestock futures contracts provide high returns during expansive monetary policy, but perform poorly during restrictive monetary policy periods.

Inflation in the Real Estate Literature

Real estate research testing inflation as an explanatory variable in valuation models is not new. As noted previously inflation has been found to have a mixed impact on farmland valuation. (See Ashton 1986, Moss 1997, Just and Miranowski (1993)) Lusht (1978) argues that in a PVM using equity yields as a measure of net income, the results will be biased unless it includes anticipated inflation. He suggests that using equity dividend models instead of equity yield models may solve this inflation problem. Additionally, he argues that inflation's effect on investment value is dependent on the original cost, the debt to equity ratio and depreciation. As the rate of inflation increases, accumulating debt will increase present values. Also, increasing depreciation will decrease present values. Lusht (1978) also notes that as anticipated inflation increases, investment levels decrease contrary to popular opinion.

Rubens, Bond and Webb (2001) examine the residential, commercial and farm real estate as effective hedges against inflation. They use annual data from 1960 to 1986 and find that residential real estate is the only effective hedge against inflation. Commercial real estate is a hedge against anticipated inflation, but not unanticipated inflation. Farmland and residential real estate are positive hedges for unanticipated inflation, but not anticipated inflation. The authors also investigate mixed-asset portfolios including variations of stocks, bonds, t-bills, business, farmland and residential real estate. None of their portfolio combinations act as effective hedges against unexpected inflation, while all are at least partial hedges for anticipated inflation.

Wurtzebach, Mueller, and Machi (1991) argue that institutions interested in long-term investments such as pension funds and insurance companies purchase a variety of assets to manage inflation risk and protect against inflation's negative effects. The study examines office and industrial properties over the time period of 1977 to 1989. Office properties are an effective hedge against inflation during low inflationary periods, while industrial properties were found to provide an effective hedge during high inflationary periods. Additionally, vacancy rates are included in the analysis and the results give support to the notion that real estate is not an effective hedge when commercial markets are imbalanced (i.e. dramatically rising vacancy rates). High inflation does not cure an overbuilt market nor help a market with high vacancy rates.

Theoretical Foundation, Summary and Hypotheses

Following the theoretical model for asset valuation, I assume investors consider the future income from farmland in their valuation of the real estate asset, farmland. Thus, the price of crops in the future is a logical consideration in the price investors are willing to pay for farmland. To the extent that agricultural futures contracts provide investors with an indication of future crop prices, it is logical that farmland investors use crop futures as input for their farmland valuation. It can be argued that futures prices for agricultural commodities are critical to investors since these prices are expectations of the future crop and livestock prices. Other sources of information related to future crop prices such as the USDA crop reports have infrequent release dates thus providing less data associated with the prediction of future income to be generated by the land.

Although futures contracts are short-term, they provide an indication of long-term trends that may be applied to farmland values by the investor.

The use of futures as a predictor of expected income with regards to real estate is an extension of the existing literature. Phipps (1984) shows that much of the older farmland PVMs are based upon "ex-post" USDA annual data that is set up to proxy "ex-ante" expectations. This study proxies "ex-ante" income with agricultural commodity futures prices. Prior use of agricultural commodity futures in real estate research is very limited. Most studies have tested the hedging ability of futures contracts, while this study includes other investor uses for futures contracts, price discovery and speculation. The purpose of this study is to examine whether futures prices are significant with respect to real estate values and whether investors use these futures prices to facilitate investment decisions. I hypothesize that agricultural commodity 6-month futures prices will have a significant positive relationship with farmland market values.

Previous farmland valuation literature has suggested that the present value models cannot be used to value farmland. Falk (1991, 1992) and others have rejected different types of PVMs for farmland similarly to Shiller's (1979, 1981) prior work in finance. For this reason, we will provide other, non-income related variables as control variables in the valuation model. Capitalization rates provide the "fad factor" as presented by Shiller (1984) and Falk and Lee (1998). Mishra, Moss, and Erickson (2008) and others have shown that interest rates are a key variable in determining farmland values. I include interest rate futures to provide expectations of changes in the interest rates. Interest rate

futures have received very little prior study in the real estate literature. The current research explores interest rate futures in models with mortgage-backed securities and thus is not applicable to farmland. I hypothesize that capitalization rates and interest rate futures have a significant negative relationship with farmland market values. Lastly, anticipated inflation is used in the valuation model. This variable provides expectations of inflation and has been shown to be a significant predictor of farmland values in prior literature by Moss (1997), Lusht (1978) and others. Farmland market values should have a significant positive relationship with anticipated inflation.

Chapter Three

Data Construction and Empirical Methodology

Data

Data used in the study is taken from three sources and covers a time period from 1991 to 2008. The National Council of Real Estate Investment Fiduciaries provides farmland market values and capitalization rates. End-of-day agricultural commodity futures prices are provided by R & C Research Incorporated in Marietta, Georgia. Economic estimates of anticipated inflation are obtained from the Livingston Survey of the Philadelphia Federal Reserve Board. Detailed descriptions and any assumptions and derivations follow.

Farmland Market Values

The National Council of Real Estate Investment Fiduciaries (NCREIF) tracks total farmland returns from a large, geographically diverse sample of U.S. farmland which, as of March 31, 2009, was comprised from 423 individual properties valued at approximately $1,915,000,000. Table 1 depicts the yearly portfolio of farmland properties used in the study. The properties are obtained, at least in part, by tax exempt institutions and held in a fiduciary environment (NCREIF, 2009). The market values are derived by appraisal methodology and based upon agriculture income producing properties on an unlevered basis. The total number of properties in the portfolio frequently changes as the membership in NCREIF changes over time. Additionally, the

disposition and purchase of new properties occurs frequently, so market values are based upon characteristics of the portfolio at the quarter end.

NCREIF provides rates of return on the properties in an index for farmland that began in 1990 and is updated quarterly. They provide total returns, which can be divided into an income return component showing average net operating income in the quarter and an appreciation return showing similar gains in market value of the properties. The income return is shown by the following:

$$\frac{NOI}{BMV + \frac{1}{2}\left(CE - PS + PP - NOI\right)} \tag{1}$$

where *NOI* is the net operating income for farmland, *BMV* is the beginning quarterly market value of the farmland, *CE* is the farmland capital expenditures during the quarter, *PS* is the partial sales of farmland tracts each quarter, and *PP* is the partial purchases of farmland tracts each quarter.

The appreciation returns are derived by the following:

$$\frac{(EMV - BMV) + PP - CI - PS}{BMV + 1/2(CI - PS + PP - NOI)} \tag{2}$$

where *EMV* is the ending quarterly market value of the farmland and *CI* is the farmland capital improvements during the quarter. (NCREIF, 2009) Farmland market values are derived from NCREIF's appreciation return.

NCREIF also provides detailed breakdowns by property type and region. My pricing models examine the total portfolio market values for farmland and examine the portfolio by property type with agricultural commodity futures tested in the appropriate model. The NCREIF property types are annual cropland and permanent cropland. Annual cropland is simply defined as row crops harvested by the soil such as commodities and vegetables. Permanent crops are harvested from trees and vines such as fruits. The difference between the two is that annual cropland can be rotated and changed, while permanent crops are less flexible. NCREIF does not classify any of the portfolio returns as farmland for grazing or the growth of livestock, therefore I am not able to test a pricing model with livestock farms as a property type.

Regional farmland price indexes are provided by NCREIF and include the following regions: Pacific, Pacific Northwest, Mountain, Corn Belt, Lake States, Southeast, Delta States, Appalachian, Northern Plains, Southern Plains, Northeast and Other (NCREIF, 2009). Table 2 provides the states that are included in each of the regional indexes. Limitations, such as climate, legal restrictions and NCREIF's lack of ownership of properties in certain areas require that the Appalachian, Northern Plains and Southern Plains regions cannot be included in the study.[1] Additionally, the Pacific West and

[1] North Dakota, South Dakota, Nebraska, Oklahoma, Minnesota, Iowa, Missouri and Wisconsin have legal restrictions that prevent institutional investment in farmland [Howard (2005)]. These restrictions are supposedly the protection of the small "family" farm.

Southeast regions are the only two regions where permanent cropland indexes are examined. These two regions are the only regions where oranges are grown.

I assume that the farmland values, as measured by NCREIF, suffer from smoothing. Smoothing is the dampening of measured risk in appraisal-based indices that results from the appraisers' partial adjustments at the disaggregate level and temporal aggregation when constructing the index at the aggregate level (Geltner, 1993). I adjust for smoothing using Geltner's (1993) methodology. This is shown by the following equation:

$$k * t = \frac{k_t - (1-\alpha)k_t - 1}{\alpha} \quad (3)$$

where k_t is the appraisal based return in year t and k*t is the actual return after the correction procedure. I use the factor of 0.40 for the correction similar to Geltner (1993) and Pagliari, Jr, Scherer, and Monopoli (2005).

Farmland Capitalization Rates

Another factor in developing farmland valuations is the capitalization rate. I would suggest that Shiller's "fad factor" is likely to be encapsulated inside the cap rate. That is, as a particular real estate asset type becomes more fashionable, for whatever reason, cap rates would tend to fall. Conversely rising cap rates, in addition to suggesting that the

market perceives more risk, may also be suggesting that the real estate asset has become less fashionable. The capitalization rate is defined as:

$$CapitalizationRate = \frac{NetOperatingIncome}{MarketValue} \quad (4)$$

The net operating income (NOI) and current market values are provided by NCREIF. NOI as shown in the capitalization rate formula is income after vacancy, credit, collections and total operating expenses, but before capital expenditures (Young, 2005). These capitalization rates are estimated quarterly.

Unfortunately the direct use of capitalization rates in the model is likely to cause spurious regression results. "Market value" is the dependent variable in the pricing model while it simultaneously appears as an independent variable (the denominator of the cap rate). Thus I include a proxy for the capitalization rates. I proxy the capitalization rate for farmland with the risk premium in the following expression:

$$R_p = R_f - R_{10-TBond} \quad (6)$$

where R_f is the income return for farmland, $R_{10\text{-TBond}}$ is used as a proxy for the long-term investor's risk-free rate and R_p is the risk premium.

Damodaran (2009) notes that this equation is known as the historical premium approach. He notes that the risk premium is the difference between expected returns and the returns

of a default free government security. Further, he states that the treasury bond provides more predictable returns and accurate estimates over longer time horizons. I use the 10-year Treasury bond as the basis for my risk free rate of return in the above equation. Ciochetti and Shilling (2007) indicate the variation in property cap rates is caused by risk premiums and not interest rates. Figure 1 shows the capitalization rates and the capitalization rate risk premiums in the Southeast Permanent Cropland region as a typical case. The risk premium term is important as it contains information on the amount of risk in the market and the given price attached to that risk. For this reason, it affects how investors evaluate assets that are risky and is a determinant of the value of that investment similar to a capitalization rate. Therefore, it is a reliable proxy.

Agricultural Commodity Futures

Data on futures contracts are from R & C Research, Inc. at Price-data.com. A listing of the differing commodity futures tested in the study is shown on Table 3. The listing is not all inclusive as R & C Research only captures data in demand from consumers of their products. Futures such as dairy products are not listed because of a lack of available data. Others agricultural commodities such as poultry are not publicly traded on the futures market. Table 3 also shows the symbol the futures exchanges use for each futures contract

Table 4 provides data on agricultural production in the United States as provided by the 2007 Census for Agriculture (USDA, 2007). Corn is the largest commodity by percentage of total sales in the United States at 13.4%. Live cattle are the largest

commodity in terms of farmland used for production at 36.2%. Crops and livestock are very similar in total agricultural sales at 48.3 and 51.7% respectfully. As for agricultural farmland needed for production, crops are grown on 44.7% as compared to livestock grazing on 49.0% of the land. The census data implies the futures contracts provided on Table 3 appear to be sufficient and comprehensive enough to develop a representative sample for the current study. I include futures contracts in my model that are the leading crops produced in each specific region.[2] Four to five differing crops are tested in each region.

Agricultural commodity futures have differing contract specifications. Table 5 provides a listing of specifications for each commodity in the study. Each of the futures contracts has differing contract sizes and tick sizes. Tick sizes are the minimum fluctuation of the price for a given futures contract and all of the commodities are $12.50 or less. The agricultural commodities are measured in pounds or bushels, with soybean meal and rough rice being the exceptions as they are measured in short tons and hundredweights. Each of the futures contracts has daily price limits at varying rates. These daily limits are caused by commodity price volatility and the chance of catastrophic losses. Daily limits may freeze prices, but do not freeze trading on the futures contracts. Most are variable and are not shown in Table 5 for the sake of brevity.[3] Settlement procedures for

[2] See http://www.ers.usda.gov/Briefing/,
http://commodities.about.com/od/gettingstarted/a/profiles.htm,
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis5219, and
http://www.epa.gov/oecaagct/ag101/cropmajor.html

[3] Details on daily price limits and deliverable grades of each commodity are varied and can be provided upon request.

agricultural commodity futures contracts are characterized by physical delivery of the goods, although many contracts settle before expiration. Most agricultural commodity futures last trade date is the business day prior to the 15^{th} day of the expiration month and delivery dates are commonly in the week following the last trading day of that same month. Futures contracts expire in different months and very few agricultural futures contracts expire in all 12 months.

Table 5 shows the varying expiration months for each of the futures contracts. A limitation of the study is that expiration dates are not always on the 1^{st} of each quarter (January, April, July, and October). I interpolate the prices of the contracts that bracket the beginning of each quarter to match the data points and provide four points per year. Further, because of weekends and holidays, futures prices do not always occur on the 1^{st} day of the month, therefore I use the end of day trading price closest to that particular day.

Interest Rate Futures

Interest rate futures prices are taken from R & C Research, Inc. similar to agricultural commodity futures. The 10-year treasury-note is used as a proxy for applicable interest rates in the study. Its ticker symbol is shown on panel A of Table 3. Buying an interest rate futures contract allows a borrower to lock an anticipated interest rate in the present, while the underlying interest rate changes with the market. The rate being represented by the futures contract is an investment rate, not a borrowing rate of interest. The 10-year

treasury-note is a medium term rate compared to longer term futures contract such as the 30-year U.S. treasury bond and the shorter term futures contracts such as the 13-week T-bill and 3-year U.S. treasury note.

Anticipated Inflation

The study uses anticipated inflation figures from the Livingston Survey of the Federal Reserve Bank of Philadelphia (2008). The Livingston Survey provides the longest running inflation estimates by economists in the United States, dating back to 1946. The estimates of anticipated inflation are actual forecasts by economists for use in the business community. The survey provides 6-month and 12-month projections of anticipated inflation. Also each estimate is made by multiple economists. I use the means of the 12-month economic estimations. The mean factors in all the economists' forecasts and 12-month estimates allow for a longer time period suitable for an investment like timberland. Again, I interpolate these forecasts similar to the futures contract prices to form quarterly data points for our study.

Empirical Methodology

I use the following general model to explain farmland market values:

$$\text{Farm} = f(\text{ACFut}, \text{CR}, \text{IFut}, \text{Inf}) \tag{6}$$

where ACFut is the agricultural commodity futures price, CR is the capitalization rate for farmland, IFut is the interest rate futures price, and Inf is anticipated inflation.

Kolb (2003) notes, that using futures prices for statistical inference can present some problems. Futures prices can be measured using price levels, difference scores or percentage changes in the price. He advises against measuring futures prices in price levels because of autocorrelation. Autocorrelation is where one observation in an equation is time dependent on a previous or future observation. As an example, first-order autocorrelation is where an observation is related to the previous observation in the time series. This phenomenon has been studied extensively and found to occur in commodity and currency futures. (See Cargill and Rausser, 1972, Taylor and Klingsman, 1979, Deaton and Laroque, 1992, and Puri, Elyasiani, and Westbrook, 2002) Kolb (2003) suggests that using price changes (difference score) or percentage price changes (returns) instead of price levels for measuring futures prices in models. He also recommends using percentage price changes when price levels vary dramatically over the holding period similar to our study. To rectify this autocorrelation problem, I use the following percentage change model:

$$(Farm_t - Farm_{t-1})/Farm_{t-1} = \alpha_0 + \alpha_1(ACFut_t - ACFut_{t-1)})/ACF_{t-1} + \alpha_2(CR_t - CR_{t-1})/CR_{t-1} + \alpha_3(IFut_t - IFut_{t-1})/IFut_{t-1} + a_4(Inf_t - Inf_{t-1})/Inf_{t-1} + \in_t \quad (7)$$

where ACFut is the percentage change in the agricultural commodity futures price, CR is the percentage change in the capitalization rate for farmland, IFut is the percentage change in the interest rate futures price and Inf is the percentage change in the anticipated inflation rate and Є is the error term.

Another issue with the use of futures contracts in statistical models is the presence of leptokurtosis. Leptokurtosis is the presence of “high peaks” and “fat tails” in the distributions of the variables. This means that too many extreme observations occur in the distributions and inferences need to be made with caution. Most of the time the futures prices move randomly, but when they deviate from this randomness, they move faster and further than researchers would expect.

An assumption of regression analysis is that residuals of underlying futures price changes are normally distributed. Kolb (2003) suggests that most studies have found that the distributions of futures prices are stable Paretian (normal but leptokurtic) or a mixture of two or more normal distributions. I examine the distributions for normalcy with histograms and use caution in making conclusions about any distributions that are non-normal. Additionally, I take the “started logs” of the necessary observations to remedy any possible normality issues with the variables (Mosteller and Tukey, 1977). This linear transformation as given by Cohen, Cohen, West and Aiken (2003) can be shown by the following:

$$(Y + c)^{\lambda} \tag{8}$$

where Y is the dependent variable, c is a small constant and λ is the exponential growth or decline. The independent variables are transformed in a similar fashion. Anticipated inflation estimates are not transformed as they are percentage rates.

After examining each variable with small constants of 15 and 25 and seeing very little difference in the results, I include the constants of 25 in the models. Three data points are censored since large percentage changes occur in capitalization rate risk premiums from one quarter to the next. Two of these data points are used in the Mountain annual cropland capitalization rate risk premium calculation and the other is used in the Pacific West annual cropland calculation. Using a small constant of 25 appears to be a superior tradeoff to using a large constant such as 100, which may change the results.

Kolb (2003) notes that futures price volatility increases as it approaches expiration and this phenomenon is known as the Samuelson Hypothesis.[4] Samuelson (1965) implies that the futures price equals the expected future spot price at a contract's expiration. The higher volatility as the futures contract nears expiration means big price changes occur in the market. This volatility results from the release of new information into the marketplace. As we recede further from the expiration date, the contract price becomes less volatile with less information coming to the market. The statistical implications are that as a futures contract draws closer to expiration, any conclusions formed from prices near expiration may be unreliable in view of the excess volatility. I remedy this problem by using six month futures prices. Most of the futures prices do not trade more than a year in advance of expiration and any that trade during this timeframe have low volume. The six month parameter provides an approximate median estimation point and is not near the expiration of the contract.

[4] See Samuelson (1965)

Two other issues that relate to agricultural commodity futures price volatility are seasonality and outliers. French (1980) examined Standard and Poor's stock data between 1953 and 1977 to find that average returns for Tuesday to Friday are positive, but average returns for Monday were negative. This became known as the "weekend effect" and suggests that patterns in asset returns are seasonal. Agricultural commodity prices may follow a similar pattern since crops have specific growing seasons. For instance, the summer months with a higher temperature may lead to higher returns in a commodity price for a crop such as oranges. Conversely, the winter months would lead to lower prices.

Outliers occur when large shifts in the futures price happen in a short period of time. Outliers in agricultural commodity prices occur for many reasons including government policy such as the elimination of agricultural subsidies in Organization for Economic Co-operation and Development (OECD) countries, weather such as a freeze or drought, or even activities such as ethanol production for bio-fuels for automobiles. I plot the futures price data to see if a seasonal indicator variable(s) is needed for a particular commodity. These indicator and/or "dummy" variables are included in the model if either seasonality or outliers occur, but they may not be necessary in all models.

Multicollinearity is the high correlation of the independent variables in multiple regression analysis. This problem causes significance levels of independent variables to be skewed and standard errors to be inflated. It should not bias the fit of the model, but each of the independent variables will be less precise. Using anticipated inflation and

interest rate futures as independent variables in the pricing model may provide multicollinearity issues. Farmland lenders know that rising inflation erodes loan profits therefore they change interest rates on new and renewing loans to decrease their risk exposure. Long term interest rates obviously contain an inflation component. After reviewing the literature, I believe that both variables may be important explanatory variables in my pricing model. I examine variance inflation factors and tolerance to make sure I do not have a multicollinearity issue.

Lastly, in view of the limited time period and limited frequency of observations in the NCREIF farmland portfolio, the model may suffer from data poverty. Data poverty is the lack of enough available data for testing the hypotheses presented in the study. Having a small sample size limits the statistical power in the study. Statistical power is the probability that the test will reject a false null hypothesis. In other words, the test does not have a Type II error. A large sample size is needed for higher statistical power as larger sample sizes decrease the variance of the estimated parameters. As the power of the test increases, then the chances of Type II error decreases. A common rule of thumb by Cohen (1988) is the use of 30 data points for each independent variable to achieve an 80% statistical power in the test. The figure of 80% is the minimum suggested power for an ordinary study so I limit the explanatory variables in the study.

To conclude whether agricultural commodity futures, farmland capitalization rates, interest rate futures or anticipated inflation have joint significance when estimating

farmland values in the pricing model, I examine the F-test for significance in the multiple regression equation. It is shown by the following:

$$F = \frac{\sum_i n_i (\bar{Y}_i - \bar{Y})^2 / (K-1)}{\sum_{ij} (Y_{ij} - \bar{Y}_i)^2 / (N-K)} \qquad (9)$$

where Y_{ij} are the j^{th} observation in the i^{th} out of K groups, $\bar{Y}_i$ is the sample mean in the i^{th} group, $\bar{Y}$ s the overall mean, n is the sample size of the i^{th} group, and N is the overall sample size. K-1 and N-K are the degrees of freedom in the F distribution. $(\bar{Y}_i - \bar{Y})^2$ is known as sum of squares error and $(Y_{ij} - \bar{Y}_i)^2$ is known as sum of squares total. Equation (9) shows the overall fit of the model.

To examine whether each independent variable is a significant explanatory variable, I examine the t-test for significance. It is shown by the following:

$$t = b_1 / SE \qquad (10)$$

where b_1 is the slope of the sample regression line and SE is the standard error of the slope.

Equations (9) and (10) provide the conclusions from which I make statistical inference on the data in the regression equation. The last statistic that I examine from the regression equation is the coefficient of determination, R^2. This statistic accounts for the variability

explained of the dependent variable, farmland market values, by the independent variables in each equation. It is shown by the following:

$$R^2 \equiv 1 - \frac{SSE}{SST} \tag{11}$$

where SSE is the sum of squares error and SST is the sum of squares total for the data. Each coefficient of determination is examined to find which individual pricing model explains the most variability in farmland market values, whether it is on a regional or national level.

As a robustness check, I examine the original farmland market value indexes that are not desmoothed with Geltner's methodology. I transform the variables into a percentage change OLS model and include seasonal dummy variables to correct for any seasonality in the variables.

As a further check, I use Johansen's cointegration procedure and do not transform the price levels of the variables. I do this to avoid the loss of information and possible confounding effects when making a data transformation (Edwards, 2002). This econometric methodology is used by Johansen (1988) and Johansen and Juselius (1990) and is shown by the following equation:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots . + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-k} + \Phi D_t + \epsilon_t \tag{12}$$

where X_t is the vector of *p* *I*(1) variables, μ is a *p x* 1 vector of intercepts, Γ1, Γk, ∏ and Φ are *p x p* matrices of coefficients, D_t is for seasonal dummy variables, ϵ_t is the is the *p x* 1 error term that is assumed to be normally and independently distributed with a mean of zero and a variance matrix of Ω, and Δ is the first difference operator. For a hypothesis of long run relationships between the variables to be correct, the rank of the matrix of the coefficients X_{t-k} has to have a finite value < p. Each of the coefficients given by the model will have an appropriate sign for any negative or positive relationship after the dependent variable is separated from the other terms in the vector.

A significant result in the cointegration models confirms a long-run equilibrium relationship between the variables. The methodology differs from the OLS regressions as cointegration models use lags in the quarterly price levels instead of a transformation of the variables to find the significant long-run relationships. The appropriate lags for each model are confirmed using criterion such as the Final Prediction Error, Akaike information, Schwarz information and Hannan-Quinn information. Further checks are made for any serial correlation with the Langrange Multiplier (LM) test.[5]

In order to use this technique, each time series variable must be integrated to the order of I(1) or stationary in their first differences. In other words, they need to contain one unit root. I test for the stationarity of the variables with the Augmented Dickey Fuller (ADF) and the Phillips-Perron (PP) Tests. These unit root tests are simple regression models that depend on certain assumptions. The ADF and PP tests that do not include a time

[5] These are not shown here for the sake of brevity, but can be provided upon request.

trend, but include a drift term are based on the alternate hypothesis of a time series variable is stationary around a fixed mean. (Campbell and Shiller, 1987) It is shown by the following model:

$$y_t = \alpha + py_{t-1} + \epsilon_t \tag{13}$$

where α *is* the constant or drift term, py_{t-1} is the coefficient and regressor and ϵ_t is the error term.

For series that are stationary around a time trend, then it is shown by the following:

$$y_t = \alpha + \delta t + py_{t-1} + \epsilon_t \tag{14}$$

where δt is the time trend in the model.

It is not probable that all of the variables in the pricing model including some futures prices are likely to be stationary in their first differences. Futures prices can follow a random walk. Therefore, I include only the time-series variables that are I(1) in the empirical analysis using Johansen's cointegration technique.

In summary, a pricing model for farmland market values is developed using regression analysis. Explanatory variables include the percentage change in agricultural commodity futures prices, interest rate futures prices, farmland capitalization rates and anticipated

inflation. Differing tests are performed on each agricultural commodity futures contract to mitigate the impact of high correlations among the contracts as well as possible multicollinearity. These tests include a regional analysis covering seven regions of the United States, and a property type analysis, annual or permanent cropland, on a regional level when applicable. Similar analyses are performed on the price levels of the variables using Johansen's cointegration time-series econometrics.

Chapter 4

Results

Summary statistics for the variables used in the study are reported in Table 6. Soybeans are the highest priced agricultural commodity futures contract at over $1324 per contract. This soybean contract price along with many other commodities peaked during the mid to late 2000s for a variety of reasons. These reasons included the deflating dollar, rising energy prices, increasing production costs, demand for food in emerging countries and foreign trade policy (Peters, Langley and Westcott, 2009). Figures 2-10 show the price ranges for the individual futures contracts used in each region.[6] While soybeans futures contracts were the highest priced futures contracts, they were not the most volatile in regards to returns. Rough rice ranged from $4.20 a contract to approximately $17.70 a contract. The rice market tends to be volatile because it is a staple food in over 50% of the world, is 12% of the United States world exports and is one of the lowest priced contracts on the futures exchanges.[7] On a percentage basis, live cattle have the least volatile returns from futures contracts ranging from a low price of approximately $62 to a high of $100. Grazing animals are not subject to the affects of weather to the same extent as crops grown on the farmland suggesting less price volatility. This is not to say that live cattle contracts are risk-free for the futures trader, as crops and livestock are both subject to risk from trade restrictions and disease.

[6] Sugar, Rough Rice, Soybeans, Wheat and Minnesota Wheat futures contract prices were adjusted in the figures to provide symmetry and clarity.

[7] See http://www.commodity-trading-today.com/rice-commodity-trading.html

Regional farmland summary statistics are also shown on Table 6. All index values have a base of 100 and are adjusted using the appreciation return provided by NCREIF (2009). The Pacific West annual croplands and the Southeast annual croplands have the highest percentage change in price over the test period. From 1991 to 2008, annual cropland prices in these two regions increased approximately 217 and 275% respectively. Permanent cropland in these same regions did not fair as well. In fact, the Southeast permanent cropland index decreased over most of the study period decreasing over 40% from 1991 to 2003 before rebounding145% by the end of the study period. Permanent cropland has trees that cannot be removed, rotated or changed each year, therefore operating risk is higher and prices are less subject to volatility (Howard, 2005).

Anticipated inflation decreased over most of the time period of 1991 to 2008 as shown in Figure 11. It reached a low of 1.50% in 2003. The interest rate futures contract prices based upon the 10-year treasury bond are reasonably flat over this same time period. It ranged from approximately $96 to $118 per contract. Most of this contract volatility occurred in the late 1990s as treasury debt shrunk during a time of federal budget surpluses.

Table 7 provides the results from the ordinary least squares (OLS) percentage change (return) regression models of the differing desmoothed market value regional indexes and their explanatory variables. Few futures contract prices are significant in any of the regions. Wheat futures contracts have a significant positive relationship with desmoothed

farmland market values in the Corn Belt region at the 10% level. The effect size is 0.17 and indicates that a 1.00% change in the return of a wheat futures contract results in a 0.17% change in the returns of farmland market values. The R^2 of the wheat model is 0.05. I fail to find significance with any other agricultural commodity futures in the Corn Belt region.

Live cattle and Minnesota wheat futures contracts have a significant positive relationship at the 1% and 10% level in the Mountain region. The effect sizes are 0.35 and 0.11 respectively. The Mountain region is the only region with a significant F-test at the 5% level in the OLS model. Additionally, the Mountain region model has the largest R^2 at 0.22. The R^2 results in all regions other than the Mountain and Pacific Northwest are less than 0.10.

Anticipated inflation has a significant negative relationship with desmoothed farmland market values at the 1% level in the Mountain region. The effect size is small at -0.008. Conversely, anticipated inflation has a positive significant relationship at the 5% level in the Pacific Northwest region giving mixed results over the time period. Its effect size is also small at 0.02. There is a negative coefficient in most of the other regions even though anticipated inflation is insignificant. Interest rate futures contracts and farmland capitalization rates fail to have a significant impact on farmland value in any of the regions studied in the regression models.

Insignificant explanatory variables may have a curvilinear relationship with farmland market values instead of a linear relationship. I tested interest rate futures, anticipated inflation and farmland capitalization rates to see if any of these variables are statistically significant when enabled as a quadratic. None of the quadratic variables are significant and the tables are not shown but are available upon request..

As a robustness check, the original farmland market value indexes that are not desmoothed are examined and provide similar results to the previous models. Wheat, as shown in Table 8, is found to have a positive relationship at the 5% level with the original farmland market values in the Corn Belt region. It has a slightly smaller effect size of 0.07. Live cattle and Minnesota wheat have similar positive significant coefficients at the 5% level in the Mountain region. Again, the effect sizes are slightly smaller at 0.10 and 0.05. Interest rate futures contracts and farmland capitalization rates are not significant in any of the models. The only significant difference found between the desmoothed and original farmland market value models is that cotton futures contracts are significant at the 10% level in the Mountain region when using the original models.

Next, I proceed with the time-series econometric tests to find any long-run equilibrium relationships between farmland market values and the independent variables. Table 9 shows the results of the augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) on each of the agricultural commodity futures contracts and anticipated inflation. The unit root tests contain the trend term. Enders (1995) shows that the unit root test with the least restriction is the model including the time trend. These models often have

low power to reject a false null hypothesis and if the test with more regressors rejects the null hypothesis, then there is no need to move forward with the other tests. Each of the futures contracts and anticipated inflation fail to reject the null hypothesis of a unit root at the 5% level. The first differences of each of the variables reject the null hypothesis of a unit root at the 5% level.

Table 10 provides the results of the ADF and PP tests on the regional desmoothed and original market value indexes and their capitalization rate risk premiums. The results are generally similar. Some ADF tests show a unit root in the first differences of the variables, but these tests have a low power to reject a false null hypothesis and each of the PP tests confirm the absence of a unit root at the 5% level. Interest rate futures contracts based upon the 10-year treasury bond, the Mountain regional index based upon original farmland market values, and the capitalization rate risk premiums for the Pacific Northwest and Mountain regions are not integrated to the order of one. Therefore, without a unit root these variables are not included in the Johansen cointegration models as they are deemed inappropriate.

The results for the Johansen Cointegration models on the desmoothed regional indexes are shown in Table 11. In general, few contracts are significant predictors of farmland market values as approximately 60% of the futures contracts tested in these cointegration models are not significantly related to farmland market values. The time-series econometric methodology contains a larger proportion of significant futures contracts

than the OLS regression analysis though. Almost every region in the time-series econometric tests has at least one futures contract that is significant.

Most of the significant futures contracts have positive coefficients between 0 and 2.50. The interpretation of the coefficients magnitude is relatively straightforward. For instance, a model with a statistically significant coefficient equaling 2.50 means that a 1.00% increase in the futures contract prices will have a 2.50% increase in the given region's farmland market values. Also, each cointegration test uses differing lags in the data that range from 1 to 5. These lags are used to correct for the autocorrelation problem presented in the methodology section. The number of lags can vary with differing size data sets and/or differing time periods and are shown in Tables 11 and 12.

Corn, sugar and orange juice futures contracts are significantly related to farmland market values in multiple regions. Sugar is significant in the Delta States, Lake States and Pacific Northwest regions. The coefficient is significantly positive in the Lake States and the Pacific Northwest and significantly negative in the Delta States. The futures contract specification represents pounds of cane sugar, but in reality the contract represents both sugar beets and sugar cane as each produces the same refined sugar product, sucrose. Sugar beets are a root crop grown in the cooler temperatures of the northern regions of the United States, while sugar cane is a grassy crop that is cultivated in the hot and wet Delta States. Therefore, the sign differences between the regions appear to lie in the changes of the real estate over the study period. When examining Figures 3, 4, and 6, there appears to be small differences between the farmland value

indexes. The Lake States farmland market values are relatively flat and smooth, which appears to lead to a positive statistically significant coefficient and the Delta States have a large increase in value at the end of the study period, which appears to lead to a negative statistically significant coefficient.

Corn and orange juice futures are significant in 2 regions and each has a positive coefficient that is between 1.00 and 2.50. Corn futures contracts are significant in the Corn Belt and the Lake States regions. Illinois and Iowa are two of the top corn production states and are located in these regions as shown in Table 2. Additionally, the United States is the top producer of corn in the world, so this result is not unforeseen (USGC, 2010). Oranges are grown in Florida and California, which are two states located across the country from each other, but these states include areas with moderate temperatures suitable for the orange cultivation. Figures 8 and 10 show similar patterns between the permanent crop farmland market values and the orange juice futures contract prices in these two states. The statistical significance between orange juice futures contracts and the Southeast permanent cropland index is expected as approximately 95% of Florida's orange crop is processed into orange juice.[8] Oranges grown in California are typically eaten as fruit rather than processed into juice, but the positive significance is unabated and steady.

A different result occurs when examining futures contracts against the Southeast and Pacific West annual cropland indexes. None of the futures contracts are statistically

[8] See http://obiolla.com/orangehistory.aspx

significant in any of the desmoothed market value models. The lack of cointegration between the variables appears to be caused by the doubling of farmland value after 2004 as shown in Figures 7 and 9. The futures contracts do not show a similar price increase.

The final significant result noted from the desmoothed market value models is the wheat futures contract. It has a positive relationship with farmland market values in the Corn Belt. This contract has one of the larger coefficients at 2.453 and has a large R^2 of 0.77. The Corn Belt models typically have the most variance explained by the test with the highest being the soybeans futures contract having an R^2 of 0.86. It is also worth noting that I tried a Corn Belt region model containing both significant predictor variables corn and wheat, but a multicollinearity issue occurred with the wheat futures contract suppressing the corn futures contracts coefficient into becoming negative. This suppression happens as the two futures contracts are highly correlated at 0.92 as shown in Table 13.

In general, farmland capitalization rates and anticipated inflation are negatively related to farmland market values in the significant cointegration models. The capitalization rates negative relationship is expected, but anticipated inflation was hypothesized to have a positive relationship with farmland market values. Farmland values in most cases rose from 1991 to 2008. Because inflation remained at a generally low level during the test period, trending slightly lower, I suspect my model yields an inaccurate picture of the relationship between inflation and farmland value. Given that inflation was not a major

economic factor during the test period, the data from 1991-2008 offers little insight into the nature of this relationship.

As a robustness check, Johansen's cointegration procedure is performed on the original farmland market value indexes and the results are presented in Table 12. The findings are similar in all of the regions. The magnitudes of each of the effect sizes are very similar to the results from Table 11. There were only a few differences noted. Cotton has a significant negative coefficient of -0.168 at the 10% level in the Delta States region. This is a very small effect size and the Delta States is the same region where sugar has a negative significant coefficient. In the Lake States region, soybeans have a significantly positive effect size of 1.615 at the 10% level. This effect size is similar to the other significant futures contracts in that specific region.

Feeder cattle futures contracts are cointegrated with annual cropland farmland market values in the Pacific West region and have a positive long-run equilibrium relationship. After examining Figure 7, I note that feeder cattle futures contracts do not have a large increase in prices at the end of the study period dissimilar to the Pacific West farmland market values. The original model includes three lags to overcome autocorrelation in models with less lags as shown by Lagrange Multiplier Tests, but I only needed one lag of the variables in the desmoothed market value model. The figure and differing test lags makes me cautious of this finding. Also, according to Cheung and Lai (1993), Johansen's procedure tends to overestimate the number of cointegrating vectors when using too many lags with small samples, which leads me to support my finding of no

cointegration using desmoothed farmland market values. Lastly, anticipated inflation has a positive significant long-run equilibrium relationship with farmland market values in the Southeast region when examining orange juice futures against the permanent cropland index. This coefficient is as hypothesized, but is generally different than most of the other results for anticipated inflation.

Chapter 5

Conclusions and Future Research

In this dissertation, I test a pricing model for farmland. I extend the existing agricultural and land economics, finance and real estate literature, by modeling the relationship between agricultural commodity futures and farmland market values. The capitalization rate (as proxied by the capitalization rate risk premium) and anticipated inflation are also tested for significance and utilized as control variables. I perform a regional analysis on the data covering the time period from quarter 4 of 1991 to quarter 2 of 2008. I use OLS regression analysis on the percentage change in the desmoothed (using Geltner's (1993) procedure) farmland market values and the explanatory variables. Additionally, I test for long-run equilibrium relationships between the variables using Johansen's cointegration time series econometric methodology. As a robustness check, I test the original farmland market values that are not corrected for smoothing, but are adjusted for seasonality with quarterly dummy variables.

In general, the changes in these futures contracts do not explain the changes in farmland market values. Approximately, 10-15% of the futures contracts tested are statistically significant at the 10% level or lower in the featured regressions. Johansen's cointegration procedure modeling long-term equilibrium relationships between the variables is slightly better with approximately 30-35% of the contracts being cointegrated with farmland market values. These results provide little evidence that the expected income generated by crops grown in various regions throughout the United States is a helpful indicator of

the present value of the farms themselves. The capitalization rate (as proxied by the capitalization rate risk premium) and interest rate futures contracts (based upon the ten-year treasury bond futures contract) are insignificant in all of the regression models.

While there is little evidence to support farmers and landowners using futures for speculation in the pricing of farmland, three conclusions were noted. Live cattle and Minnesota wheat futures have a significant positive relationship with Mountain region farmland market values on a quarterly basis. This means that if a live cattle futures contract price trends upward each quarter, there is a concurrent change in the farmland values in the states of the Mountain region. Additionally, wheat futures contracts have a positive relationship with farmland market values in the Corn Belt. Based on the time period of the study, investors can examine prices trending upward or downward in the wheat futures contracts to make decisions on farmland investments in the Corn Belt. It is worth noting that only three states modeled in our study have larger than 4% ratios of agriculture gross domestic product as compared to total state gross domestic product. They are Iowa in the Corn Belt region at 6.4% and Idaho and Montana in the Mountain region at 5.5 and 4.2%. While, these findings do not make a convincing argument that farmers or real estate investors in states with relatively high farm GDP should rely on futures contracts, this ratio is a possible explanatory variable to examine in future farmland pricing models.

The last implication is taken from the Johansen's cointegration test results. Corn, sugar, and orange juice futures contracts have a positive long-term equilibrium relationship with

farmland values in multiple regions. This result means that each of these futures is a reliable predictor of changes in farmland values over a longer time horizon than the quarterly regression models. Since farmland is considered a long-term investment, trends in these futures prices may be considered when making decisions on increasing or decreasing the holdings in a farmland investment.

This study examines present value models, one of three forms of asset valuation models. I conduct a test using agricultural commodity futures prices as “ex ante” expectation of future income, but these futures prices are not considered good indicators of changes in farmland values with the exception of a few cases in the Corn Belt and Mountain regions. This model differs from Falk (1991, 1992) as he tested “ex post” Iowa farmland rents that were lagged to set up an expectations model, but in each case the proxy for changes in expected income were not accurate indicators of changes in farmland prices. This result does not imply that all present value models should be rejected when evaluating farmland, but the use of agricultural commodity futures as a proxy is not considered a good indicator of changing farmland prices during this particular time period. Relative value models and option pricing models for farmland were not examined in this study.

It should be noted that low statistical power may affect the conclusions of the study. When performing statistical tests, researchers want to maximize the power of the test and thus minimizing the probability of Type II error (Hogg, McKean and Craig, 2005). A small sample size is the basis for this low power and is a common occurrence in real estate research. I develop a parsimonious regression model due to the small sample size,

but other variables such as a ratio of farm gross domestic product to state gross domestic product may or may not improve the R^2 of future farmland pricing models. Additional factors affecting the conclusions include the magnitude of the effect sizes of the explanatory variables as well as the alpha levels used in the regression and cointegration models. The futures prices coefficients are small, but are the appropriate hypothesized sign. In line with convention, I examined differing alpha levels ranging from one to ten percent, but did not relax this standard to reduce the probability of rejecting a false null hypothesis.

Future extensions to the model may include explicitly lagging the futures contract prices by 6-12 months to see if the changes in these contracts are a predictor of future changes in farmland values. Similarly, one may examine the changes of a ratio of the current agricultural commodity futures and current spot prices divided by current spot prices as compared to the changes in farmland prices over time. This would be useful as investors could examine trends in agricultural commodity price projections when making farmland investment decisions. Some but not all of the institutional investors are already using futures contracts for the hedging of risk, but very few if any are presently using these contracts for farmland investment decisions per interviews with executives of Hancock Natural Resources Group and Cozad Asset Management, Inc. Additionally, one may examine a proxy for urbanization as it appears to have a significant influence over farmland values. The Mountain region contained the best pricing models in the regression analysis and has arguably the lowest farmland market values least affected by urbanization. The other regions may be significantly affected by urbanization.

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Table 1 – NCREIF Farmland Portfolio

Year	# of Properties	Farmland Market Value
1991	197	$338,254,779
1992	282	$441,534,894
1993	334	$532,621,275
1994	402	$663,519,949
1995	422	$712,632,985
1996	442	$837,484,338
1997	431	$856,053,504
1998	427	$916,600,051
1999	386	$964,064,652
2000	333	$928,140,231
2001	311	$851,964,137
2002	300	$808,324,626
2003	297	$826,969,247
2004	299	$897,708,749
2005	309	$1,131,372,686
2006	372	$1,430,171,430
1007	369	$1,142,255,360
2008	401	$1,798,100,729

Note: The market values for the farmland and the number of properties is year end. Market values are based upon independent real estate appraisals. Source: NCREIF, 2009.

Table 2 – NCREIF Farmland Geographic Regions and Gross Domestic Product

Region	State	GDP/Yr	Farm GDP/Yr	% Farm GDP to Total GDP
Corn Belt				
	Illinois	$633,697	$6,284	0.99%
	Indiana	$254,861	$3,714	1.46%
	Iowa	$135,702	$8,734	6.44%
	Missouri	$237,797	$3,205	1.35%
	Ohio	$471,508	$3,324	0.70%
	Total	$1,733,565	$25,261	1.46%
Delta States				
	Arkansas	$98,331	$3,331	3.39%
	Louisiana	$222,218	$1,890	0.85%
	Mississippi	$91,782	$2,232	2.43%
	Total	$412,331	$7,453	1.81%
Lake States				
	Michigan	$382,544	$2,863	0.75%
	Minnesota	$262,847	$5,692	2.17%
	Wisconsin	$240,429	$4,512	1.88%
	Total	$885,820	$13,067	1.48%
Mountain				
	Arizona	$248,888	$2,054	0.83%
	Colorado	$248,603	$2,479	1.00%
	Idaho	$52,747	$2,905	5.51%
	Montana	$35,891	$1,496	4.17%
	Nevada	$131,233	$262	0.20%
	New Mexico	$79,901	$1,269	1.59%
	Utah	$109,777	$584	0.53%
	Wyoming	$35,310	$365	1.03%
	Total	$942,350	$11,414	1.21%
Pacific Northwest				
	Oregon	$161,573	$3,984	2.47%
	Washington	$322,778	$7,037	2.18%
	Total	$484,351	$11,021	2.28%
Pacific West				
	California	$1,846,757	$27,259	1.48%
	Total	$1,846,757	$27,259	1.48%
Southeast				
	Alabama	$170,014	$2,368	1.39%
	Florida	$744,120	$6,156	0.83%
	Georgia	$397,756	$3,786	0.95%
	South Carolina	$156,384	$1,139	0.73%

	Total	$1,468,274	$13,449	0.92%
Appalachian				
	Kentucky	$156,435	$2,388	1.53%
	North Carolina	$400,192	$3,940	0.98%
	Tennessee	$252,127	$1,155	0.46%
	Virginia	$397,025	$1,666	0.42%
	West Virginia	$61,652	$242	0.39%
	Total	$1,267,431	$9,391	0.74%
Northern Plains				
	Kansas	$122,731	$3,584	2.92%
	Nebraska	$83,273	$5,627	6.76%
	North Dakota	$31,208	$3,405	10.91%
	South Dakota	$36,959	$3,472	9.39%
	Total	$274,171	$16,088	5.87%
Southern Plains				
	Oklahoma	$146,448	$1,907	1.30%
	Texas	$1,223,511	$9,779	0.80%
	Total	$1,369,959	$11,686	0.85%
Northeast				
	Connecticut	$216,174	$371	0.17%
	Delaware	$61,828	$445	0.72%
	Maine	$49,709	$736	1.48%
	Maryland	$273,333	$947	0.35%
	Massachusetts	$364,988	$892	0.24%
	New Hampshire	$60,005	$238	0.40%
	New Jersey	$474,936	$698	0.15%
	New York	$1,144,481	$2,717	0.24%
	Pennsylvania	$553,301	$3,447	0.62%
	Rhode Island	$47,364	$76	0.16%
	Vermont	$25,442	$410	1.61%
	Total	$3,271,561	$10,977	0.34%
Other				
	Alaska	$47,912	$296	0.62%
	Hawaii	$63,847	$332	0.52%
	Washington D.C.	$97,235	$1	0.00%
	Total	$208,994	$629	0.30%

Note: State and farm gross domestic product dollars are for the year 2008 and are delineated in millions. The states are shown in regions as designated by NCREIF. Source: U. S. Bureau of Economic Analysis.

Table 3 – Futures Contracts, Symbols and Expiration Month Symbols

Panel A - Futures Contracts and Ticker Symbols

Foods:	
Frozen Orange Juice	OJ
Rough Rice	RR
Sugar #11	SB
Grains:	
Corn	C
Oats	O
Soybeans	S
Soybean Meal	SM
Soybean Oil	BO
Wheat	W
Kansas City Wheat	KW
Minnesota Wheat	MW
Fiber:	
Cotton #2	CT
Meats:	
Feeder Cattle	FC
Live Cattle	LC
Financials:	
Ten Year Treasury Note	TY

Source: R&C Research, Inc.

Table 4 – U.S. Agricultural Sales and Number of Farms by Commodity

Panel A - Percentage of U.S. Agricultural Sales by Commodity

Crops:	
Corn	13.4
Wheat	3.6
Soybeans	6.8
Fruits	6.3
Vegetables	4.9
Cotton	1.6
Livestock:	
Live Cattle	20.6
Poultry and Eggs	12.5
Dairy Products	10.7
Hogs	6.1
Sheep and Goats	0.2
Horses	0.7

Panel B - Percentage of U.S. Agricultural Farms by Commodity

Crops:	
Corn	15.8
Wheat	7.2
Soybeans	12.9
Fruits	5.1
Vegetables	3.1
Cotton	0.8
Livestock:	
Live Cattle	36.2
Poultry and Eggs	6.8
Dairy Products	3.2
Hogs	3.4
Sheep and Goats	5.5
Horses	5.2

Note: Percentages are based upon total number of dollar sales and farms in the United States in 2007. Not all categories of crops and livestock are listed in the table. Source: U.S. Department of Agriculture.

Table 5 – Futures Contract Specifications

	Contract Size	Tick Size	Contract Exp. Mo.
Foods:			
Frozen Orange Juice	15,000 Pounds	$7.50	F, H, K, N, U, X
Rough Rice	2000 Hundredweights	$10.00	F, H, K, N, U, X
Sugar #11	112,000 Pounds	$11.20	H, K, N, V
Grains:			
Corn	5000 Bushels	$12.50	H, K, N, U, Z
Oats	5000 Bushels	$12.50	H, K, N, U, Z
Soybean	5000 Bushels	$12.50	F, H, K, N, Q, U, X
Soybean Meal	100 Short Tons	$10.00	F, H, K, N, Q, U, V, Z
Soybean Oil	60,000 Pounds	$6.00	F, H, K, N, Q, U, V, Z
Wheat	5000 Bushels	$12.50	H, K, N, U, Z
Kansas City Wheat	5000 Bushels	$12.50	H, K, N, U, Z
Minnesota Wheat	5000 Bushels	$12.50	H, K, N, U, Z
Fiber:			
Cotton #2	50,000 Pounds	$5.00	H, K, N, V, Z
Meats:			
Feeder Cattle	50,000 Pounds	$12.50	F, H, J, K, Q, U, V, X
Live Cattle	40,000 Pounds	$10.00	G, J, M, Q, V, Z
Financials:			
10 Yr. Treas. Note	100,000 Dollars	$15.625	H, M, U, Z

Source: CME Group, New York Mercantile Exchange, Minneapolis Grain Exchange, and Kansas City Board of Trade. Futures monthly expiration codes are as follows: January (F), February (G), March (H), April (J), May (K), June (M), July (N), August (Q), September (U), October (V), November (X), and December (Z).

Table 6 – Summary Statistics

Variable	Minimum	Maximum	Mean	Standard De
Sugar	5.800	17.870	9.649	2.382
Orange Juice	66.450	194.500	107.100	27.364
Feeder Cattle	58.617	112.850	84.863	13.872
Rough Rice	4.205	17.695	8.247	2.437
Corn	215.500	591.250	272.525	64.950
Oats	112.500	436.000	166.407	54.216
Soybeans	431.000	1324.125	634.927	153.689
Soybean Meal	136.400	339.000	190.408	37.064
Soybean Oil	15.660	53.850	24.132	6.880
Live Cattle	61.670	100.350	74.811	9.709
Cotton	36.795	88.160	63.318	11.659
Wheat	268.500	945.417	377.200	119.815
Kansas City Wheat	296.000	1005.084	392.341	123.228
Minnesota Wheat	304.250	1049.667	405.313	128.125
Ten Year Treasury	95.913	117.969	107.649	4.967
Anticipated Inflation	0.015	0.045	0.030	0.006
Corn Belt Annual Cropland	107.024	290.492	162.916	47.295
Corn Belt Capitalization Rates	0.031	0.064	0.043	0.007
Corn Belt Risk Premiums	-0.031	0.004	-0.012	0.007
Delta States Annual Cropland	100.030	179.700	118.731	20.551
Delta States Capitalization Rates	0.047	0.072	0.061	0.006
Delta States Risk Premiums	-0.013	0.019	0.005	0.007
Lake States Annual Cropland	100.130	147.978	114.131	10.371
Lake States Capitalization Rates	0.044	0.082	0.062	0.009
Lake States Risk Premium	-0.006	0.022	0.100	0.007
Mountain Annual Cropland	99.897	186.566	120.235	19.853
Mountain Capitalization Rates	0.042	0.073	0.055	0.007
Mountain Risk Premium	-0.026	0.016	0.000	0.007
Pacific NW Annual Cropland	99.781	152.924	111.829	10.370
Pacific NW Capitalization Rates	0.040	0.091	0.051	0.008
Pacific NW Risk Premiums	-0.032	0.028	-0.004	0.011
Pacific West Annual Cropland	99.528	317.042	149.445	58.333
Pacific West Annual Cropland Capitalization Rates	0.032	0.072	0.051	0.009
Pacific West Annual Cropland Risk Premiums	-0.022	0.009	-0.003	0.008
Pacific West Permanent Cropland	99.823	175.110	119.230	22.766
Pacific West Permanent Cropland Capitalization Rates	0.039	0.245	0.092	0.047
Pacific West Permanent Cropland Risk Premiums	-0.023	0.200	0.036	0.053
Southeast Annual Cropland	101.101	374.485	163.961	74.027
Southeast Annual Cropland Capitalization Rates	0.029	0.064	0.046	0.008
Southeast Annual Cropland Risk Premiums	-0.023	0.008	-0.007	0.007
Southeast Permanent Cropland	58.325	142.902	86.909	21.109
Southeast Permanent Cropland Capitalization Rates	0.038	0.183	0.070	0.027
Southeast Permanent Cropland Risk Premiums	-0.033	0.134	0.014	0.028

Note: Farmland values, capitalization rates and capitalization rate risk premiums are based on quarterly data taken from NCREIF. The farmland market values are calculated using NCREIF appreciation returns and are converted to indexes with an initial value of

100 that increases and decreases based upon said appreciation returns. Agricultural commodity and interest rate futures prices are daily closing prices on the first day of each quarter from R&C Research Inc. Anticipated inflation are yearly economic projections in December and June from the Livingston Survey of the Philadelphia Federal Reserve Bank. Anticipated inflation, capitalization rates, and capitalization rate risk premiums are percentage rates.

Table 7 – Ordinary Least Squares Regression Results on the Desmoothed Farmland Market Values

Region	Commodity	Constant	Futures Price	Capitalization Rate	Anticipated Inflation	Interest Rate Futures	R^2	F	n
Corn Belt									
	Corn	2.621**	-0.059	0.003	-0.002	0.242	0.017	0.260	66
	Feeder Cattle	3.109**	0.139	0.005	-0.001	0.169	0.019	0.291	66
	Live Cattle	1.331	0.272	0.003	-0.001	0.312	0.040	0.641	66
	Soybean	2.583**	-0.042	0.004	-0.001	0.237	0.014	0.210	66
	Wheat	1.721	0.172*	0.005	0.000	0.288	0.057	0.917	66
Delta States									
	Cotton	3.038***	0.012	-0.002	0.000	0.046	0.014	0.221	66
	Rough Rice	3.216***	-0.069	-0.001	-0.001	0.072	0.036	0.577	66
	Soybean	3.208***	-0.062	-0.002	0.000	0.067	0.031	0.485	66
	Sugar	3.114***	-0.006	-0.002	0.000	0.041	0.014	0.217	66
	Wheat	2.777***	0.077	-0.002	0.000	0.063	0.040	0.633	66
Lake States									
	Corn	3.455***	-0.088	-0.006	-0.002	0.021	0.024	0.269	49
	Oats	3.473***	-0.078	-0.005	-0.003	0.004	0.022	0.251	49
	Soybean	3.408***	-0.074	-0.005	-0.002	0.020	0.020	0.227	49
	Sugar	2.777**	0.094	-0.004	-0.002	0.048	0.049	0.570	49
Mountain									
	Cotton	2.942***	0.100	-0.004	-0.008***	-0.010	0.151	2.714	66
	Feeder Cattle	3.502***	-0.040	-0.002	-0.008***	-0.045	0.124	2.159	66
	Live Cattle	1.772*	0.352***	-0.002	-0.008***	0.100	0.221	4.337	66
	Minn. Wheat	3.007***	0.111*	-0.003	-0.008***	-0.042	0.162	2.944	66
	Sugar	3.147***	0.032	-0.002	-0.008***	-0.007	0.130	2.282	66
Pacific NW									
	Sugar	3.290***	-0.039	0.001	0.027**	0.016	0.110	1.857	65
Pacific West									
	Cotton	3.660**	-0.014	-0.009	-0.010	-0.113	0.052	0.804	64
	Feeder Cattle	4.444*	-0.183	-0.008	-0.010	-0.189	0.057	0.887	64
	Live Cattle	2.569	0.242	-0.010	-0.010	-0.030	0.061	0.966	64
	Rough Rice	3.609**	0.017	-0.009	-0.010	-0.129	0.052	0.808	64
Pacific West Permanent Crops									
	Orange Juice	3.563***	0.028	0.000	-0.002	-0.135	0.009	0.134	66
Southeast									
	Cotton	1.888	-0.076	0.002	-0.118	0.489	0.027	0.178	47
	Soybean	2.760	-0.230	0.001	-0.090	0.373	0.076	0.982	47
	Sugar	2.566	-0.146	0.002	-0.142	0.348	0.059	0.182	47
	Wheat	1.967	-0.076	0.001	-0.101	0.465	0.026	0.196	47
Southeast Permanent Crops									
	Orange Juice	3.210*	0.128	0.004	0.002	-0.129	0.033	0.513	66

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

Note: The regression equation is performed on percentage change returns shown by the following:

$$Farm_t = \alpha_0 + \alpha_1 (ACFut_t - ACFut_{t-1)}) / ACF_{t-1} + \alpha_2 (CR_t - CR_{t-1}) / CR_{t-1} + \alpha_3 (IFut_t - IFut_{t-1}) / IFut_{t-1} + a_4 (Inf_t - Inf_{t-1}) / Inf_{t-1} + \in_t$$

Table 8 – Ordinary Least Squares Regression Results on the Original Farmland Market Values

Region	Commodity	Constant	Futures Price	Capitalization Rate	Anticipated Inflation	Interest Rate Futures	R^2	F	n
Corn Belt									
	Corn	2.725***	-0.004	0.307	0.000	0.155	0.034	0.537	66
	Feeder Cattle	3.722***	-0.002	0.003	0.000	0.153	0.034	0.533	66
	Live Cattle	2.319***	0.095	0.002	0.000	0.182	0.066	1.073	66
	Soybean	2.702***	0.004	0.003	0.000	0.154	0.034	0.536	66
	Wheat	2.376***	0.078**	0.003	0.000	0.180	0.119	2.054	66
Delta States									
	Cotton	3.085***	0.012	0.000	0.000	0.030	0.006	0.098	66
	Rough Rice	3.132***	0.000	0.000	0.000	0.028	0.002	0.032	66
	Soybean	3.146***	-0.008	0.000	0.000	0.030	0.004	0.059	66
	Sugar	3.087***	0.008	0.000	0.000	0.033	0.007	0.108	66
	Wheat	2.992***	0.035	0.000	0.000	0.036	0.036	0.602	66
Lake States									
	Corn	3.035***	0.042	0.000	0.000	0.016	0.034	0.384	49
	Oats	3.085***	0.016	-0.002	0.000	0.027	0.016	0.176	49
	Soybean	3.005***	0.036	-0.001	0.000	0.016	0.029	0.331	49
	Sugar	2.984***	0.029	-0.002	0.000	0.046	0.037	0.428	49
Mountain									
	Cotton	3.248***	0.047*	-0.001	-0.004***	-0.054	0.215	4.186	66
	Feeder Cattle	3.378***	0.009	0.000	-0.004***	-0.057	0.170	3.116	66
	Live Cattle	2.981***	0.100**	0.000	-0.003***	-0.026	0.229	4.536	66
	Minn. Wheat	3.278***	0.052**	0.000	-0.003***	-0.069	0.233	4.634	66
	Sugar	3.324***	0.019	0.000	-0.004***	-0.051	0.188	3.538	66
Pacific NW									
	Sugar	2.975***	-0.008	0.000*	0.011***	0.083	0.139	2.430	65
Pacific West									
	Cotton	3.483***	-0.001	-0.002	-0.004	-0.079	0.038	0.586	64
	Feeder Cattle	3.603***	-0.027	-0.002	-0.003	-0.090	0.039	0.600	64
	Live Cattle	3.395***	0.020	-0.002	-0.003	-0.072	0.039	0.594	64
	Rough Rice	3.281***	0.010	-0.002	-0.003	-0.090	0.039	0.603	64
Pacific West Permanent Crops									
	Orange Juice	3.557***	0.039	0.000	0.000	-0.143	0.039	0.615	66
Southeast									
	Cotton	2.916***	-0.032	0.001	-0.089	0.126	0.045	0.301	47
	Soybean	3.236***	-0.087	0.001	-0.078	0.082	0.079	0.954	47
	Sugar	2.703***	0.019	0.001	-0.079	0.141	0.045	0.391	47
	Wheat	2.823***	0.000	0.001	-0.084	0.123	0.042	0.301	47
Southeast Permanent Crops									
	Orange Juice	3.443***	0.067	0.000	0.001	-0.136	0.043	0.685	66

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Note: The regression equation is performed on percentage change returns shown by the following:

$$Farm_t = \alpha_0 + \alpha_1 (ACFut_t - ACFut_{t-1})) / ACF_{t-1} + \alpha_2 (CR_t - CR_{t-1}) / CR_{t-1} + \alpha_3 (IFut_t - IFut_{t-1}) / IFut_{t-1} + a_4 (Inf_t - Inf_{t-1}) / Inf_{t-1} + \in_t$$

Table 9 – Unit Root Tests of Futures Contracts and Anticipated Inflation

	Lags	ADF Test	Critical Value	Bandwidth	PP Test	Critical Value
Sugar	0	-2.297	-3.479	0	-2.297	-3.479
Orange Juice	1	-3.202	-3.480	1	-2.494	-3.479
Feeder Cattle	3	-3.023	-3.482	5	-2.625	-3.479
Rough Rice	1	-0.672	-3.480	2	-0.278	-3.479
Corn	2	0.940	-3.481	7	1.613	-3.479
Oats	0	1.969	-3.479	4	2.276	-3.479
Soybeans	0	1.239	-3.479	0	1.239	-3.479
Soybean Meal	0	-1.719	-3.479	2	-1.857	-3.479
Soybean Oil	0	1.758	-3.479	1	1.735	-3.479
Live Cattle	0	-2.220	-3.479	1	-2.142	-3.479
Cotton	0	-1.583	-3.479	3	-1.983	-3.479
Wheat	0	2.505	-3.479	0	2.505	-3.479
Kansas City Wheat	0	2.530	-3.479	4	2.691	-3.479
Minnesota Wheat	0	3.192	-3.479	2	2.941	-3.479
Ten Year Treasury	1	-3.999	-3.480	2	-3.049	-3.479
Anticipated Inflation	3	-3.336	-3.482	2	-2.955	-3.479
Δ Sugar	0	-8.160	-3.480	5	-8.349	-3.480
Δ Orange Juice	1	-5.773	-3.481	1	-6.522	-3.480
Δ Feeder Cattle	0	-8.016	-3.480	5	-8.045	-3.480
Δ Rough Rice	0	-6.066	-3.480	4	-5.900	-3.480
Δ Corn	1	-5.303	-3.481	6	-4.827	-3.480
Δ Oats	0	-4.827	-3.480	0	-4.827	-3.480
Δ Soybeans	0	-6.572	-3.480	1	6.557	-3.480
Δ Soybean Meal	0	-8.080	-3.480	1	-8.081	-3.480
Δ Soybean Oil	0	-6.873	-3.480	3	-6.961	-3.480
Δ Live Cattle	1	-8.509	-3.481	7	-10.687	-3.480
Δ Cotton	0	-6.771	-3.480	1	-6.774	-3.480
Δ Wheat	0	-5.994	-3.480	3	-6.063	-3.480
Δ Kansas City Wheat	0	-5.318	-3.480	0	-5.318	-3.480
Δ Minnesota Wheat	0	-5.150	-3.480	1	-5.169	-3.480
Δ Ten Year Treasury Note	3	-5.645	-3.483	0	-5.339	-3.480
Δ Anticipated Inflation	1	-5.546	-3.481	6	-3.388	-3.48

Note: MacKinnon asymptotic critical values are shown at the 5% level. The test includes the intercept and trend. Lags are determined by the Schwartz Information Criterion (SIC) for the Augmented Dickey Fuller test, while the Phillip-Perron test bandwidth is determined by the Newey West procedure with a Bartlett kernel. Δ.is the first difference operator. Unit root tests were performed with the intercept term only as a check, but were not shown for the sake of brevity.

Table 10 – Unit Root Tests of Regional Agricultural Market Value Indexes and Capitalization Rate Risk Premiums

	Lags	ADF Test	Critical Values	Bandwidth	PP Test	Critical Values
Corn Belt Desmoothed	5	-1.516	-3.485	9	-3.010	-3.479
Δ Corn Belt Desmoothed	5	-2.365	-3.486	2	-21.115	-3.480
Corn Belt Original	4	-1.908	-3.483	2	-0.103	-3.479
Δ Corn Belt Original	5	-2.478	-3.486	4	-9.982	-3.480
Corn Belt Cap. Rate Risk Prem.	6	-3.056	-3.486	4	-2.525	-3.479
Δ Corn Belt Cap. Rate Risk Prem.	3	-6.250	-3.483	4	-5.650	-3.480
Delta States Desmoothed	5	-0.304	-3.485	20	-1.481	-3.479
Δ Delta States Desmoothed	4	-2.542	-3.485	34	-17.614	-3.480
Delta States Original	4	-0.980	-3.483	5	1.070	-3.479
Δ Delta States Original	3	-1.912	-3.483	0	-7.969	-3.480
Delta States Cap. Rate Risk Prem.	1	-2.142	-3.480	4	-2.607	-3.479
Δ Delta States Cap. Rate Risk Prem.	0	-6.739	-3.480	4	-6.829	-3.480
Lake States Desmoothed	1	0.296	-3.506	1	-0.725	-3.504
Δ Lake States Desmoothed	0	-12.702	-3.506	1	-12.793	-3.506
Lake States Original	0	-1.219	-3.504	3	0.687	-3.504
Δ Lake States Original	0	-6.284	-3.506	3	-6.352	-3.506
Lake States Cap. Rate Risk Prem.	0	-2.030	-3.504	0	-2.030	-3.504
Δ Lake States Cap. Rate Risk Prem.	0	-5.301	-3.506	3	-5.288	-3.506
Mountain Desmoothed	3	2.881	-3.482	15	-1.581	-3.479
Δ Mountain Desmoothed	2	-9.347	-3.482	31	-16.058	-3.480
Mountain Original	3	4.569	-3.482	21	4.921	-3.479
Δ Mountain Original	3	-2.414	-3.483	7	-8.817	-3.480
Mountain Cap. Rate Risk Prem.	8	-3.201	-3.489	1	-3.614	-3.479
Δ Moutain Cap. Rate Risk Prem.	7	-5.073	-3.489	1	-8.544	-3.480
Pacific NW Desmoothed	2	2.537	-3.483	6	-1.431	-3.480
Δ Pacific NW Desmoothed	2	-2.492	-3.482	6	-12.369	-3.481
Pacific NW Original	3	-0.039	-3.483	5	2.560	-3.480
Δ Pacific NW Original	2	-1.603	-3.483	6	-7.665	-3.481
Pacific NW Cap. Rate Risk Prem.	3	-4.298	-3.483	3	-3.604	-3.480
Δ Pacific NW Cap. Rate Risk Prem.	3	-5.849	-3.485	6	-5.641	-3.481
Pacific West Desmoothed Annual	3	1.325	-3.485	6	-1.420	-3.481
Δ Pacific West Desmoothed Annual	3	-4.030	-3.486	16	-18.541	-3.482
Pacific West Original Annual	0	0.791	-3.481	4	1.085	-3.481
Δ Pacific West Original Annual	0	-9.156	-3.482	2	-9.150	-3.482
Pacific West Cap. Rate Risk Prem. Annual	1	-2.843	-3.482	4	-2.221	-3.481
Δ Pacific West Cap. Rate Risk Prem. Annual	0	-4.656	-3.482	1	-4.636	-3.482
Pacific West Desmoothed Perm	1	-1.269	-3.480	6	-1.961	-3.479
Δ Pacific West Desmoothed Perm	0	-11.567	-3.480	5	-11.589	-3.480

Pacific West Original Perm	4	-2.796	-3.483	4	-0.879	-3.479
Δ Pacific West Original Perm	0	-6.017	-3.480	1	-5.977	-3.480
Pacific West Cap. Rate Risk Prem. Perm	0	-2.389	-3.479	1	-2.581	-3.479
Δ Pacific West Cap. Rate Risk Prem. Perm	0	-7.118	-3.480	2	-7.100	-3.480
Southeast Desmoothed Annual	4	-3.276	-3.518	5	-1.074	-3.508
Δ Southeast Desmoothed Annual	0	-8.038	-3.510	9	-8.872	-3.510
Southeast Original Annual	1	-0.265	-3.510	1	0.452	-3.508
Δ Southeast Original Annual	0	-4.652	-3.510	3	-4.606	-3.510
Southeast Cap. Rate Risk Prem. Annual	1	-1.944	-3.510	2	-1.634	-3.508
Δ Southeast Cap. Rate Risk Prem. Annual	0	-4.961	-3.510	1	-5.000	-3.510
Southeast Desmoothed Perm	2	-0.026	-3.481	4	-0.743	-3.479
Δ Southeast Desmoothed Perm	1	-8.742	-3.481	7	-12.127	-3.480
Southeast Original Perm	0	1.135	-3.479	3	0.899	-3.479
Δ Southeast Original Perm	0	-6.700	-3.480	3	-6.713	-3.480
Southeast Cap. Rate Risk Prem. Perm	4	-1.686	-3.483	2	-3.038	-3.479
Δ Southeast Cap. Rate Risk Prem. Perm	3	-6.943	-3.483	2	-5.448	-3.480

Note: MacKinnon asymptotic critical values are shown at the 5% level. The test includes the intercept and trend. Lags are determined by the Schwartz Information Criterion (SIC) for the Augmented Dickey Fuller test, while the Phillip-Perron test bandwidth is determined by the Newey West procedure with a Bartlett kernel. Δ.is the first difference operator. Unit root tests were performed with the intercept term only as a check, but were not shown for the sake of brevity.

Table 11 – Johansen's Cointegration Results on the Desmoothed Farmland Market Values

Region	Commodity	Trace Statistic	Maximum Eigenvalue Statisitc	Futures Price	Capitalization Rate	Anticipated Inflation	Lags	R^2	n
Corn Belt									
	Corn	48.223**	24.800	2.274***	13.962	-30.341***	4	0.805	66
	Feeder Cattle	35.326	20.633	0.698	-22.315	-41.322	1	0.689	66
	Live Cattle	38.885	21.109	1.098	-19.563	-40.398	1	0.671	66
	Soybean	26.836	14.584	1.053	-1.925	-39.376	5	0.864	66
	Wheat	56.220***	32.025***	2.453***	59.579***	8.410	3	0.772	66
Delta States									
	Cotton	40.811	21.985	-0.230	-15.939	-26.058	1	0.410	66
	Rough Rice	33.206	15.847	0.016	-10.291	-23.993***	1	0.408	66
	Soybean	44.578*	23.377	0.15	-2.176	-11.938*	2	0.574	66
	Sugar	59.098***	30.746**	-0.946***	-19.279*	13.380	3	0.645	66
	Wheat	47.549*	27.550*	0.059	-3.957	-12.921**	2	0.569	66
Lake States									
	Corn	93.002***	65.710***	1.194***	55.079***	72.650***	2	0.420	49
	Oats	58.202***	32.326**	0.035	-41.707***	-12.039	3	0.560	49
	Soybean	91.535***	61.519***	-0.462	-321.340***	-415.786***	4	0.604	49
	Sugar	62.737***	30.960**	1.630***	-59.278***	-90.233***	1	0.551	49
Pacific NW									
	Sugar	58.222***	45.548***	0.098***	N/A	-11.092***	2	0.445	65
Pacific West									
	Cotton	37.623	15.505	-1.476	70.991	35.179	1	0.466	64
	Feeder Cattle	37.111	18.919	1.736	-30.523	-23.274	1	0.446	64
	Live Cattle	38.163	16.961	1.883	-24.566	-24.747	2	0.526	64
	Rough Rice	32.837	16.572	0.681	-11.349	-73.106	4	0.625	64
Pacific West Permanent Crops									
	Orange Juice	61.281***	31.350**	2.469***	-8.036***	-56.605***	1	0.323	66
Southeast									
	Cotton	35.551	19.858	-0.899	-63.863	-128.249	1	0.273	47
	Soybean	35.940	22.249	-1.516	-87.637	-164.205	1	0.310	47
	Sugar	40.640	20.233	0.901	38.188	184.040	1	0.290	47
	Wheat	39.468	19.538	-0.574	-43.699	-47.143	2	0.336	47
Southeast Permanent Crops									
	Orange Juice	59.290***	32.989***	1.242***	-0.972	7.299	1	0.185	66

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

Note: The test assumes no exogenous variables, but seasonal dummy variables are used in the test. The cointegration equation is shown by the following: $\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-k} + \Phi D_t + \epsilon_t$

Table 12 – Johansen's Cointegration Results on the Original Farmland Market Values

Region	Commodity	Trace Statistic	Maximum Eigenvalue Statistic	Futures Price	Capitalization Rate	Anticipated Inflation	Lags	R^2	n
Corn Belt									
	Corn	54.600**	29.480**	1.772***	12.753	-28.783***	4	0.721	66
	Feeder Cattle	37.556	20.767	1.036	-29.323	-36.737	2	0.536	66
	Live Cattle	30.281	14.837	1.301	-39.717	-42.573	2	0.537	66
	Soybean	33.405	21.146	0.843	-5.686	-40.016	4	0.719	66
	Wheat	51.585**	32.442**	1.051***	4.014	-30.041***	4	0.729	66
Delta States									
	Cotton	53.603**	32.163**	-0.168*	-8.201**	-15.583***	1	0.417	66
	Rough Rice	45.405*	26.121*	-0.101	-6.000	-13.843**	1	0.429	66
	Soybean	47.675*	25.160*	0.029	-0.808	-8.560*	2	0.521	66
	Sugar	59.213***	30.489**	-0.594***	-3.792	10.724	2	0.548	66
	Wheat	54.390***	33.910***	0.047	-1.894	-10.016***	2	0.531	66
Lake States									
	Corn	74.386***	37.333***	1.296***	39.809***	66.097***	3	0.482	49
	Oats	61.879***	33.083***	0.428	-62.024***	-7.598	3	0.536	49
	Soybean	67.112***	46.097***	1.615*	256.805***	302.252***	2	0.463	49
	Sugar	62.006***	37.009***	2.693***	-151.672***	-181.541***	3	0.650	49
Pacific NW									
	Sugar	28.766*	10.890*	0.140***	N/A	-12.389***	3	0.420	65
Pacific West									
	Cotton	36.677	18.427	-2.244	-60.425	2.960	3	0.432	64
	Feeder Cattle	80.934***	58.636***	1.964***	-16.084***	-12.280***	3	0.322	64
	Live Cattle	38.908	16.094	1.839	23.841	22.043	2	0.314	64
	Rough Rice	31.386	16.906	0.732	-5.949	-70.956	4	0.482	64
Pacific West Permanent Crops									
	Orange Juice	68.569***	30.814**	3.773***	-22.707***	-101.263***	1	0.326	66
Southeast									
	Cotton	37.156	19.594	-0.940	-55.394	-105.064	1	0.338	47
	Soybean	36.544	21.463	-1.509	-82.894	-153.364	1	0.375	47
	Sugar	40.524	20.412	0.305	-50.749	-168.695	1	0.345	47
	Wheat	40.487	19.879	-0.001	-17.175	-25.914	2	0.366	47
Southeast Permanent Crops									
	Orange Juice	64.133***	33.868***	1.030***	-0.764	11.084**	1	0.184	66

* Significant at the 10% level

** Significant at the 5% level

*** Significant at the 1% level

Note: The test assumes no exogenous variables, but seasonal dummy variables are used in the test. The cointegration equation is shown by the following: $\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-k} + \Phi D_t + \epsilon_t$

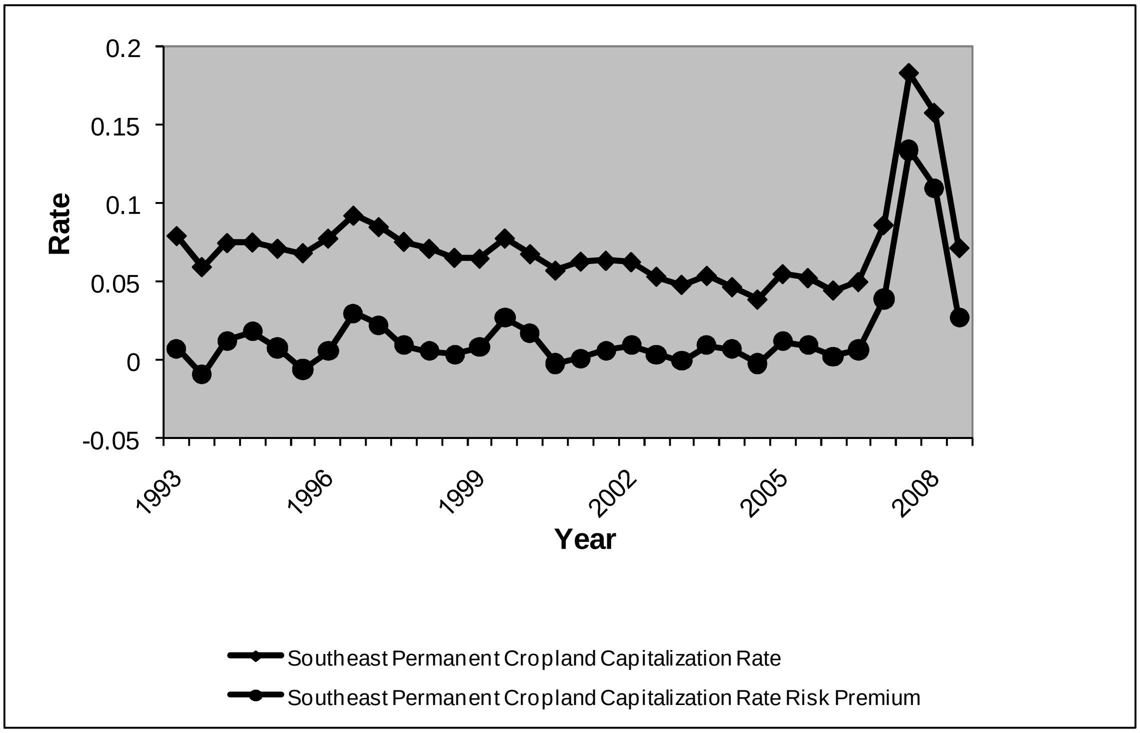
Table 13 – Futures Contracts Correlation Matrix

	Corn	Cotton	Feeder Cattle	Live Cattle	Minnesota Wheat	Oats	Orange Juice	Rough Rice	Soybean	Sugar	Interest Rate	Wheat
Corn	1.000	0.372***	0.243**	0.496***	0.917***	0.935***	0.508***	0.807***	0.899***	0.310**	0.287**	0.927***
Cotton		1.000	-0.461***	-0.285**	0.265**	0.180	0.094	0.545***	0.436***	0.362***	0.115	0.325***
Feeder Cattle			1.000	0.932***	0.393***	0.416***	0.257**	0.224*	0.318***	0.081	0.061	0.366***
Live Cattle				1.000	0.595***	0.633***	0.390***	0.412***	0.546***	0.146	0.152	0.605***
Minnesota Wheat					1.000	0.928***	0.441***	0.755***	0.891***	0.312***	0.302**	0.974***
Oats						1.000	0.539***	0.712***	0.857***	0.314***	0.327***	0.939***
Orange Juice							1.000	0.460***	0.374***	0.496***	0.089	0.474***
Rough Rice								1.000	0.848***	0.448***	0.399***	0.768***
Soybean									1.000	0.320***	0.398***	0.911***
Sugar										1.000	0.073	0.353***
Interest Rate											1.000	0.276**
Wheat												1.000

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

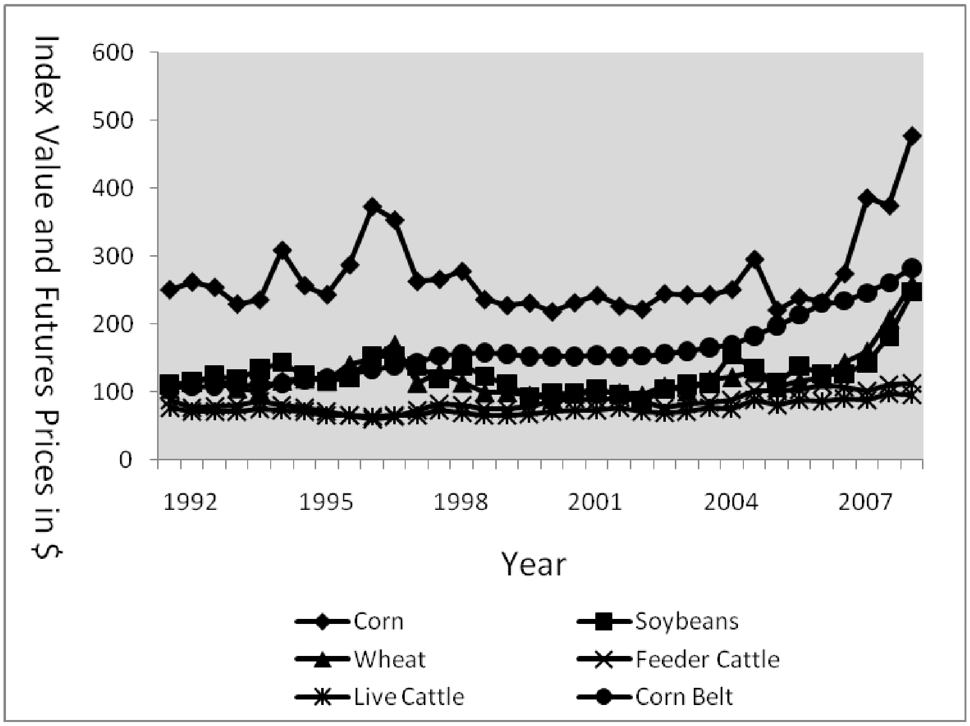
Note: The variables are the futures contracts tested in the study. The interest rate futures contract is based upon the ten year treasury bond. All futures contract data is taken from R & C Research, Inc.

Figure 1 – Regional Capitalization Rate and Capitalization Rate Risk Premiums



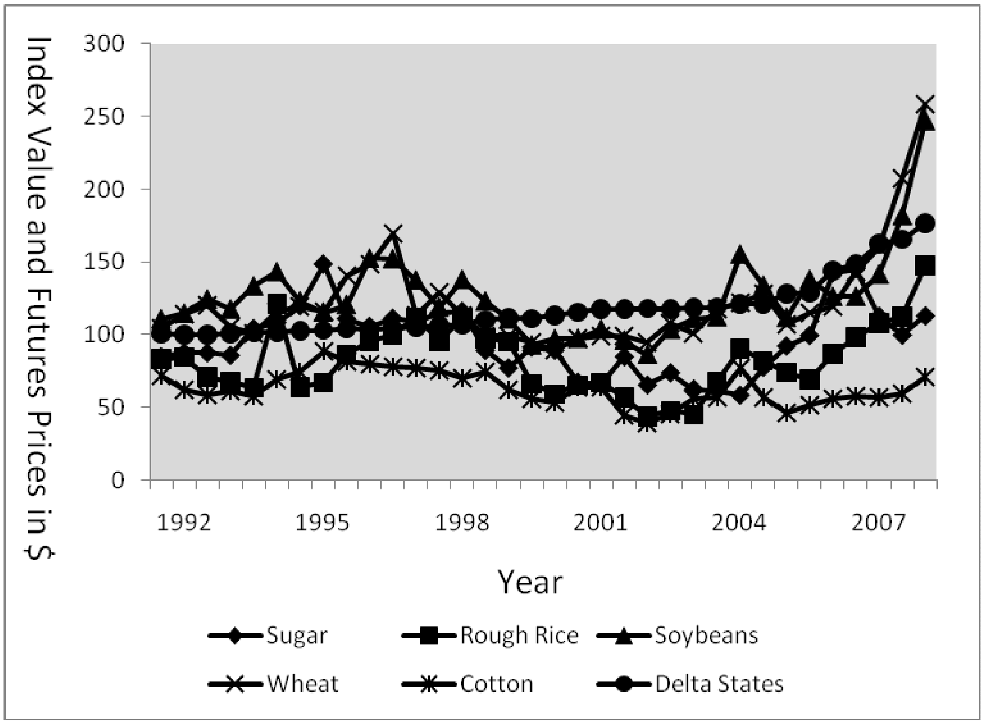
Capitalization rates are derived using net operating income and market values for farmland from NCREIF. Risk premiums are derived from the NCREIF income return for farmland minus the 10-year Treasury Bond rate.

Figure 2 – NCREIF Corn Belt Farmland Market Value Index and Agricultural Commodity Futures Prices (1991-2008)



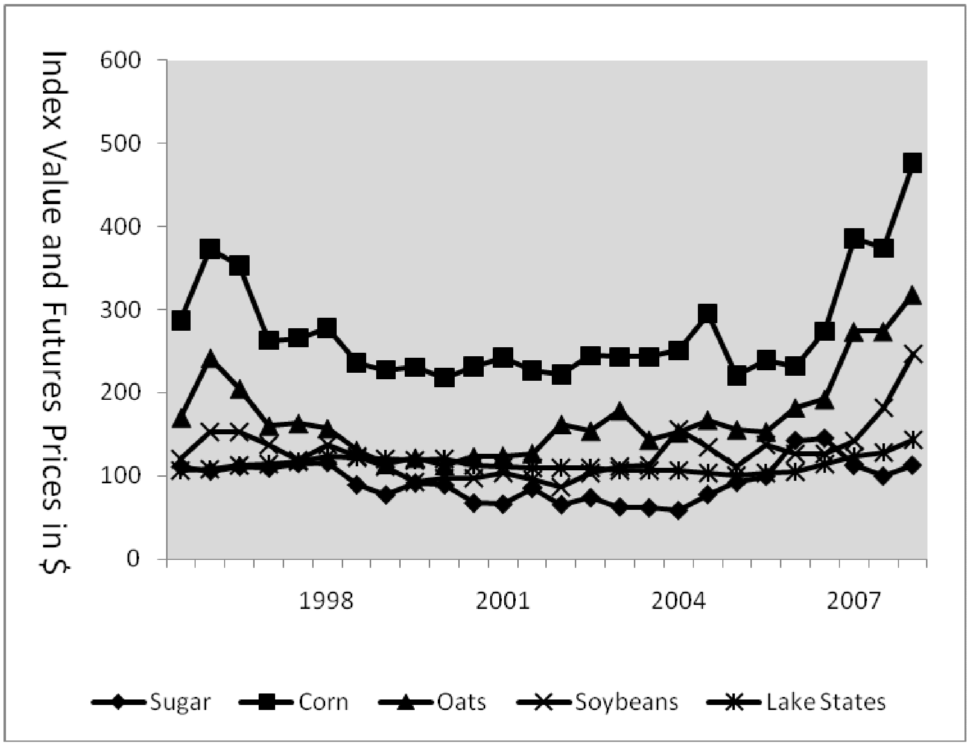
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc.

Figure 3 – NCREIF Delta States Farmland Market Value Index and Agricultural Commodity Futures Prices (1991-2008)



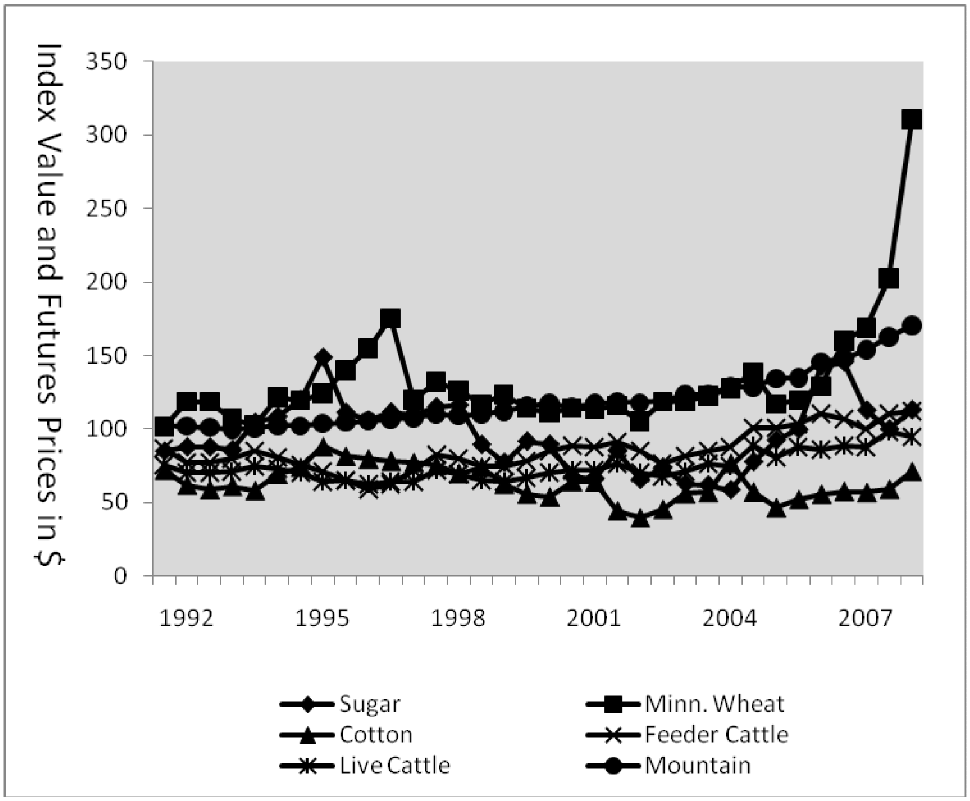
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc.

Figure 4 – NCREIF Lake States Farmland Market Value Index and Agricultural Commodity Futures Prices (1995-2008)



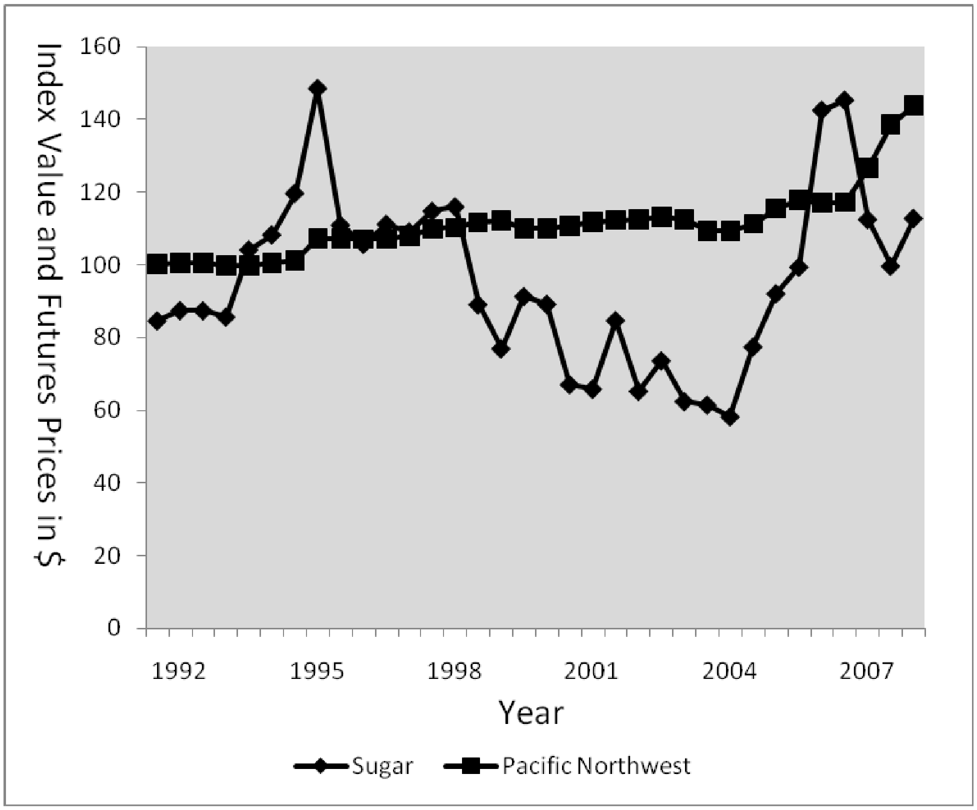
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc

Figure 5 – NCREIF Mountain Farmland Market Value Index and Agricultural Commodity Futures Prices (1991-2008)



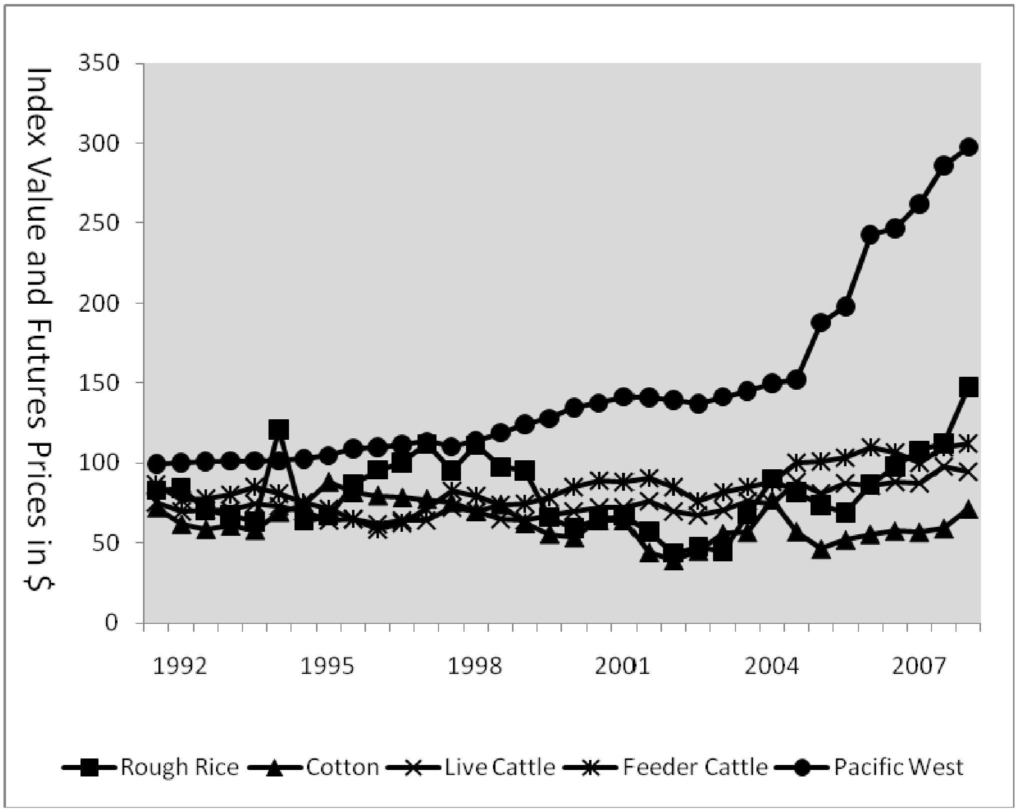
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc

Figure 6 – NCREIF Pacific Northwest Farmland Market Value Index and Agricultural Commodity Futures Prices (1991-2008)



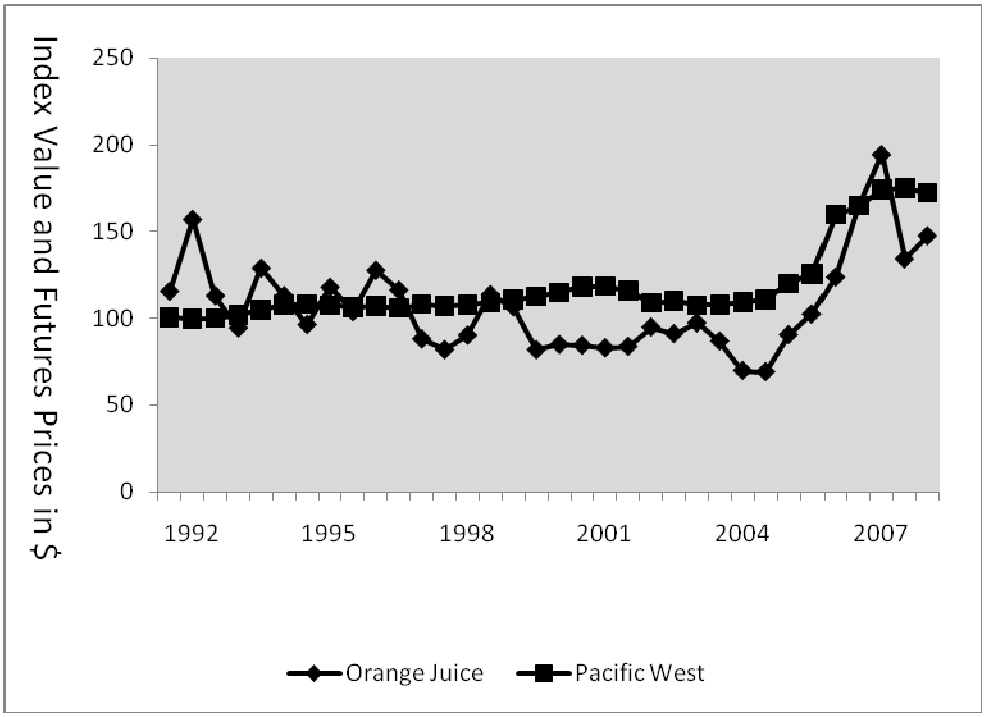
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc

Figure 7 – NCREIF Pacific West Annual Cropland Farmland Market Value Index and Agricultural Commodity Futures Prices (1991-2008)



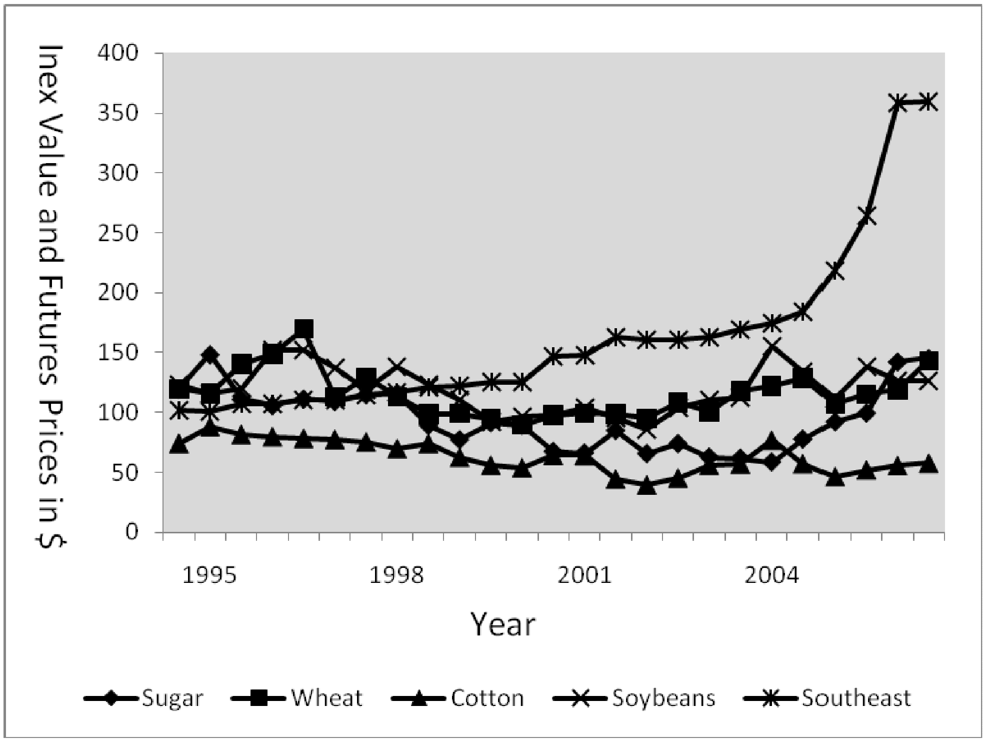
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc

Figure 8 – NCREIF Pacific West Permanent Cropland Farmland Market Value Index and Agricultural Commodity Futures Prices (1991-2008)



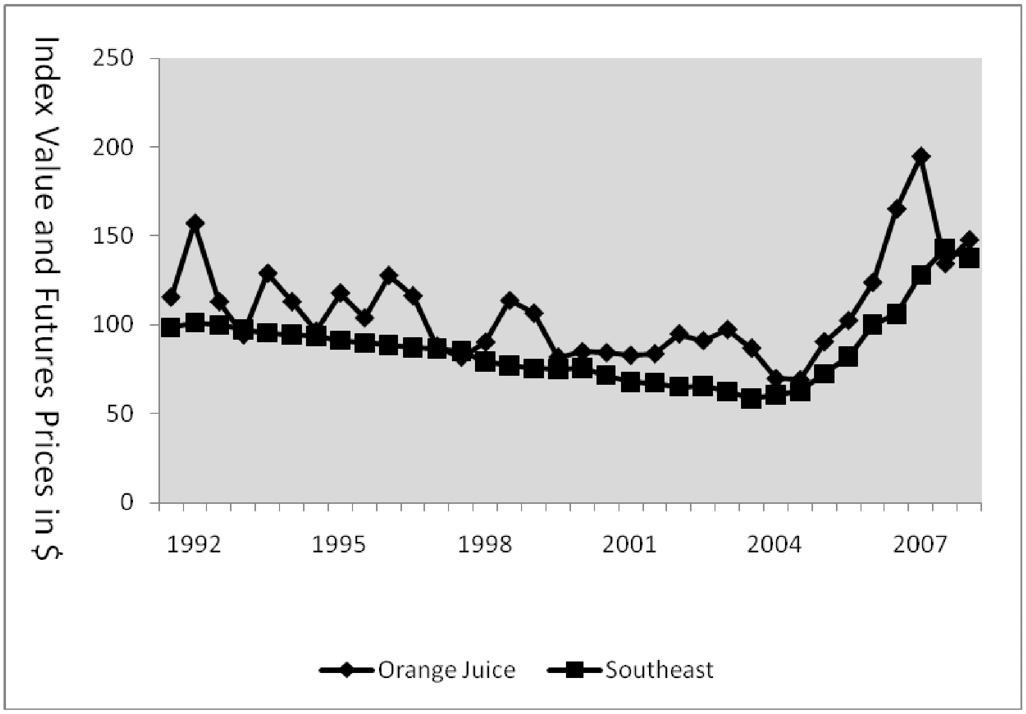
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc

Figure 9 – NCREIF Southeast Annual Cropland Farmland Market Value Index and Agricultural Commodity Futures Prices (1994-2006)



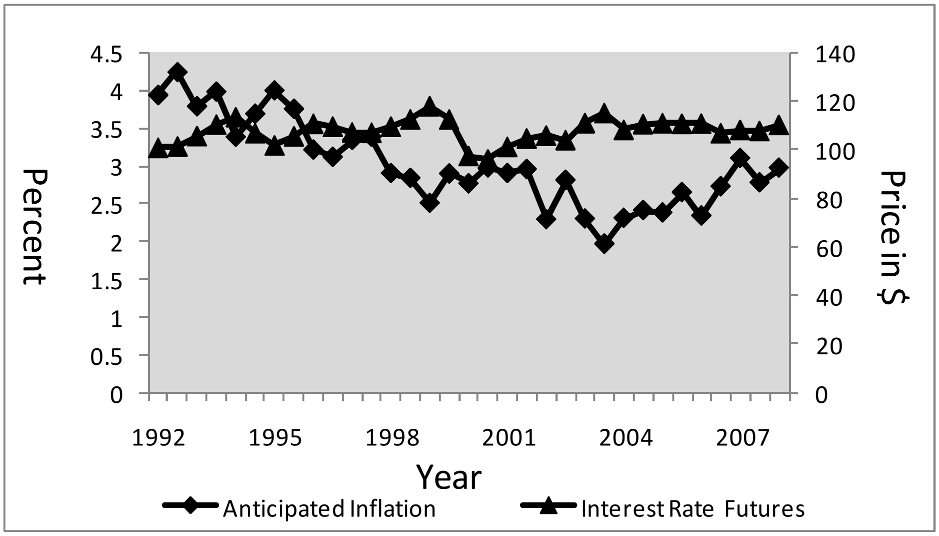
Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc

Figure 10 – NCREIF Southeast Permanent Cropland Farmland Market Value Index and Agricultural Commodity Futures Prices (1991-2008)



Note: Farmland market value is measured in an index using appreciation returns provided by NCREIF. The agricultural commodity futures prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc.

Figure 11 – Anticipated Inflation and Interest Rate Futures Contracts (1991-2008)



Note: Anticipated inflation is taken from the consumer price index of the mean estimates of economists at the Livingston Survey of the Federal Reserve Bank in Philadelphia, Pennsylvania. The interest rate futures contract is the 10 year treasury bond. The prices are measured in dollars per contract taken from the quarterly closing prices provided by R&C Research, Inc.