U.S. FARMLAND PRICE DYNAMICS: CAUSE-EFFECT RELATIONSHIPS

A Thesis

by

MERI DAVLASHERIDZE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2007

Major Subject: Agricultural Economics

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Approved by:

Chair of Committee,	David A. Bessler
Committee Members,	Hae-Shin Hwang
	Curtis F. Lard
Head of Department,	John P. Nichols

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ABSTRACT

U.S. Farmland Price Dynamics: Cause-Effect Relationships.

(August 2007)

Meri Davlasheridze, Diploma, Tbilisi State University, Georgia

Chair of Advisory Committee: Dr. David A. Bessler

Time-series methods are used to investigate farmland price dynamics in the United States (aggregate) as well as seven large agricultural states: California, Georgia, Iowa, Kansas, New York, Ohio and Texas. Vector Autoregressive Analysis (VAR) and Directed Acyclic Graph (DAG) methodology are used to unveil the contemporaneous and dynamic relationship of farmland values with four other variables commonly cited in farmland literature: real returns to farm assets, farm acreage, debt-to-asset ratio and interest rates.

As empirical findings from DAG of all seven states and US aggregate analysis suggest, farmland values are greatly dictated by the financial condition of farm businesses (debt-to-asset ratio) as well as macroeconomic condition of the United States (interest rates) in contemporaneous times. An indirect effect of the fundamental contributor (returns to farm assets) via debt-to-asset ratio has also been discovered. Impulse Response Functions and Forecast Error Variance Decomposition as an alternative VAR tool agree with the findings of DAG when looked at the short term horizon. This specifically indicates farmland price dependence on debt-to-asset ratio and its lagged values, through time macroeconomic condition (interest rates) affects Farmland Prices with a further effect on Returns to Farm Assets. New York, California and Texas

have exhibited slightly different patterns as compared to the other four states and US aggregate results. Farmland prices in New York are greatly dictated by interest rates, by debt-to-asset ratio in California and have exhibited particular exogeneity in Texas regardless of time horizon.

Consistency in farmland price behavior in individual states and in the USA aggregate provides a strong basis to generalize finding over the other states. Consideration of other factors relevant to individual states should be considered to generate better explanations for some of the unexplained portion of my research. These might include, but are certainly not limited to, rapid urban expansion and commercial development in highly urbanized states, the impact of cattle farming and energy sector in Texas.

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CHAPTER I

INTRODUCTION

1.1 Statement of the Problem

Farmland represents the central asset of farm households, and thus serves as a major source of credit collateral for a landowner operator farmer. For owners not operating land, it generates income in the form of rent. It is important to understand the factors that contribute to appreciation of farmland values. Such understanding is important not only for the landowner, but also for operators (renters) and farm lenders.

An appreciated value of land adds to its owner's wealth and increases the operational cost for the land operator. These completely different approaches have become major issues in past and current research on farmland values (Moss and Schmitz 2003).

At the initial stages of farmland market development in the United States, only purely production related factors such as soil productivity, soil quality, irrigation, crops planted, etc. were considered (Cochrane 2003).

The value of farmland is not unrelated to the dynamics of other economic sectors and integration of different markets. Several authors have considered various potential determinants when studying farmland price behavior. These include, but are not limited to, the accelerated urbanization and commercial development process, access to credit, closeness to metropolitan areas, etc.

This thesis follows style and format of the *American Journal of Agricultural Economics.*

Forming an expectation of future returns has become a crucially important element when looking at the future potential return stream from farm assets. Popularity and growth of the financial and capital markets may also have influenced choice behavior of economic agents; they may also have influenced farmland values.

The Present Value Model has been a starting point for much of research on farmland and farm assets. In a basic capitalization framework, the fundamental determinant of the land value is the future stream of earnings (returns) discounted by a discount factor. Future sources of income capitalized in farmland prices are thus derived from pure market income (rent) and various government programs. This simple approach has been modified several times by allowing time variation in interest rates and different types of expectations of income (Just and Miranowski 1993; Weersink et al. 1999). Such a model has not performed the best in predicting the erratic swings in land values and price deviations from their observed path (Featherstone and Baker 1987; Falk 1991).

This is particularly true when looking at the short-term horizon (Schmitz 1995; Falk and Lee 1998). Neither this nor structural simultaneous supply-demand equation models have performed well in explaining price variations. Land supply is highly inelastic. Accordingly, the demand side is a primary force in land price discovery. Unfortunately, one-sided approaches do not provide strong arguments or empirical results when dealing with the nature of farmland (Burt 1986).

One consideration in the study of farmland price dynamics is the observed existence of boom-bust cycles, which refers to huge deviations of land prices from its fundamental values as derived from the Present Value Model (Featherstone and Baker 1987; Falk 1991; Moss and Schmitz 2003). Boom-bust cycles have a great impact on a farmer's economic well-being, regardless of whether he/she is a farm operator or landowner. Predicting expected swings will greatly help reduce the negative effects of such cycles. In order to predict these swings, it is important to understand the economic causes that contribute most to such phenomena.

1.2 Objectives

The primary objectives of this research are to explore how the returns to farm assets, debt to asset ratio, farm acreage, and interest rates explain farmland values, as well as how they behave in major agricultural states (California, Georgia, Iowa, Kansas, New York, Ohio, and Texas); secondly, how the picture changes across major states; and last, how results differ when data are considered as a national aggregate.

The study considers Vector Autoregressive Representation (VAR) modeling of time series data. The latter is practically free from *prior* assumptions about certain economic relationships of variables in the model dictated by an economic theory. In addition, the study uses Directed Acyclic Graph (DAG) techniques, tools of artificial intelligence, to suggest the contemporaneous cause-effect relationship between variables. This approach differs from previous research as it allows the data to reveal itself and give more privilege to empirical patterns prevalent in historical observations (Bessler 1984).

Empirical findings, as opposed to prior theories, allow researchers to narrow the gap between theory and practice. Although the thesis provides a somewhat similar approach to at least one study that has been done previously, it offers different perspectives implied by DAG methodology. Further, the variables used in the thesis are imputed, suggesting the current research is different from earlier work in the area. There has never been consistency in identifying standard proxies for any proposed (or even repeated) variables, which always leaves room for alternative considerations in model building (Melichar 1979).

Farmlands are not homogeneous across the United States. Nor are the effects of economic variables expected to exhibit similar results across different states. Highlighting characteristic commonality among major farming states offers an opportunity to search for potential factors that favor specific behavior. Previous studies utilizing time series data have performed econometric analysis mostly on average national level data; with a few exceptions, large agricultural states have been considered. The current research provides a unique opportunity to look at large agricultural states separately and identify areas where further research on a broader (panel data) study can be undertaken.

Besides a contemporaneous time horizon, the proposed thesis provides an outlook of different time spans (1 through 6-year), by decomposing forecast error variance of variables into shares of potential contributors. This attributes relative explanatory power to each variable studied, allowing for the possibility of identifying how the behavior of determinants differs over the short versus the long run. This type of analysis inherently benefits policy makers by allowing them to evaluate potential impacts on specific policies in different time horizons, and it helps reduce any negative impact if such effect is pre-cautioned.

This thesis is organized into five chapters:

The first chapter provides an introduction and nature of the study, with problem specifications and appropriate objectives. In Chapter II, a general review of the farmland literature is offered. Both theoretical and empirical literature is covered. Chapter III offers a discussion on the model used in this thesis. Chapter IV provides results from the analysis of seven states and a national aggregate. Chapter V concludes and offers suggestions for further research.

CHAPTER II

FARMLAND PRICING LITERATURE REVIEW

2.1 Farmland Pricing and Marketing Theory

Farmland represents the fundamental asset of agriculture. The nature of farmland is somewhat different from other assets and generally complicates the pricing and valuation process. Economic understanding of farmland valuation has evolved over time. This understanding is more complex than just representing land as a static production factor that does not depreciate or does not exhaust over time. The transformation of farmland into non-usable land as a result of land erosion or deterioration is just one of the factors determining the change of value of the asset. Two more recent factors in contemporary times are urban sprawl and commercial development. Both generate serious concerns and are highly debatable among current researchers. As economic development continues, the influence of direct or indirect issues associated with farmland value may change. These in turn are reflected in the development of different approaches to research and analyses, which may differ in approaches researchers take in their study of farmland pricing and market behavior.

One factor that has contributed to structural changes in farmland economics is change in ownership. In the past, farmland was owned and operated by farmers; currently, the tendency has moved in favor of farm operators who do not necessarily own the farmland. Population migration from rural to urban areas has contributed to the enlargement of farm size, and has greatly concentrated its operation and specialized its production.

Sherrick and Barry (2003) classify features of farmland that draw special consideration and attention, specifically:

(a) The nature of non-depreciability of farmland;

(b) High capital gains relative to current returns to farmland;

(c) The low correlation of farmland values to the returns of other speculative assets or stocks;

(d) Developmental, commercial, recreational, and huge urban influence on farmlands;

(e) Government payments that are capitalized into land values, and

(f) A fixed supply of land resources, which makes farmland marketing completely different from other capital assets.

These features characterize only some of the natural and economic properties of farmland and greatly complicate modeling of farmland valuation.

As mentioned earlier, ownership is an important component in modeling farmland values as it determines the origination of returns (rent) to farmland, subsidies, etc. Comprehending the peculiarity of farmland rents and factors influencing their values helps to understand farmland valuation itself.

In the larger picture, rents and capital gains from farmland are considered fundamental (market) factors affecting farmland prices. Urbanization, commercial development, and other similar elements constitute non-agricultural factors and also greatly influence farmland values (Moss and Schmitz 2003).

Considering farmland pricing from the standpoint of a supply-demand framework, the supply is nearly fixed and makes only insignificant changes over short periods of time. Various authors believe it is hard to characterize buying and selling behavior of suppliers and demanders in the farmland market. Phipps (1982) states that both sides of the market are motivated by profit and wealth maximization and their decision is partly determined by the expectation of future returns and economic gains. Other categories of buyers have been identified as well: those who buy farmlands for speculative purposes; for diversifying overall systematic risk in their asset portfolio; or to hedge against inflation, etc. Consequently, consideration of these categories of buyers or sellers requires their inclusion in the econometric modeling. To summarize, the supply-demand framework is restricted by the inelastic nature of a supply, which leaves the demand side of the model as the primary contributor in price identification. The formation of expectations of future capital gain or an income stream is an area of research relevant to the demand side of the model (see figure 1).

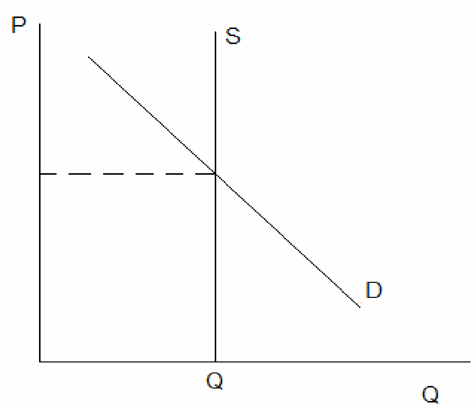

Figure 1. Short-run demand and supply of land

Many authors in the farmland value literature argue and, as most empirical studies indicate, government programs contribute a great deal to farmland prices. Before reviewing some of the significant findings in this regard, it would be relevant to review some government support policies and programs. As stated in Gardner's (2003) research on U.S. commodity policies, there are several policies that are considered when determining valuation factors; specifically, production subsidy programs, decoupled programs such as Loan Deficiency Payments (LDPs) and Production Flexibility Contract Payments (PFCPs), which was introduced by the 1996 Federal Agricultural Improvement and Reform Act (FAIR). LDP payments are based on total units produced and therefore their effect is reflected more on the operator-farmer than on the landowner. Its effect on farmland value is similar to the effect of most programs designed to support commodity prices. Consumers share the benefit of this program as well, because direct payment programs lower product price relative to what it would have been without the price support.

The picture is totally different with respect to PFCPs. The recipient of the payment has absolute freedom to decide what to do with the increased income. The process of government subsidies is complicated in the sense that the subsidy is shared between the landowner and the tenant (land operator), where the owner rents the land with considerable benefits going to landowners. As a result payments, money can either be reinvested into farms or in other assets or just spent without restrictions. These programs have become the subject of major congressional debates. As a result, many owners of PFCP programs are forced to cash-lease their lands so that they get the rent, which captures the benefit of the program. Under the other alternative, the specific renter, not the landowner, is identified as a beneficiary and the payments are made based on bushels grown. Under such program schemes, the government payment is capitalized into the rent paid and inevitably contributes to an increased amount of rent. These arrangements contribute to controversial opinions about the government support policies. In fact, this policy increases the rents paid, which benefits landowners, but increases operational expenses for operator farmers. Based on this analysis, government payments increase the value of farmland and are considered in many econometric analyses of farmland prices (Weersink et al. 1999; Clark, Klein, and Thompson 1993).

The main reason for stressing the importance of government programs as a fundamental element in understanding land prices is because such an understanding relies on the Present Value Model.

According to the basic Present Value Model, fundamental determinants of farmland prices are future returns to farm assets and interest rates. The current price of an asset is a discounted sum of expected future returns of that particular asset:

$$P_0 = \sum_{t=0}^{\infty} R_t /(1+r)^t ,$$

where P_0 is the current land price, R_t is net rent paid on the land at the end of the period t, and r is the discount rate. Here, the discount rate (r_i) is considered to be constant. Modifications have been made to this simple model by allowing the discount rate to vary with time and by imposing expectation operator at returns to land as the rent is realized at the end of the time period t and future returns are unobservable. By relaxing these restrictions, more flexibility has been given to the model, which allows decomposition of contribution into fundamental factors versus non-agricultural factors (Falk and Lee 1998).

Falk (1991) formally tested the explanatory power of the traditional Present Value Model, using current and expected future returns and a discount rate to find a rational behind these variables. The empirical research was conducted on Iowa farmland prices from 1921-1986. Empirical evidence suggested weak power of the Present Value Model. He tested the hypothesis to see whether speculative forces not related to the rent were driving forces of capital gain of farmland assets. His finding further confirmed the findings of Burt (1986) regarding the speculative forces. Specifically, he showed that rent constitutes a significant portion of farmland value and that there is no significant evidence that prices are driven by the same speculative forces that determine prices of other assets and precious metal. In order to identify the magnitude of deviation of farmland prices from its expected future rent, Falk used the spread between farmland value and rent, further justifying the statement by Campbell and Shiller (1987) that if the present value model is correct, then "the spread can be interpreted as the rational forecast of the present value of all future changes in net returns." This means that asset return cannot be predicted based on past prices and rents. His research also employs a VAR representation of time series data. Results show that 50% of real cash rents could be predicted based on its past values and past spread. The Granger Causality Test (spread Granger causes changes in rents) indicates that the current market accounts for more information than past values, which means that information would be reflected in future changes of farmland values.

One way of formally testing the Present Value Model was to test the difference between theoretical and observed spreads. As Iowa results showed, prices tend to overreact to movements in rents (speculation). Overall, research indicates a larger volatility of land prices as compared to rents, regardless of the high correlation between these two variables. Falk (1991) provides reasons for possible failure of the statistical model and attributes it primarily to an existence of rational bubbles and to the fact that discount rate is not time varying.

When considering the returns to farmland it is important to identify sources. As mentioned earlier, many authors consider two possible sources of returns; one derived from economic activities (market return), and the other derived from government payments. This demarcation became a basis of economic analysis of a modified Present Value Model by Alfons Weersink et al. (1999). The main reason for such analysis was to identify land price responsiveness (price elasticity) relative to the changes in different sources of returns. Not only was time variation allowed, but also a differentiated discount rate was introduced into the model. These allowed the authors to discount government payments more than the income derived from the market. The primary reason for this assumption was the hypothesis that income from government was more transitory than that from the market. Besides the attempt to measure the long-term responsiveness of land prices to the fundamental sources of income, the research also looked at short-run price elasticity. With the latter, it is easier to capture expectations of market agents. The analysis employed two approaches, one stressed a rational expectation hypothesis and the other focused on stochastic processes in both government- and market-driven returns. Two hypotheses were provided:

- Discount factors from both sources are same versus different.
- Whether trend in price is derived from government or market returns.

Empirical analysis of Ontario, Canada data confirmed *a priori* expectation of the research, that the discount rate was different between these two sources and that the trend in price was primarily driven by government payment programs.

Quite interestingly, short-term elasticity of land price with respect to both sources of income was found to be small, although market-based returns exhibited more response than government-based returns. Long-term response was inelastic; however, results from short-term response were reversed. Government source of returns have been shown to have 50% more explanatory power than that of a market. Based on such results, it is important to comprehend economic consequences of any government programs.

A significant contribution to the study of farm asset dynamics is the study by Featherstone and Baker (1987). Their article is of particular interest to this research because it also employs VAR methodology that allows freedom of proposed variables and allows every variable in the model to influence every other variable with lags. Their findings are based on U.S. data from 1910-1985 and takes into account only land values, returns, and interest rates. Granger Causality Tests suggest that farm asset values were caused by returns and asset values themselves. Such a strong causal relationship of asset value to itself suggests the potential existence of asset bubbles, which further have been tested by Schmitz (1995). Their research provides some evidence and shows that traditional Present Value Model could encompass huge price swings in agricultural assets.

Explaining and predicting boom-bust cycles are a concern relevant to various assets. Some researchers attribute its occurrence to three major reasons (Tirole 1985):

a) Asset durability;

b) Asset scarcity; and

c) Common belief in future returns.

Durability of the asset implies that an asset will be used for several production periods. And, of course, farmland is normally used for several production cycles depending on the crops planted.

High quality farmland is definitely a scarce asset, specifically when looking long term, since the supply of land is considered to be fixed. With the current pressure of urbanization, farmland has tended to decrease in quantity; thus, it can be identified as a scarce resource.

American farmers definitely exhibit common beliefs in future returns. Stemming from the nature of farm returns, it is generally believed to be driven by the expectation of the same commodity markets (cash or futures). Schmitz (1995) considers additional reasons as potential attributors to land assets, specifically:

- Greed;
- Prestige of owning farmland ("we can buy out our neighbor because John Deere can sell us a new four wheel drive tractor on credit");
- Credit availability; and
- Perception that the land can always be sold at a higher price.

Although Schmitz' research is based on Canadian farmers, his findings can easily be applicable to the American cases; farmlands in both countries have exhibited similar patterns.

Forming an expectation of future returns is a complicated notion. Most research in farmland pricing assumes a Bayesian approach of expectation that the expected future value is derived partly from past values and partly by current information, although expectations described by Bayes Theorem do not always reflect actual behavior of economic agents (Kahneman and Tversky 1974). Over- or underestimating the value of past or current information frequently results in overreactions in prices, and thus price bubbles.

It is noteworthy to mention that this type of behavior has long been suspected in farm asset markets by many researchers. Featherstone and Baker considered the existence of quasi-rational economic agents in farm asset markets. Price bubbles reflect a situation where prices heavily depend on their own expected value, and have been detected quite frequently in land prices (Schmitz 1995; Featherstone and Baker 1987). If arbitrage over time somehow prevents price bubbles in other assets, it is somewhat risky with agricultural assets because of the inexistence of short selling and high incurred transaction costs along with weak information about market prices (Chavas 2003; Lence 2003; Miller 2003). Findings regarding the existence of boom-bust cycles and huge deviation of land prices from their fundamental determinants have greatly contributed to further questioning of possible determinants of such deviations.

A very significant finding and an attempt to distinguish conceptually farm wealth and Ricardian rent has been addressed by Schmitz (1995). Although at first glance there might be a one-to-one relationship between these two, empirical evidence suggests that they deviate significantly. Perception of a high expected land value in the future may contribute to a farmer's wealth, but associated rent may not change at all due to the fact that it actually is realized at the end of the time period. This is where other variables appear to be important. Schmitz considers credit availability and expansion as a potential cause for demand for land to increase, which ultimately increases wealth, but not rents. These and other reasons have motivated researchers to look at other forces that drive changes of farmland values. In this context, it is interesting to review the literature on the importance of farm accumulated debt and its influence on farmland values. A primary theory in financial literature that refers to the asset and debt relationship is known as the Modigliani-Miller (M-M) theorem. This theorem simply ignores the importance of debt on asset values (Mishra, Moss, and Erickson 2007). The basic rationale of this theorem is that consumers hold assets in the economy in the form of stocks (equity) or bonds (debt) and that the aggregate balance sheet does not vary in proportions of equity and debt. Derived from this perspective, debt should not affect farmland values. Although, as has been discussed, debt has a significant effect on farmland as it determines the profitability and identifies liquidity of farmland as well as risk. Credit and its availability ultimately affect farmland markets. Mishra, Moss, and Erickson, when studying farm debt effect on asset valuation, found a statistically significant debt-servicing ratio in the land value model; in fact, their work has suggested that an increase in debt-servicing ratio reduced farmland values for the U.S. as a whole and seven U.S. regions considered individually. (Debt-servicing ratio measures the amount of income needed to service the debt). These results further confronted the M-M theorem, since it ignores the importance of debt on asset valuation. Researchers consider financial conditions in agriculture to be greatly mitigating a boom-bust cycle. Decline in land value reduces the debt-servicing ratio, which in turn has a multiplicative effect on original decline of land values and vice versa (Mishra, Moss, and Erickson 2007).

Among other determinants, inflation and interest rates as a measure of cost of capital (opportunity cost) have been studied in the farmland valuation literature. Increasing land values in the 1970 have partially been attributed to high inflation rates. The inflation rate not only reduces the rate of capitalization, but during inflationary periods, land serves as a hedge against inflation (Just and Miranowski 1993). Moss (1997) has proposed an information strategy that looks at the relative importance of inflation, interest rates and returns to farm assets. The results suggested the greatest importance of inflation in Florida; inflation explained 5.62 times as many bits of information as returns to assets and 12.99 times as many bits of information as the cost of capital (1960-1994). Generalized analysis of U.S. data showed variation across regions. Specifically, regions where government payments constitute a higher share in farmland returns have shown to be influenced more by returns, in other regions, 82% of bits of information were attributed to inflation.

Just and Miranowski's findings have also suggested the relative importance of inflation and opportunity cost (interest rate). Their research is particularly interesting when comparing different models with four different expectations: rational, adaptive, extrapolate, and naïve. The majority of price changes have been greatly attributed to naïve expectations and can partly be explained by inflation and interest rates; especially those periods characterized with large price swings and overreactions.

Lastly, the literature has considered the significant effects of urbanization and commercial development on the nature of farmland markets. The effects of urbanization on agriculture cannot be measured only by the total acreage of farmland transformed into urban areas, but also by the total area that has a high conversion probability.

Boundaries of urbanization have several implications; one is worth noting and relevant for this thesis (Barnard, Wiebe, and Breneman 2003). As urbanization approaches rural areas, land prices rise greatly compared to their production value. In this kind of environment, potential of future land conversion or development is counted as the present value of land. Many urban economists do not feel cautious about an increasing concern of urban sprawl due to the fact that official inventory of urban and built up area comprise only a small share of the total U.S. land. In fact, as figures suggest, even doubling or tripling the urban area would have a negligent effect on an aggregate U.S. agricultural output (Bernand, Wiebe, and Breneman 2003).

Research data collected at U.S. national and state levels have been challenged by looking for the best proxy for urbanization. Micro models at a county level have shown more significance in this regard.

The research of urban sprawl conducted by Grigorios Livanis, Charles B. Moss, Vincent E. Breneman, and Richard F. Nehring (2006), using county-level data, shows the effects of urbanization on farmland values. Increasing prices of farmland in contiguous urban areas can be explained not only by development potential of these lands (urbanization), but also by an “increased agricultural rent” as the proximity to urban areas develops high valued crop markets. Two perspectives are considered: urban expansion as explained by higher returns to agriculture and urbanization as a potential transformation of farmlands into urban and development uses. In some areas, the production of high value crops has competed well with land values for urbanization, thus keeping the land in agriculture.

The joint influence of farm and non-farm factors on real estate value has also been addressed (Hardie, Narayan, and Gardner 2001). Both effects turn out to have a significant impact on farmland prices. Furthermore, farmland values show more responsiveness to non-farm factors than to farm earnings. The study of urbanization is a very broad research area, especially when considering the uncertainty associated with timing of potential future conversion of farmlands into commercial use.

Awokuse and Duke (2006) revisited the previous study on farmlands conducted by Just and Miranowski (1993) to further elucidate the debate regarding the causal structure of farmland determinants. Their research differs from previous ones in a methodological approach; it is the first paper that investigates contemporaneous causation through Directed Acyclic Graph modeling. Their consideration also covers a number of different variables that have traditionally been considered in farmland literature. Based on a data-driven analysis embedded in the DAG, they were able to confirm results from most of the previous co-integration analysis that, on a broader scale, net returns to assets and debts are the most relevant factors that capture fluctuation of land values, although other macroeconomic variables (interest rates, inflation) are found to have an indirect effect through returns or debts.

To summarize, the school of farmland valuation has evolved primarily due to the dynamic changes of land prices, starting from the simple Present Value Model. Analyses have expanded to account for expectations, urbanization, and spatial and temporal changes of fundamental and non-fundamental variables.

The many models used in the current state of research and analysis of farmland values continue to fail to provide answers to the many irregularities found in farmland prices.

CHAPTER III

THEORETICAL FRAMEWORK AND APPLICATIONS

3.1. The Time Series Models (TS)

As the thesis employs time series data, some understanding of the properties of time series modeling is essential to our study. Time series models assume that the variables of interest have time-ordered patterns. So that each observation is not a random draw, unrelated to its historical realization. Each data point depends on its lagged values and a disturbance term.

In the strictly univariate framework of time series models other variables are not considered, specifically mathematic illustration of such models are as follows:

(1) $Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_p Y_{t-p} + \varepsilon_t$

where β_0 is an intercept, β's are unknown parameters to be estimated, p is lag period to be determined, and ε_t is disturbance term or so-called "white noise," which implies that it is not correlated with other error terms, has zero mean, and has a constant variance over time ($\sigma_e^{\,2}$).

These types of models are called autoregressive models, denoted by AR(p), where p is number of lagged periods used in the model.

Stationarity of time series data implies that the expected value of Y_t across time does not vary $E(Y_t) = E(Y_{t+k})$, variance of Y_t is $\sigma_y^{\,2}$ and it is also constant over time Var y_t = Var y_{t+k}, and so is the covariance between y_t and y_{t+k}, specifically COV (y_t, y_{t+k}) = COV (y_{t+m}, y_{t+k+m}), for any k, m, and t.

Unfortunately in real life time series are not stationary, i.e., as time goes by observations deviate from their historical mean. Such behavior is classified as non-stationary. The solution of this problem is that time series data can be differenced until we eliminate the non-stationary property in differenced series. If the series is differenced p times, it is said to be integrated to order P, I(P). Specifically, the first order integrated model would look like $Y_t = Y_{t-1} + \varepsilon_t$, if the error term exhibits random walk property, then the difference $\Delta Y_t = Y_t - Y_{t-1} + \varepsilon_t$, is the representation of the stationary time series with integrated order of 1 (Gujarati 2003).

3.2 Vector Autoregressive Model (VAR)

VAR, as an econometric modeling tool, was introduced to economists by Sims (1980). He suggested treating all variables in the model equally, without *a priori* distinction between exogenous and endogenous variables. The reason these types of models are called autoregressive is that on the right-hand side of the equation appear lagged values of a dependent variable, along with lagged values of other variables (a multivariate form of equation (1)).

In the VAR every variable is allowed to be influenced by every other variable with lags (Awokuse and Bessler 2003). Due to the freedom of *a priori* restrictions of such models, VAR is particularly important to unveil dynamic relationships between certain variables that may not be considered otherwise. This type of approach is helpful where expectations are considered. Time series behavior is frequently associated and explained as economic agents forming their prior expectations about the future. As expectations are related to recent and past observations, it is of vital importance to account for lagged variables.

In VAR, theory is used to select the variables studied. Theory is not used to zero-out or remove one variable as a "cause" of another variable, *a priori*. The main goal to develop such models is to let data reveal economic relationship themselves (Bessler 1984).

One way of formulating a VAR model is to assume it is stationary. Specifically, series is a weak form stationary stochastic process if it has constant mean and covariance through time (Gujarati 2003).

Another way of VAR modeling considers balancing in order of integration of series on both sides of the equation.

"Plausible principal of model formulation is that nonstationarities in the "explanatory" variable ought, if possible, to explain nonstationarities in the dependent variable." (Nerlove, Grether, and Carvalho 1979).

This last type of consideration does not assume stationarity in series rather in residuals. The idea is to have a balanced order of integration on both sides of the equation.

I (p) = I (p) + I (0)   {I (p) dominates}

The following equation corresponds to the generalized form of VAR representation:

(2) $$X_i = \sum_{i=1}^{k} B_i X_{t-i} + u_t$$

where X_t and u_t are random vectors with dimensions m x1, B_i is a coefficient matrix with an appropriate dimension. u_t is assumed to be a "white noise" i.e.

$E(u_t) = 0$

$\sum_u = E(u_t u_t^{'})$ for t=s (m x m positive definite matrix)

$= 0$ for $t \neq s$

According to Bernanke (1986), the observed innovations, u_t, can be modeled in terms of underlying “driving” sources of innovations. These driving sources of variation are orthogonal and can be written as

(3) $e_t = A\, u_t$

Zero restrictions on A are used to produce an identified structural VAR.

A VAR is considered not identified if in the m variable VAR model we have m(m-1)/2 parameters free. Doan (2000) suggests the following rule*: if there is no combination of i and j (i≠j) for which both* A_{ij} *and* A_{ji} *are nonzero, the model is identified.*

Innovation accounting techniques such as impulse response, forecast error decompositions, and historical decompositions are performed on a transformed VAR which has the following representation and is described in detail below.

(4) $$AX_i = \sum_{i=1}^{k} AB_i X_{t-i} + Au_t$$

Equation (4) is a representation having orthogonalized residuals, making interpretations easier than if non-orthogonalized innovations (residuals) are considered.

3.3 Testing for Stationarity

A test of stationarity is also referred to as a unit root test. If the equation is expressed in $y_t = \rho y_{t-1} + e_t$, where e_t is a stationary error term and $-1 \leq \rho \leq 1$. When $\rho = 1$, then the model becomes a random walk; thus, the series are non-stationary. If $|\rho| \triangleleft 1$, then we have a stationarity in series; thus, Y_t follow I(0) order.

The most commonly used test to check for stationarity are the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests. To perform the DF test, the simple Ordinary Least Squares (OLS) regression is performed of the following form: $\Delta x_t = \beta_0 + \beta_1 x_{t-1}$, Δx_t is the first difference (x_t-x_{t-1}).

The ADF test is performed on the following representation:

$\Delta x_t = \beta_o + \beta_1 x_{t-1} + \Sigma_{i=1}^{n} \alpha_1 \Delta x_{t-i}$.

The null hypothesis for the DF and ADF tests is that X_t is non-stationary (there is a unit root) in testing of the DF and ADF, H_0: $\beta_1 = 0$.

A Monte-Carlo generated critical value, at 5% significance level on the DF t-statistic is -2.89. If t-statistics of estimated β_i coefficients are less than -2.89, we have a stationary series, i.e., we reject the null hypothesis. This is a one-tailed test.

3.4. Innovation Accounting – Impulse Reponses

As estimated coefficients from the VAR models are difficult to interpret, and impulse response function via innovation accounting is usually used to study the dynamics of the model, specifically to observe how a one-time-only shock in the current innovation affects the whole system. To perform this type of analysis, it is important to present the estimated VAR in the Moving Average form. To trace out the effect of a one-time-only shock in an innovation term, we set all past and future X's and errors to equal zero, except those referring to current time of the variable being shocked. We set this equal to one (1.0). This type of representation allows us to see the dynamics exhibited by the estimated VAR model (Bessler, 1984). To investigate the effect of a one-time-only shock in an innovation, 0-1 simulation mechanism is being used, which assigns 0 to all past and future innovations and X's and 1 to the current X and innovation term. The response can be carried out iteratively in various time horizons.

It has to be noted that the results may not exactly ascribe dynamics embedded by certain variables in the model if we do not account for contemporaneous correlation among shocks in each series. Ignoring historical patterns of correlation would mislead our analysis.

Under ideal conditions we would like to see contemporaneously uncorrelated innovation terms, which implicitly assumes the variance-covariance matrix to be an identity. The orthogonalizing transformation of the variance matrix is used to obtain the form in which the condition stated above is guaranteed.

Under earlier VAR work, a Choleski decomposition was applied on an untransformed variance-covariance matrix (∑) (positive-defined MxM matrix), by finding a lower triangular matrix H of rank m such that

(5) $\sum = H\, H'$

where H' is a transpose of matrix H, diagonal elements of H matrix are greater than zero.

By performing pre-multiplication on both sides of equation (5) by H' and then post-multiplying it by $(H')^{-1}$, we get the following:

(6) $(H') \sum (H')^{-1} = H'\, H\, H' (H')^{-1} = I$

$\{(H')^{-1} = (H^{-1})'\}$

From this type of transformation, we have to find matrix A so that the new innovation term $e_t = A\, u_t$ has the variance-covariance matrix equal to identity (I).

The selection of A is such that $A=H^{-1}$, where H is a Choleski decomposition for the original variance-covariance matrix. Transformed form VAR is already presented above (see equation (3)).

To conceptualize, Choleski decomposition allows researchers to order series, which implies that series ordered first are causes in contemporaneous time of those ordered second, second-ordered series cause third-ordered series, etc. The Bernanke factorization, discussed below, allows researchers to relax the Choleski patterns.

Although if contemporaneous correlation between series is weak it implicitly reflect on weak causal relationship between series, if they are zero then ordering does not matter, if σ_{ij} is different from zero, then it is harder to identify the ordering of series.
In this context, if we have the strictly structural VAR, the economic theory is imposed to dictate existing contemporaneous relationships between variables.

The Bernanke factorization makes it possible to consider a more general pattern of causation between series. As already mentioned, factorization assumes modeling of observed innovations (e_{ij}) from VAR as a linear function of orthogonalized innovations (u_{ij}).

(7) $$\begin{bmatrix} u_{1,t} \\ u_{2,t} \\ u_{3,t} \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{bmatrix} \begin{bmatrix} e_{1,t} \\ e_{2,t} \\ e_{3,t} \end{bmatrix}$$

Bernanke's approach of identification looks for distinct, mutually orthogonal behavioral shocks that drive the model, and lagged relationships among the variables are not restricted. The "Bernanke decomposition" assumes an over-identified structure for the VAR innovations, and also requires a particular *causal ordering* on the variables. This imposition may itself be arbitrary in case theory does not give clear identification of causal structure (Bessler 1984). Recent innovations in DAG modeling can help in providing the causal-ordering behind the Bernanke factorization. A DAG-generated contemporaneous structure helps identify some type of causal inference through study of the variance-covariance matrix of variables. This will be discussed below.

3.5 Forecast Error Variance Decomposition

The forecast error variance decomposition procedure allows us to look at the variables in different time horizons. Based on the innovations of the series we can identify ones that have the most explanatory power over time.

Using a VAR representation of X series ($X_t = \Phi_1 X_{t-1} + \ldots + \Phi_k X_{t-k} + e_t$**),** if we assume that all future error terms are equal to zero ($e_{t+2}, e_{t+3}, \ldots = 0$), one can forecast values of X up to any time horizon in the future. The forecasted value in t+1 from current time (t) will be based on all possible available information, although as we proceed in time we use forecasted values as a proxy of the past information. When actual values are observed, we can estimate the fit of our forecast by differentiating forecasting and actual values of X, an estimated difference accounts for the forecast error (($X_{t+h} - X^f_{t+h}$) = forecast error at horizon h). If we reverse this type of judgment and present it in the Moving Average representation we can forecast future X by setting the forecast of future error term equal to zero;

(8) $$X_{t+h} = \Theta_0 e_{t+h} + \Theta_1 e_{t+h-1} + \Theta_2 e_{t+h-2} + \Theta_3 e_{t+h-1} + \ldots$$

Forecast of X in time t+h can be written as follows:

(9) $$X^f_{t+h} = \Theta_0 (e^f_{t+h} = 0) + \Theta_1 (e^f_{t+h-1} = 0) + \ldots + \Theta_k e_t + \Theta_{k+1} e_{t-1} + \Theta_{k+2} e_{t-2} + \ldots$$

where (e^{f}_{t+h} =0, h=0,1,2,...).

Subtracting equation (9) from equation (8) gives forecast error at time t+h

$FE_{t+2} = \Theta_0 e_{t+2} + \Theta_1 e_{t+1}$

This forecast is a moving average representation of order (h-1).

3.6 Directed Acyclic Graphs (DAG)

Directed graphs are a visual representation of a causal relationship between variables. It investigates non-time sequence asymmetry in such relationship. A formal description of DAG follows, which consists of ordered triple <V, M, E>:

V represents the non-empty set of vertices (variables)

M is non-empty set of marks (symbols that are assigned to the end of undirected edges.

E is the set of ordered pairs.

Each member in E is an edge; those vertices that are connected by an edge are adjacent.

Depending on the direction of the graphs, DAG can be sorted into the following categories:

(i) Undirected graphs that do not have an arrow, and thus do not indicate a specific direction of causation (e.g., A − B).

(ii) Directed graphs containing only directed edges (A → B)

(iii) Inducing path graph that has both directed and bi-directed edges (A ↔ B); and

(iv) Partially oriented inducing path graphs that have directed (→), bi-directed (↔), non-directed (o − o), and partially directed edges (o →) (Awokuse and Bessler 2003).

Directed acyclic graphs are based on the notion of conditional independence, which allows identifying common causes between variables or by conditioning, screen-off certain relationships that might be present.

(10) $$\Pr(x_1, x_2, x_3, ...x_n) = \prod_{i=1}^{n} \Pr(x_i | pa_i)$$

Pr is a probability operator for vertices x_1, x_2, … x_n and pa_i is a realization of some subset of variables that precede X_i in order (X_1, X_2, X_3, … X_n). Judea Pearl (1995) provided a thorough study on causal diagrams in *Biometrica*. He proposed the notion of d-separation so that the decomposition of conditional independence can be used to read off the graph.

Definition of d-separation:

Let X, Y, and Z be three disjoint subsets of vertices in a directed acyclic graph, G, and let *p* be the path between a vertex in X and a vertex in Y; "path" refers to any succession of edges regardless of their directions. Z is said to block *p* if there is a vertex *w* on *p* satisfying one of the following conditions:

(i) *w* has a converging arrow along *p* and neither w nor any of its descendants are on Z, or

(ii) *w* does not have a converging arrow along *p*, and *w* is in Z.

Z is said to d-separate X from Y on graph G ($X \perp Y | Z$)$_G$, if and only if Z blocks every path from a vertex in X to a vertex in Y.

As shown by Geiger, Verma and Pearl (1990) there is a one-to-one correspondence between the set of conditional independences, ($X \perp Y | Z$), implied by equation (10), and a set of triples (X, Y, Z) that satisfy d-separation criterion in Graph G. Specifically, if a set of vertex consists of A, B, and H vertices, the G implicitly assumes that conditioning on H, A and B are uncorrelated, this condition holds if and only if H d-separates them.

The exact notion of d-separation was incorporated by Spirtes, Glymour, and Scheines (1993) in PC algorithm using the notion of sepset to build Acyclic Graphs.

Notion of sepset refers to the (those) conditioning variable(s) that remove(s) edges between two adjacent variables in the vertex set V. Removal of edges are done sequentially based on zero correlation and partial (conditional) correlation. If we have the triple in the vertex set V (X, Y, Z), these vertices have edges between them, but not necessarily directed:

X −Y −Z, X and Y are adjacent in such set and so are Y and Z, but X and Z are not adjacent.

Y is not sepset if edges are arrowed to Y both from X and Z

(11) $X \rightarrow Y \leftarrow Z$

When we have the following structure where $X \rightarrow Y - Z$ (X and Y are adjacent, Y and Z are also adjacent, X causes Y, but Z is not arrow headed to Y). This type of form implicitly excludes the option from equation (11), where Z can possibly cause Y; this logical inference leaves us only with direction $Y \rightarrow Z$, so that the final causal form would be: $X \rightarrow Y \rightarrow Z$.

When this relationship is investigated empirically, we test hypothesis whether conditional correlations between variables are significantly different from zero using Fisher's *z* statistics, where *z* is defined as $z(\rho(i, j/k)\ n) = ½\ (n - |k| -3)^{1/2} ln\ \{(|1 + \rho\ ((i, j/k)|)\ (|1- \rho\ (i, j/k)|)^{-1}\}$, n refers to the number of observations used to estimate correlations; *ρ (i, j/k)* is a correlation between series *i* and *j* conditioned on series *k*; conditioning on k correlation between *i* and *j* series is removed; and |k| is the number of variables in *k*.

If distribution of *i*, *j* and *k* are assumed to be normal and *r(i, j /k)* is a sample correlation between *i* and *j* series conditioned on *k* , then *z(ρ(i, j/k) n) - z(r(i, j/k) n)* is standard normal (Awokuse and Bessler 2003).

Type I and II errors in PC algorithms are associated with the fact that the causation and/or direction of arrows can be excluded when they should be present. Spirtes, Glymour, and Scheines (1993) have investigated the probability of the presence of these types of errors, as they suggest chances of errors are quite small. However, if the sample size is small (less than 200 observations), then there is a considerable chance of an error; it would omit edge when it should not. The error related to arrowheads is more probable than incorrect edges between vertices. As a result, they have suggested decreasing significance level for big samples and increasing it for a small sample size. Typically, it is recommended to use 10% significance level for sample size consisting from 100 to 300 observations, 20% for that of less than 100 (Spirtes, Glymour, and Scheines 1993).

Advantage of using DAG for a VAR identification is a notion of freedom from *a priori* restrictions. This type of analysis allows us to compare results revealed by data to those dictated by a theory (structural model).

3.7 Number of Appropriate Lags in VAR Models

It is important to choose the correct number of lags in the VAR. In general, lags can go in length infinitely, but as time goes back the explanatory power of remote lags diminishes. Also, including too many lags reduces degrees of freedom in our models. The selection of optimal number of lags is determined by various statistical tests.

One of the approaches for lag identification is the use of the Likelihood ratio test. $L(k) = (T-c)(\log|\Sigma k-1| - \log|\Sigma k|)$; $k = 0, 1, \ldots, K$, where Σk is the variance/covariance matrix of residuals from a VAR with k lags; T is the number of observations; C is a small sample adjustment equal to the number of right-hand side variables in each equation of the VAR; "log" is the natural logarithm; and K is the maximum lag *a priori* suggested by a theory.

The null hypothesis for the likelihood ratio test is that the parameter associated at lag k is not statistically different from zero. We reject the null hypothesis for the high value of L (k) (it is distributed Chi-squared with two degrees of freedom). 1% significance level is suggested for this test (Sims 1980).

Loss functions are also used to identify lags in univariate and multivariate models, Schwartz loss function (SL) and Hannan and Quinn's M measure are more recommended by authors.

$$SL = \log|\Gamma| + (m\times k)(\log T)/T$$

$$M = \log|\Gamma| + (2.01)(m\times k)(\log(\log T))/T,$$

where Γ is the error covariance matrix estimated with k regressors in each equation, T is the total number of observations on each series, and in practice SL is used for large samples (Schwarz 1978). SL is computed for various lags and the one with minimum value Schwartz loss function is selected.

CHAPTER IV

RESULTS

4.1 Data

Annual data for seven U.S. states (CA, GA, IA, KS, NY, OH, TX) farmland values from 1950 until 2003 was provided by ERS, USDA. Average U.S. level data was also obtained from ERS, U.S. dataset covering the period from 1960 to 2003. Imputed returns to farm assets have been used (source of USDA).

Specifically, total net returns to farm assets has been derived as a sum of returns to asset and total real capital gains on farm assets. Individually, net returns to assets and total real capital gains on farm assets have been computed as follows:

Total real capital gains on farm assets equal Real capital gains on farm physical assets plus Real capital gains on farm financial assets.

Returns to farm assets equal Income returns to farm assets and operators' labor and management,[1] plus Net rent to nonoperator landlords,[2] plus interest on real estate debt,[3] plus interest on nonreal estate debt, minus interest on operator dwelling, minus

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[1] Ken Erickson, * Returns to operators is similar to net farm income, with only one difference. The NFI measures the net income generated from the farm business AND the operators on farm dwelling, while returns to operators measures the net income generated by the FARM BUSINESS. The difference between NFI and RETOPER is the amount of net income attributed to the farm operator's dwelling. Both the gross income and expenses for these accounts differ only by the income or expense for the farm operator and other farm dwellings. */

/* Returns to operators = gross receipts of farms (excluding)
- nonfactor payments
- factor payments */

[2] Including government payments, capital consumption, and operator dwellings.

[3] Inclusion of interest paid on farm debt is justified by the fact that returns refer to assets not to equity (Melichar 1979).

imputed returns to operator's labor,[4] minus imputed returns to management.[5]

Land values refer to farmland and building value per acre. Both land value and returns to asset (net return) have been deflated using the GDP deflator.

Debt to asset ratio figures were obtained from the Economic Research Service (ERS), USDA. These figures refer to the ratio of farm accumulated debt to farm asset value. Farm Acreage and GDP deflator was also obtained from ERS, USDA. The 10-Year Treasury Bond rate was obtained from the website of the Financial Forecast Center (http://www.forecasts.org/data/index.htm). There is non-uniqueness in arguments regarding considering different interest rates. They all have their disadvantages and advantages. Researchers do not agree on choosing interest rates; some consider municipal bonds rates, while others give priorities to Moody's AAA, etc. The preference for the 10-Year Treasury Bond rate is primarily because of its matching maturity of farm real estate loans. All data are in Appendix D.

The primary reason for selecting five variables in addition to land values for study was the recommendations of previous researchers, who have used the same methodology to study farm asset dynamics. Awokuse and Duke (2006) suggest future study to focus on a small set of variables, arguing that additional variables do not fulfill the model rather, they induce spurious results.

It has been a challenge to develop an aggregate measure for urban influence relative to the increasing demand of land for development and recreational purposes.

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[4] (labor hour X wage rate

[5] [0.05*(crop receipts + livestock receipts + government payments - feed purchased - livestock and poultry purchased)].

The majority of previous studies concerned with this issue have failed to find a close proxy. The most commonly used measure of population density not only results in insignificant effect but fails to capture a growing concern of urbanization and commercial development (Awokuse and Duke 2006). Thus, we do not pursue analysis with population density. Basic summary statistics for each series, as well as statistics of residuals from levels VAR model in all seven U.S. states and an aggregate U.S. level, are provided in tables B.1. & B.2., respectively (see Appendix B).

4.2 Testing for Stationarity

VAR in levels were fit separately to investigate the relationship between land values (in real terms), farm acreage, real returns to farm assets, debt-to-asset ratio (D/A ratio) and interest rates in seven (7) U.S. states as well as in the U.S. aggregate measurement.

Before any autoregressive applications, the tests for stationarity were performed on each series. Both Dickey-Fuller and Augmented Dickey-Fuller tests were conduced on all series. Because of inconsistency in results in both tests and variation between series, VAR was performed on undifferentiated series (Levels Lagged VAR) and residuals were checked for stationarity (Nerlove, Grether, and Carvalho 1979). Computed t-statistics for all original series and residuals from VAR are provided in Tables B.3. and B.4., respectively (see Appendix B). The residuals were obtained from the three lags of level VAR. Estimated t-statistics for all residuals are less than t-test critical value for DF test (-2.89). This allows us to perform a VAR analysis in levels.

The values of variables were normalized due to the huge difference in variations in the series and difficulties to plot impulse function representations on a same scale chart.

Schwarz criteria was used to investigate the lengths of appropriate VAR lags. Summaries are provided in table B.5. in Appendix B, along with Akaike and Phi information. The lag corresponding to the minimum number of Schwarz loss is usually suggested to determine number of lags in the series. The results indicate a single lag VAR resulting in the lowest Schwarz loss in all seven states and U.S. data. However, as has been found and discussed in previous literature (Hsiao 1979), we want to guard against under-fitting. The number of lags suggested by minimum Schwarz criteria for small sample size may be under-fit so three lags were selected to guard against biased estimators. The consequence of fitting too small a model results in bias, while the consequence of over-fitting is inefficiency. Since analysis is performed on a small sample size, the choice has been given to the latter direction (Hsiao 1979).

Results for R^2 and Durbin-Watson (DW) statistics are provided in table B.6. in Appendix B.

4.3 Results of F-tests from VAR

The results of VAR estimation corresponds to the normalized original series and three time lags of modeled variables. As suggested by Sims (1980), interpretation of the VAR estimated coefficients is difficult; therefore, we provide F statistics from VAR models to show effects of lagged variables on individual series (see tables B.7.-B.14., Appendix B).

As can easily be detected, farmland values are almost exogenous in the seven states and an aggregate U.S. analysis. Land values are almost always determined by their lagged values. A few exceptions have been identified. At the 5% significance level, farmland values in NY are influenced by lagged D/A ratio, by interest rates in Georgia, and by real returns to farm assets in Iowa. Returns appear to affect farmland values in Ohio, if the significance level is increased up to 10%. In Kansas, lagged values of farm acreage influences farmland prices at α=10%. The TX, CA and U.S. aggregate farmland value analysis does not exhibit any strong influence of lagged values of variables in the model except for itself. Results from the major agricultural states (KS, IA, GA, OH, NY) show some significance of primary determinants (returns to farm assets).

Perhaps part of the reason CA and TX did not show results similar to other states is because other factors affecting farmland prices are not considered in this analysis. For example, in California omitted variables may be speculative forces, urbanization, and commercial development; whereas in Texas omissions may well be factors related to cattle farming or considerations of energy sector and urbanization.

Other than the lagged figure of farm acreage, current farm acreage numbers are affected by lagged values of real returns to farm assets (CA, GA, IA, USA), as well as lagged value of farmland prices (GA, KS, NY, USA). USA aggregate analysis shows the farm acreage to be significantly affected by interest rate, at the 5% level. Farmer decisions related to farm acreage are greatly determined by the prices they have to pay for land, as well as expected returns on farm assets acquired (capitalization framework approach).

Real returns to assets appear to be completely exogenous at the aggregate U.S. level and are not influenced even by their own lagged values. A similar pattern has been detected in Texas. This behavior may be explained by the unobservable nature of future farm returns.

However, several states show a significant effect of lagged farm acreage on returns to assets (CA, GA, IA, KS). Lagged farmland values are also significant determinants of returns to farm assets in GA, IA, NY, and OH. This latter result is reasonable as capitalized gains from owning a certain acreage of land are captured in the returns to farm assets. Lagged Interest rates affect returns in CA at the 5% significance level; whereas the lagged D/A ratio is significant in NY and IA, at the 5% and 10% significance levels, respectively.

Debt-to-asset ratios are exogenously determined in three states (CA, IA, and KS). The importance of lagged interest rates, along with their own lagged values, co-influence D/A ratios in GA, NY, OH, and USA data. Although in OH the lagged value of interest rate and D/A ratio, along with lagged farm acreage and returns, have shown a strong influence at the 5% and 10% significance levels, respectively. In Texas, a slightly different pattern has been detected. The D/A ratio is determined by lagged farm land prices along with lagged D/A ratios, at α-level of 10%.

Interest rates are influenced by lagged values of other proposed variables. One might not consider analyzing the model generating their current values as agriculture has a small proportion in the U.S. economy. However, as has well been documented in several research papers, the price index of agricultural and mineral commodity has been observed in predicting monetary condition in the economy (Frankel 2006).

4.4 Directed Acyclic Graphs Results

The innovations (residuals) from the estimated VAR can be used to study contemporaneous information flow among our five variables.

Several assumptions and restrictions have been imposed on the DAGs, primarily caused by the difficulty of identifying the contemporaneous causal-effect pattern across states. First, interest rates were assumed to be completely exogenous, followed by so called 'second-tiered' variables (returns from farm assets, acres, and D/A ratio). These variables were treated as exogenous variables when referring their relationship to farmland values. However, interest rates were permitted to affect these 'second-tiered' variables. The results reported here are based on the 20% significance level, as recommended by Spirtes, Glymour, and Scheines (1993). The results are given in figures C.1.-C.8., Appendix C.

D/A ratio is identified in the cause-effect relationship contemporaneously affecting farmland values. Except for New York State, the rest of the states considered in this research and the U.S. aggregate analysis show strong evidence that the D/A ratio is a primary determinant of farmland values. These results further confirm the research by Mishra, Moss, and Erickson (2007) regarding the debt-servicing ratio's influence on farmland values.

In Georgia, real returns to farm assets, acres, and interest rates influence farmland values indirectly through their effect on D/A ratio. A slightly different pattern is depicted in the DAG model found for Texas. Specifically, interest rates directly influence farm asset values, further influencing D/A ratio along with returns to assets and acres.

In Ohio, farmland values also exhibit indirect effects of interest rates via D/A ratio. Analysis of aggregate U.S. data shows D/A ratio and interest rate both directly influence farm asset values in contemporaneous time. CA and IA show a similar pattern of D/A ratio directly affecting farm asset values, and interest rates affecting returns to farm assets and D/A ratio. Similarly, in IA, interest rates directly influence farm asset values. KS also shows independent effect of D/A ratio and interest rates on land values. Farm returns and D/A ratio show an unidentified relationship, which can be partially explained by the small sample size.

As mentioned above, NY is the only state where the D/A ratio does not influence land value in contemporaneous time. Quite interestingly, it is the only state where acres appear to be an important determinant of farmland prices along with interest rates.

The results from DAG can be justified by the economic relationship between variables. The significant importance of D/A ratio is not surprising due to the increasing effect of credit constraints captured by this indicator. Debt and asset values identify sector solvency and financial condition of the farm. In fact, asset values considered in D/A ratio already encompasses returns to asset and capital gains holding them. Although returns to assets have been considered as a fundamental contributor to farm asset values, generally its importance is largely cited when long-run market equilibrium is considered (Schmitz 1995). The contemporaneous relationship is weak between these two variables, perhaps because actual returns are not realizable until a future time. However, as stated above, their contemporaneous effect has been carried over into the D/A ratio.

The effect of interest rates on asset values as a measure of cost of capital also confirms the economic rationale behind its relationship to farm assets. It is tied to credit constraints and financial conditions. The size of interest rates determines farmers' wealth and affects future investment decisions.

A U.S. aggregate analysis and that of four (4) states (TX, NY, KS, IA) finds interest rates to be a strong direct determinant of farm asset prices in contemporaneous times. In the other three (3) states, interest rates have an indirect effect on farm values through their effect on D/A ratio.

4.5 Impulse Response Graphs Results

Impulse response graphs depict responses of variables to a one-time-only shock in the innovations of a selected variable in the model. As my primary interest is in farmland values, it is essential to investigate how, on average, farmland values react to shocks in all right hand side variables in the model. In addition, the responses of other variables are of great interest and worthy of consideration. The impulse graphs for all seven states and US aggregate are provided (See figures C.9.-C.16., Appendix C).

As depicted in figure C.9.-C.16., land values respond positively to a one-time-only shock in land value innovations. They deviate from market equilibrium, on average, for ten years. Initially, they exhibit a gradual increase for three years, sustain increased prices up to six years, and then show a slow decrease. TX is the only state analyzed here that shows a 15-year departure of land prices from its equilibrium level. NY shows an instantaneous increase with sustained prices for three years, and a gradual descent for two years to its market equilibrium in the fifth year.

Farmland values respond negatively to a one-time-only shock in acres. CA and TX farmland values individually exhibit a slightly positive response for the first five years, then slowly turn negative. NY is the only state where a shock in farm acreage causes land values to increase. Data indicate that it takes around eight years until prices get back to equilibrium, followed by a negative response.

Except for three (3) states, land prices respond positively to shocks in real farm asset returns. The increase is sustained for an average of 11-13 years until prices return to the pre-shock level. Land prices in NY respond negatively to a one-time-only shock in innovations of returns, and CA and TX also show a negative, but negligent response.

The results are particularly interesting with a one-time-only shock in innovations in D/A ratio, since prices respond negatively to a shock in this ratio. The majority of states and U.S. aggregate data reveal a similar pattern. Misha, Moss, and Erickson (2007) argue that if there is not a corresponding increase in income, relative to an increase in agricultural debt, this simply implies increased bankruptcy risk. The latter conditions may urge bankers to raise interest rates charged on debt and, as a result, farmland values decline. However, a negative response does not last longer than 4-5 years, after this asset value turn returns to a positive value responding to a shock in D/A ratio. Another argument can be used, it is generally presumed that appreciated values of farmland serve as collateral for banks to finance farming, i.e., increase a total dollar amount of debts (Schmitz 1995).

The U.S. aggregate picture shows that restoration of land price equilibrium is delayed several years following a shock.

Farmlands in NY have a slightly positive response to a shock in D/A ratio and are quickly restored to equilibrium before turning negative.

Farm asset prices also respond negatively to a shock in interest rates. GA, NY and the aggregate U.S. graphs show that since a shock causes prices to deviate a great deal from historical values and is sustained for a long period of time. KS and OH exhibit a negative response changing to positive only after ten years. Land prices in TX have a dampened but positive response, gradually decreasing until equilibrium is restored. TX is the only state where a negative effect was not detected. This last result may be due to the fact that Texas land has considerable oil and gas reserves and increasing interest rates change the rate of usage of storable resources.

Increase in interest rates implies a reduction in capital asset values; however, it has to be noted that because of the non-liquid nature of farm assets, its response to a change in interest rates is not as spontaneous (prompt) as with other financial assets (stocks, bonds, etc.). But as 10-year Treasury Bond rate proxies an average interest rate on agricultural debt, then their inverse relationship clearly describes financial contraction caused by an increase in risk.

4.6 Forecast Error Variance Decomposition Results

Forecast Error Variance Decomposition (FEVD) is an alternative way of looking at relative effects of variables in the model that contribute to a certain degree of variation in the variable of interest. The standard error of the forecast is decomposed at a specific time horizon in percentage terms of past innovations of each series in the VAR. Specifically, in the framework of this research, FEVDs look at forecast error decomposition in land values, acres, returns to farm assets, D/A ratio and interest rates. Although the output of shocks is generated for 26 years, only zero to six years are presented here. Zero (0) refers to the contemporaneous time, whereas years 1-6 are associated with year 1 through year 6 time horizons. Due to the nature of this research, consideration of 0 and 1 time horizons offers a picture for contemporaneous and short-term casual-effect relationships. At the same time, looking at 5-6 years provides an alternative outlook for the possible long-term behavior of prices and other variables. The results are different, yet similar in some ways, from state to state. Regardless of the exogenous nature of land itself reflecting in its quality, location, etc., the results are generalized across states and, consequently, comparisons to U.S. aggregate results are presented.

The empirical results of forecast error variance decomposition are consistent with the results obtained above. Specifically, in regards to contemporaneous time, we see similar patterns. Besides land value itself, D/A ratio appears to contribute a significant portion of the variation in land prices.

Land value itself explains changes in its forecast error variance as low as 21.06% in an aggregate U.S. data to as high as 86.05% for New York. In Iowa and Texas, land value accounts for nearly 50% of explanatory power with other variables proposed. The results are presented in tables B.15.-B.22., Appendix B.

In Kansas and in Ohio, D/A ratio explains more than 50% of variation in farmland price uncertainty, 57.11% and 55.78%, respectively. Standard errors in U.S. aggregate land values have also been identified by D/A ratio (51.22%). The lowest percentage of D/A ratio has been detected in Georgia, 13.67%, if not counting New York, where D/A ratio has a zero (0) value contribution in farmland value variations in contemporaneous time.

Farm acres and returns to assets contribute very small percentages to land variance decomposition. Returns from farm acreage account for around 2% of variation in land value in only Georgia, Kansas, and Texas; whereas acreage explains land value variation in New York by 7.92%, in Texas 3.16%, and 0.56% in Georgia.

Interest rates are the third greatest contributor of land value forecast errors, after the effect of land value itself and D/A ratio. U.S. aggregate data show it to be the second largest contributor after D/A ratio, attributing 27.73%. Iowa and Texas farmland values have been greatly influenced by interest rates (approximately 12%); California exhibits the lowest share of interest rates of all the states presented here (1.54%). In New York, where variations in farmland values have been almost exogenously explained by land values (86.05%), interest rates share half of the remaining variation with farm acreage.

The results of one-year horizons slightly defer from the contemporaneous analysis, with each of the variables exhibiting incremental increases in percentage.

Farm asset returns appear to contribute more to land values as time increases, although results still show D/A ratio and interest rates as the major contributors to uncertainty in land values. In a six-year time horizon, as depicted in tables B.15.-B.22., Appendix B, farm asset returns explain 25% of the variation in forecasts of Iowa land prices; around 10-11% in U.S. aggregate data, for Ohio and Kansas. In Georgia, farm asset returns contribute only 8% of the uncertainty in land value. Texas and California exhibit the lowest percentage of returns, approximately 0.5%. Farmland values in New York do not appear to be greatly explained by returns either, although this share (3.14%) is larger than that found in TX and CA.

In the long run (six years), acreage and interest rates show increasing importance; whereas the D/A ratio shows a decreasing influence. In USA aggregate analysis, the latter's share in year 6 drops from 51.22% in year 1 to 12.55%. The relative decrease is similar in other states where D/A ratio appeared to be dominant in the first few years. New York is still the only state where D/A ratio play almost no significant role in land value variation regardless of the time span.

While D/A ratio declines in relative importance, interest rate gains importance in its percentage contribution to variations of farmland prices. In some states, the increase in interest rate's share is particularly huge. In New York, interest rate's share increases up to 47.60% at the end of period 6, from as low as 6.03% in contemporaneous time. In Georgia, this swing is from 3.33% to 48.05%. Interest rates in Iowa, Ohio, and Texas indicate very consistent shares in farmland variation, on average explaining 10% of it at any time horizon presented here.

California and Kansas also show a small but continuous increase in interest rate's share of forecast uncertainty in land values, although its relative share still remains low in both states [CA – 1.54% (contemporaneous), 8.90% (6-year horizon); KS – 3.77% (contemporaneous), 6.62% (6-year horizon)].

The U.S. aggregate picture shows an increasing pattern in the share of interest rate on land values. An increase occurs in the third year; years 3 to 6 show slight changes. From 27.73% of explanation in contemporaneous time, interest rates contribute up to 48.84% in farmland price variation at the end of year 6.

Changes in farm acreages appear to be primarily exogenous in contemporaneous time, slowly being influenced by other variables, mostly farmland values, interest rates, and returns throughout the next six years. In most states, acreage itself explains most of variation, except for New York, where at the end of year 6 horizon, interest rates explain 25.11% of farm acreage variation. Although the other six (6) states analyzed here do not exhibit the pattern as seen in New York, U.S. aggregate results are consistent not only with that of New York, but also shows a completely different pattern. Starting from year 1, variation in acreage is shared with the D/A ratio (31.88%); along with past acreage (59.34%), interest rates, and land value, explaining about 4.5% each. As the time horizon increases, the share of farm asset return increases. In fact, starting from year 3, as shown in U.S. aggregate analysis, returns explain 41.03% up to 58.07% (year 6) of farmland acreage variations, jumping basically from zero contribution in the contemporaneous time. The relative importance of debt-to-asset ratio in explaining acreage decreases from 31.88% (contemporaneous) to 13.89%, and interest rates explain up to 5.5% at the end of year 6. Land values determine 6.89% of acreage variation and acreage itself decreases noticeably from a highly exogenous indicator (100% - contemporaneous) till 15.74% in the 6-year time horizon. These results practically indicate how the decision related to farm acreage is strongly tied to land values, availability of credit, and returns to farm assets.

Forecast error variance decomposition in real returns to farm assets shows a very similar pattern in all seven states, as well as U.S. aggregate data. Specifically, real returns are explained by interest rates; in some states by D/A ratio, small portions of unexplained variation is being attributed to farmland values and farm acreage. The rationale behind these types of results are easily justifiable by economic theory. A 10-year Treasury Bond rate, as a proxy for the cost of capital imitating the interest rates on farm accumulated debts, determine the size of this ratio (via the effect on farm accumulated debt and asset value).

As can be noticed from the results of U.S. aggregate analysis, in the year 6 time horizon, returns themselves explain 68.14% of variation, interest rate – 16.49%, and land values and D/A ratio sharing 6.19% and 7.36%, respectively.

Interest rates are exogenous over the first few years, as forecast error variance in interest rates are primarily attributed to interest rates (their previous errors). The relative contribution of other variables in the explanation of interest rate’s error variance is shared by land values at the longer horizons. This was discovered in several states, as well as for the U.S. as a whole.

To conclude, the results generated by the VAR Forecast Error Variance Decomposition for different time horizons once again confirm increasing and dominant power of debt and interest rates to land values. The results from Error Decomposition are consistent with those depicted by DAG and impulse response function.

Due to the difference in imputation procedures of variables, as well as variation in applied methodology, the results obtained were not expected to be exactly the same in numbers as those of other research papers. They are easily compatible with those that have questioned a traditional asset pricing model and have provided some evidence of its weak power in explaining farmland prices (Falk 1991; Schmitz 1995; Featherstone and Baker 1987; Mishra, Moss, and Erickson 2007).

It is of great interest to compare the findings of this research with the results of he research paper by Awokuse and Duke (2006) about the causal structure in land price determinants, since it employs the exact methodology. A significant difference between these two papers is the inconsistency in imputing returns to farm assets, as well as number of variables used in analysis. Their analysis of U.S. and Kansas data finds strong evidence of a direct effect of farm debts on farmland values, although it differs from this thesis in finding a direct contemporaneous cause between returns to farm assets and land prices (returns causing prices). Inflation and acreage appeared to be indirect contributors of land prices.

In our research Kansas, farmland values were directly affected by D/A ratio and interest rates. Returns have appeared to have an indirect effect (in some cases unidentified because of the sample size) via D/A ratio. The results from U.S. data were similar to Kansas State.

A parallel can be drawn with the findings of Featherstone and Baker (1987), although they only considered fundamental variables (returns and interest rates). Their VAR analysis suggested that farmland values tended to deviate from fundamental determinants and that these deviations were attributed to other variables, not considered in their analysis, but suggested (debt, inflation, etc.).

The significant importance of D/A ratio is consistence with the findings of Mishra, Moss, and Erickson (2007). They consider an extensive effect of financial condition on farm asset values and their significance during the boom-bust cycles in farmland history.

Just and Miranowski (1993) also have placed great weight on the importance of interest rates, debt, and inflation during that time as specifically evidenced in the state of Iowa. Schmitz also considers debt constraints to be a primary determinant to erratic price swings, which prevailed in Canada in the 70s and 80s. Easy credit amounted to an increase in wealth without an appropriate increase in net farm income, which inherently resulted in appreciation in farmland values. In this context, net farm income as a fundamental determinant of farm prices is not as dominant as we thought before we conducted this study.

CHAPTER V

DISCUSSION AND CONCUSIONS

From the analysis performed in this thesis and from the theoretical framework of farmland valuation, one conclusion can be easily drawn. The literature on farmland is mixed on explanations of why farmland values change. This is a complicated area in which a consensus in results is a challenge to achieve. One might explain difficulties by the fact that empirical estimation, measures, and methods differ across states by a dynamic evolution and integration of other sectors of economy that have a direct affect on agriculture.

Limitations of the traditional Present Value Model that uses returns to farm assets and interest rates have been confirmed several times, primarily by those researchers that employed time series analysis of fundamental components (Featherstone and Baker 1987; Falk 1991; Schmitz 1995; etc.). This thesis is in accord with these authors. However, it offers an alternative estimation tool (DAG) to unveil contemporaneous causal-effect relationships prevailing and revealed in the data.

In most dynamic analyses, farmland prices favor fundamental determinants (returns to farm assets) in a long-run horizon. However, the relationship between returns and farmland values is not always identifiable when viewed in the short run (Schmitz 1995). Importance of farmland to agriculture as the major capital asset is unquestioned. Due to its increasing importance, the dynamic of farmland prices is a subject of much research and investigation.

Unfortunately, attempts to understand the behavior of farmland value are still obscure. Differences in explanations found by researchers cause repeated revisions in methodological approaches, variables used, and extended time spans. Recent findings that incorporate consideration of non-fundamental factors (macroeconomic or financial variables) have offered a significant improvement and progress in modern analysis (Awokuse and Duke 2006; Mishra, Moss, and Erickson 2007; Schmitz 1995).

The research methodology utilized in this thesis does not claim to be unique, nor does it attempt to fully describe farmland value dynamics. An advantage of the proposed analysis is that relationships between variables are mitigated by data without *a priori* restrictions. Because of the lack of these restrictions, quantitative results and their magnitude are different from results found in previous research. However, a general path of perceived farmland valuation has been found. Specifically, in contemporaneous time the DAG graphs indicate debt to asset ratio causes farmland values. Interest rates also cause farmland values. With a few exceptions, interest rates and returns to farm assets indirectly affect land values through the D/A ratio.

The importance of the debt to asset ratio in farmland pricing is a particularly valuable finding of this research. The effects of macroeconomic variables over a longer horizon via the interest rate, is also a strong result of this study.

Real returns to farm assets do not appear to be a driving force in several of the states analyzed. Real returns to farm assets certainly play an important role in determining land prices in the major agricultural states such as Iowa, where it explains 25% variation in farmland prices. Further, the numbers for Georgia, Kansas, and Ohio are around 10% each. Real returns explain about 11% of farmland values across the United States. The importance of fundamental determinants has been identified in a longer time horizon. Interestingly, neither California, Texas, nor New York have shown to be greatly affected by fundamental contributors. This can easily be understood by other relevant factors found in these states besides those considered here. For example, California has shown great dependence on farm solvency condition as identified by Debt to Asset ratio regardless of the time horizon. Interest rates are greatly dictating agricultural land prices in New York. Texas farmlands exhibit a distinctive exogeneity from all the variables suggested; 78% of land price variation for long-term horizons have been determined by farmland value itself; with interest rates and debt to asset ratio sharing the remaining small percentage. Ohio is the only state where farm acreage determines land prices in the long run. The primary reason that state results are not completely consistent with each other is attributed to huge variations in their farming nature and economic situation in the separate states.

This thesis was designed to generate and interpret results under the same approach for each individual state. Peculiarities and idiosyncratic elements relevant to each state were not considered. In this context, it would have been relevant to generate a proxy for a variable that could closely describe the increasing pressure of urbanization, commercial development, and other speculative forces in California. Similarly, one should consider the cattle farming dominance over crop production in Texas.

Some of the inconsistency in answers, as well as irregularities in the behavior of different variables unveiled by various techniques employed by VAR (Impulse Response

Functions, Forecast Error Decomposition), can be attributed to the limited number of observations. Dynamic structure of relationships is not easily detectible with a small sample size. For these reasons, results from these analyses might be somewhat misleading.

We can clearly draw a pattern that has been dominant in all seven states as well as in the U.S. aggregate analysis. Land prices have been greatly dictated by their lagged values, which as suggested by Featherstone and Baker (1987) is due to overreactions in prices.

As depicted by impulse response graphs, positive shocks in farm acreage have resulted in reduced farmland values in all cases considered. This draws our attention to several factors. Increased land supply implies reduced prices; however, this might not have significance on farmland, because of an inelastic nature of farmland supply. Inverse relationships of farm acreage and values could be discussed in relationships with returns to farm assets. Increased acreage corresponds to increased supply of crops produced, which further results in a reduction in the value of market-driven returns. Farmers' perception of lower returns capitalized in the present value of farmland reflects in lower land values (Phipps 1982; Melichar 1979). Farming decisions are greatly dictated by economic factors. Lower gains decrease interest in farming, demand for land decreases, and as a result prices for land drop. In fact, many government programs have been designed to decrease farm acreage in order to boost market return and improve economic welfare of farmers (Gardner 2003).

The debt to asset ratio has been identified as a major contributor to farmland price movements not only in a contemporaneous time, but in most cases, at relatively longer time horizons. Quite interestingly, farmland prices respond similarly to positive shocks in the D/A ratio in all seven states, exhibiting an initial negative response, turning positive, and eventually returning back to equilibrium. Mounting importance of debt has drawn the attention of several researchers studying farm dynamics, especially after agreeing on a propensity of farmland markets to fads and/or bubbles. Their importance has been highlighted in the works of Schmitz, Mishra, Moss, and Erickson, Just and Miranowksy, Awokuse and Duke, as well as others. Certainly, farmlands are major collateral for agricultural loans; therefore, its value is an important determinant for the financial status of farms. Depending on the size of a debt to asset ratio, banks decide whether to increase or decrease financing agricultural businesses via manipulation of interest rates.

10-Year Treasury Bond rate, as a measure of cost of capital, has also been a big contributor of farmland prices in all seven states and the United States as a whole. As mentioned earlier, the agricultural sector suffers severely in its ability to attract external sources of funding. Debt is a significant source of funding for most agricultural businesses. Changes in interest rate affect farm financial conditions. Increase in debt increases default risk, and consequently reduces farm asset values (Mishra et al. 2007). Farmland that comprises approximately 70% of farm assets is particularly affected by macroeconomic variables. The dynamic integration of markets in a modern economy impacts business decisions between farming or more profitable sectors of the economy.

Due to the limitation of data of urban pressure on farmlands, this aspect of the problem was not considered in this analysis. The decision has partially been made based on recommendations by Awokuse and Duke (2006). As a result of their research, population density was not statistically significant for U.S. and for the state of Kansas. Consequently, population density was not studied here.

A more thorough analysis is suggested over an extended time period and inclusive of more states to investigate whether similar patterns are identifiable in other U.S. states. It is believed that a proxy should be developed for urbanization/commercial development pressure of farm sectors in highly urbanized states. It would be interesting to conduct VAR and DAG analyses on panel data for all U.S. states considering both fixed and random effects models for each state.

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APPENDIX A

ABBREVIATIONS and ACRONYMS

U.S. states:

CA – California
GA – Georgia
IA – Iowa
KS – Kansas
NY – New York
OH – Ohio
TX – Texas
USA – United States of America

Acronyms of Variables Used in Tables and Graphs:

VAL = LVALUE – Farmland Value (in real terms)
ACRE = Farmland Acreage
RA = RETURN(S) – Real Returns to Farm Assets
DA = D/A RATIO – Debt-to-Asset Ratio
INT = INTRATE – 10-Year Treasury Bond Rate

Technical Terms:

PVM – Present Value Model
VAR – Vector Autoregression
DAG – Directed Acyclic Graph
FEVD – Forecast Error Variance Decomposition
DW – Durbin-Watson
DF – Dickey Fuller
ADF – Augmented Dickey Fuller
SIC – Schwarz Information Criterion
AIC – Akaike Information Criterion
Phi – Hannan and Quinn Criteria

APPENDIX B

Table B.1. Summary Statistics for Original Series of Farmland Value, Farm Acreage, Returns to Farm Assets, Debt-to-Asset Ratio, Interest Rates in 7 U.S. States (1950-2003) and Aggregate USA (1960-2003)[6]

LVALUE	CA	GA	IA	KS	NY	OH	TX	USA
Mean	22.30	11.43	17.18	6.49	11.52	18.34	6.19	9.77
Std Dev	6.52	5.42	7.04	1.97	3.41	6.52	1.84	2.40
Skewness	0.12	-0.10	1.55	1.26	-0.54	0.75	0.04	0.48
Kurtosis	-0.75	-1.02	1.64	0.80	-1.20	-0.07	-0.68	-0.51
Min	10.31	2.71	10.44	4.15	5.55	9.17	3.13	5.87
Max	35.74	22.11	37.13	11.85	16.74	34.91	10.34	15.14
ACRE	CA	GA	IA	KS	NY	OH	TX	USA
Mean	34054.72	16423.58	33884.91	48883.02	10890.00	17041.32	140635.85	1034248.56
Std Dev	3984.18	4755.87	829.83	1181.87	2855.67	1944.29	8404.72	71503.08
Skewness	-0.27	0.62	-0.74	0.12	0.58	0.60	0.33	0.31
Kurtosis	-1.31	-0.84	0.10	-1.71	-0.96	-0.78	-1.29	-1.18
Min	27100.00	10800.00	31700.00	47200.00	7650.00	14600.00	130000.00	938650.00
Max	39200.00	25800.00	34900.00	50500.00	16800.00	21400.00	154000.00	1167699.00
RETURN	CA	GA	IA	KS	NY	OH	TX	USA
Mean	47174.00	10518.02	31519.40	12391.44	-205.33	3923.79	20405.47	337327.73
Std Dev	19536.79	4943.70	13646.49	8486.38	2435.01	4663.86	10395.59	130571.88
Skewness	-0.04	0.19	1.55	1.68	-0.26	-0.73	1.11	2.06
Kurtosis	-1.07	-0.24	6.55	6.91	-0.25	1.36	6.31	8.45
Min	12920.50	-641.53	3937.83	-2436.59	-5571.73	-11516.35	-9632.81	80511.03
Max	79988.23	22392.53	92653.77	50374.97	5572.60	12688.64	65051.95	917735.13
D/A RATIO	CA	GA	IA	KS	NY	OH	TX	USA
Mean	18.76	17.70	17.76	17.22	17.20	12.43	12.57	16.41
Std Dev	3.18	4.93	4.19	3.40	4.04	2.44	1.41	1.90
Skewness	0.02	0.53	1.16	-0.45	-0.28	0.19	-0.35	1.27
Kurtosis	-1.00	-0.11	2.90	0.28	0.25	-0.26	-0.44	1.73
Min	13.46	9.75	10.28	9.96	8.52	7.73	9.43	13.29
Max	24.63	28.35	31.64	25.25	26.32	17.98	14.78	22.19
INTRATE	CA	GA	IA	KS	NY	OH	TX	USA
Mean	6.43	6.43	6.43	6.43	6.43	6.43	6.43	6.43
Std Dev	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79
Skewness	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Kurtosis	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Min	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Max	13.92	13.92	13.92	13.92	13.92	13.92	13.92	13.92

[6] All abbreviations and acronyms are provided in Appendix A

Table B.2. Summary Statistics for Residuals Obtained from VAR Models[7]

LVALUE*	CA	GA	IA	KS	NY	OH	TX	USA
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std Dev	0.14	0.11	0.19	0.17	0.12	0.17	0.20	0.16
Skewness	0.37	0.48	0.22	-0.04	0.58	-0.42	-0.18	0.07
Kurtosis	-0.01	1.46	1.86	2.02	2.98	1.31	2.74	1.56
Count	51.00	51.00	51.00	51.00	51.00	51.00	51.00	41.00
ACRE*	CA	GA	IA	KS	NY	OH	TX	USA
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std Dev	0.03	0.05	0.14	0.06	0.06	0.04	0.08	0.02
Skewness	0.34	-1.49	-3.35	-0.62	-0.38	-2.01	1.87	-0.23
Kurtosis	2.17	4.81	17.02	-0.49	1.91	6.74	8.36	0.07
Count	51.00	51.00	51.00	51.00	51.00	51.00	51.00	41.00
RETURN*	CA	GA	IA	KS	NY	OH	TX	USA
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std Dev	0.37	0.54	0.77	0.68	0.59	0.74	0.81	0.73
Skewness	0.37	0.25	1.90	1.50	-0.01	0.11	1.22	2.25
Kurtosis	0.99	2.55	8.16	4.81	-0.77	-0.05	5.38	8.81
Count	51.00	51.00	51.00	51.00	51.00	51.00	51.00	41.00
D/A RATIO*	CA	GA	IA	KS	NY	OH	TX	USA
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std Dev	0.25	0.15	0.25	0.23	0.18	0.22	0.31	0.23
Skewness	-0.32	-0.06	0.62	-0.02	0.00	0.65	-0.17	0.21
Kurtosis	0.00	-0.43	3.26	1.31	0.34	0.55	1.00	0.24
Count	51.00	51.00	51.00	51.00	51.00	51.00	51.00	41.00
INTRATE*	CA	GA	IA	KS	NY	OH	TX	USA
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std Dev	0.24	0.23	0.21	0.19	0.25	0.21	0.28	0.23
Skewness	0.51	-0.24	0.14	0.10	0.06	-0.24	0.55	0.26
Kurtosis	-0.33	0.28	-0.38	0.26	-0.73	0.00	1.56	-0.14
Count	51.00	51.00	51.00	51.00	51.00	51.00	51.00	41.00

Note: *Vector Autoregressive Models were fitted to investigate relationships between farmland values, farm acreage, real net returns to farm assets, Debt-to-Asset Ratio and Interest Rates in seven states: California (CA), Georgia (GA), Iowa (IA), Kansas (KS), New York (NY), Ohio (OH), Texas (TX) and in United States of America (USA).
*Lvalue=Residuals from VAR model where farmland value is considered to be a function of lagged values of itself as well as Farm Acreage (acres), Real Returns to Farm Assets (Returns), Debt to Asset Ratio (D/A Ratio), 10Year Treasury Bond Rate (Interest Rate)
*Acres= Residuals from VAR model where farmland acreage is considered to be a function of lagged values of itself as well as Real Farmland values (Lvalue), Real Returns to Farm Assets (Returns), Debt-to-Asset Ratio (D/A Ratio), 10-Year Treasury Bond Rate (Interest Rate)
*Returns= Residuals from VAR model where Real Returns to Farm Assets is considered to be a function of lagged values of itself as well as Real Farm Land Value (Lvalue), Farm Acreage (acres), Debt-to-Asset Ratio (D/A Ratio), 10-Year Treasury Bond Rate (Interest Rate)
*D/A Ratio= Residuals from VAR model where Debt-to-Asset Ratio is considered to be a function of lagged values of itself as well as Real Farmland Value (Lvalue), Farm Acreage (acres), Real Returns to Farm Assets (Returns), 10-Year Treasury Bond Rate (Interest Rate)
*Interest Rate= Residuals from VAR model where 10-Year Treasury Bond Rate is considered to be a function of lagged values itself as well as Real Farmland Value (Lvalue), Farm Acreage (acres), Real Returns to Farm Assets (Returns), Debt-to-Asset Ratio (D/A Ratio), 10-Year Treasury Bond Rate (Interest Rate).

[7] All abbreviations and acronyms are provided in Appendix A

Table B.3. Tests for Non-Stationarity on Original Series of Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio, Interest Rates in 7 U.S. states* (1950-2003) and USA (1960-2003)[8]

	LVALUE		ACRE		RETURN		D/A RATIO		INTRATE	
	DF	ADF (K=3)	DF	ADF (K=3)	DF	ADF (K=3)	DF	ADF (K=3)	DF	ADF (K=3)
CA	-0.41	-1.18	2.14	0.45	-2.26	-1.80	-1.64	-2.16	-1.56	-1.77
GA	0.05	-0.46	-3.49	-3.20	-2.91	-1.16	-1.53	-2.11	-1.56	-1.77
IA	-1.26	-2.94	2.03	1.78	-4.76	-2.79	-2.10	-2.62	-1.56	-1.77
KS	-1.28	-2.22	-0.41	-0.77	-3.78	-3.11	-2.34	-2.43	-1.56	-1.77
NY	-0.91	-0.96	-2.99	-2.76	-3.20	-2.26	-2.39	-2.64	-1.56	-1.77
OH	-1.00	-2.25	-5.06	-3.21	-4.95	-2.55	-1.93	-2.65	-1.56	-1.77
TX	-1.43	-1.67	-1.13	-1.54	-5.91	-2.88	-2.67	-2.56	-1.56	-1.77
USA	-1.19	-2.39	-2.69	-2.67	-4.00	-2.67	-1.23	-2.33	-1.38	-1.76

Note: * DF refers to the Dickey Fuller test on the null hypothesis that the series listed in the headings are non-stationary in States listed as well as in USA. Test for each series are based on an OLS Regression, where first difference of each series given in each US states and USA are regressed on a constant and one lag of the levels of itself (undefferenced lagged value of each series). The figures in the table refer to t-statistics associated with the estimated coefficients on lagged levels variable. The 5% critical value for DF t-statistics in -2.89. The null hypothesis is rejected for the t values less than this critical value.
ADF refers to the Augmented Dickey Fuller Test on the null hypothesis that the series listed in the headings are non-stationary in levels (number of levels k=3) in 7 states listed as well as in USA. The test is similar to the test described for DF, except that k=3 lags of dependent variable are added to the regression.

[8] All abbreviations and acronyms are provided in Appendix A

Table B.4. Tests for Non-Stationarity on Residuals Obtained from 3 Level Lagged VAR Models* in 7 U.S. States* (1950-2003) and USA (1960-2003)[9]

	LVALUE		ACRE		RETURN		D/A RATIO		INTRATE	
	DF*	ADF* (K=3)	DF	ADF (K=3)	DF	ADF (K=3)	DF	ADF (K=3)	DF	ADF (K=3)
CA	-7.71	-4.37	-7.53	-4.71	-6.87	-3.40	-7.30	-2.63	-5.69	-3.29
GA	-6.85	-2.78	-7.64	-5.15	-5.66	-4.11	-7.28	-3.05	-5.91	-3.80
IA	-7.51	-2.71	-6.71	-4.10	-6.71	-3.81	-6.94	-3.03	-6.46	-4.61
KS	-7.16	-4.05	-6.32	-2.79	-6.56	-3.58	-6.86	-3.34	-8.10	-4.04
NY	-6.58	-4.47	-6.74	-3.59	-6.63	-4.19	-7.49	-4.15	-5.60	-4.30
OH	-7.02	-2.49	-6.76	-4.28	-7.88	-3.82	-6.87	-2.97	-6.29	-3.06
TX	-7.09	-3.34	-7.17	-3.36	-7.07	-4.41	-7.17	-3.54	-6.29	-3.83
USA	-6.54	-3.21	-6.64	-3.51	-6.33	-3.27	-6.63	-3.80	-6.00	-3.24

Note: *Individual VAR model was fitted for each series in seven US states as well as for USA aggregate analysis. The series listed in headings of columns represent dependent variables for each VAR models.

*Headings LVALUE, ACRE, RETURN, D/A RATIO, INTRATE refer to names of data series that have been used in VAR models as dependent variables to obtain residuals. DF refers to the Dickey Fuller test on the null hypothesis that the residuals from series associated to VAR dependent variable listed in the headings are non-stationary in States listed as well as in USA. Test for each series are based on an Ordinary Least Squares Regression, where first difference of residuals from each VAR model in each US states and USA are regressed on a constant and one lag of the levels of itself (undefferenced lagged value of VAR residuals). The figures in the table refer to t-statistics associated with the estimated coefficients on lagged levels variable. The 5% critical value for DF t-statistics in -2.89. The null hypothesis is rejected for the t values less than this critical value.

ADF refers to the Augmented Dickey Fuller Test on the null hypothesis that the residuals obtained from VAR models listed in the headings are non-stationary in levels (number of levels k=3) in 7 states listed as well as in USA. The test is similar to the test described for DF, except that k=3 lags of dependent variable are added to the regression.

[9] All abbreviations and acronyms are provided in Appendix A

Table B.5. Number of Appropriate Lags (k) in Leveled Lags VAR Models for 7 U.S. States and USA Aggregate Models[10]

State	No of lags (k)	SIC*	AIC*	Phi*
CA	0	41.3207	40.7731	41.1569
	1	31.0959	28.8098	30.1129
	2	32.3213	29.2968	30.5191
	3	33.9661	29.2032	31.3447
GA	0	37.8487	37.3010	37.6849
	1	28.7828	26.4967	27.7998
	2	30.8055	27.7810	29.0033
	3	32.0159	27.2529	29.3945
IA	0	40.0475	39.4998	39.8836
	1	31.8062	29.5201	30.8232
	2	33.4823	30.4577	31.6800
	3	35.3601	30.5972	32.7387
KS	0	36.3249	35.7772	36.1611
	1	25.7226	23.4365	24.7396
	2	27.2954	24.2709	25.4932
	3	29.0720	24.3091	26.4506
NY	0	34.6417	34.0940	34.4778
	1	26.3605	24.0744	25.3774
	2	28.1883	25.1637	26.3860
	3	29.7369	24.9740	27.1155
OH	0	37.8956	37.3479	37.7318
	1	27.0081	24.7220	26.0251
	2	28.4464	25.4219	26.6442
	3	29.8932	25.1303	27.2718
TX	0	38.4001	37.8525	38.2363
	1	30.6263	28.3402	29.6433
	2	32.5057	29.4811	30.7034
	3	34.4224	29.6594	31.8010
USA	0	49.4571	48.8116	49.2707
	1	38.9131	37.0397	37.7946
	2	39.7301	35.6290	37.6796
	3	41.2329	35.9041	38.2504

Note: *SIC=Schwarz Information Criteria, AIC=Akaike Information Criteria, phi=Hannan and Quinn criteria
SIC, AIC and Phi are calculated using residual sum of squares (RSS) as follows:
Schwarz: T log(RSS)+2k
Akaike: T log(RSS)+k(log T)
Phi: Log (RSS) +(2.01)(k)log(log T)/T
K – number of lages, T- number of observations. Number of lags corresponding to the minimum value of each criteria provides the reasonable lag length.

[10] All abbreviations and acronyms are provided in Appendix A

Table B.6. R^2 and Dubrin-Watson* Statistics Results from each VAR* Models for 7 U.S. States and USA[11]

State	Goodness of fit	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
CA	R^2	0.97	0.99	0.86	0.94	0.94
	R Bar ^{2}	0.97	0.99	0.8	0.91	0.91
	DW Statistic	2.17	2.24	2.04	2.14	1.69
GA	R^2	0.98	0.99	0.72	0.97	0.94
	R Bar ^{2}	0.98	0.99	0.59	0.96	0.91
	DW Statistic	2.03	2.19	1.73	2.16	1.75
IA	R^2	0.96	0.98	0.41	0.93	0.95
	R Bar ^{2}	0.95	0.97	0.17	0.9	0.94
	DW Statistic	2.22	1.98	2.03	1.98	1.93
KS	R^2	0.97	0.99	0.55	0.94	0.96
	R Bar ^{2}	0.96	0.99	0.37	0.91	0.95
	DW Statistic	2.14	1.9	1.92	2	2.29
NY	R^2	0.98	0.99	0.66	0.96	0.93
	R Bar ^{2}	0.97	0.99	0.51	0.95	0.9
	DW Statistic	1.96	1.99	1.97	2.22	1.64
OH	R^2	0.97	0.99	0.45	0.95	0.95
	R Bar ^{2}	0.95	0.99	0.22	0.93	0.93
	DW Statistic	2.08	2	2.22	2.07	1.94
TX	R^2	0.96	0.99	0.36	0.88	0.92
	R Bar ^{2}	0.94	0.99	0.08	0.84	0.88
	DW Statistic	2.1	2.11	2.1	2.14	1.88
USA	R^2	0.97	0.99	0.48	0.94	0.95
	R Bar ^{2}	0.95	0.99	0.17	0.91	0.91
	DW Statistic	2.19	2.19	2.12	2.21	2.04

Note: * Individual VAR model was fitted for each series in seven US states as well as for USA aggregate analysis. The series listed in headings of columns represent dependent variables for each VAR models.

*R^2, R Bar^2 are the measures of goodness of fit of each VAR model; R^2=RSS/TSS (RRS=regression sum of squares; TSS=Total sum of squares))

R Bar^2 = 1-(n-1/n-k-1)(1-R^2), where k is number of variables in the model (k=5), n – total number of observations

DW is Dubrin-Watson Test to test serial correlation among series; it is calculated as follows:

$$\left[\left(\sum_{t=2}^{n} (\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2 \right) / \sum \hat{\varepsilon}_t^{\ 2} \right] \leq 4$$

[11] All abbreviations and acronyms are provided in Appendix A

Table B.7. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in California, 1950-2003[12]

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	116.16 (0.00)	1.69 (0.18)	0.59 (0.62)	1.55 (0.21)	0.83 (0.48)
ACRE	1.54 (0.22)	1700.27 (0.00)	3.06 (0.04)	0.37 (0.76)	0.17 (0.91)
RETURN	2.05 (0.12)	1.22 (0.31)	6.52 (0.001)	1.40 (0.25)	3.53 (0.02)
D/A RATIO	0.93 (0.43)	0.43 (0.73)	0.14 (0.93)	55.03 (0.00)	0.15 (0.92)
INTRATE	4.67 (0.007)	3.39 (0.02)	1.69 (0.18)	0.49 (0.68)	12.29 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (54). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

Table B.8. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in Georgia, 1950-2003

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	119.03 (0.00)	1.01 (0.39)	1.33 (0.28)	2.21 (0.10)	3.98 (0.01)
ACRE	3.10 (0.03)	253.33 (0.00)	2.42 (0.08)	0.25 (0.85)	0.22 (0.87)
RETURN	2.22 (0.10)	3.83 (0.01)	0.13 (0.94)	1.32 (0.28)	1.49 (0.23)
D/A RATIO	3.92 (0.01)	1.38 (0.26)	1.01 (0.39)	44.23 (0.00)	4.91 (0.005)
INTRATE	6.12 (0.001)	0.02 (0.99)	2.29 (0.09)	0.19 (0.89)	14.77 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (54). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

[12] All abbreviations and acronyms are provided in Appendix A

Table B.9. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in Iowa, 1950-2003[13]

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	114.67 (0.00)	0.81 (0.49)	2.95 (0.04)	0.45 (0.71)	0.70 (0.55)
ACRE	0.13 (0.94)	325.24 (0.00)	1.19 (0.32)	0.17 (0.91)	0.73 (0.54)
RETURN	3.07 (0.04)	2.36 (0.08)	0.97 (0.41)	2.31 (0.09)	0.33 (0.80)
D/A RATIO	1.95 (0.13)	0.34 (0.79)	0.43 (0.72)	30.40 (0.00)	1.31 (0.28)
INTRATE	9.41 (0.00)	4.99 (0.005)	0.41 (0.74)	2.35 (0.08)	11.85 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (54). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

Table B.10. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in Kansas, 1950-2003

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	173.46 (0.00)	2.70 (0.06)	0.60 (0.61)	1.63 (0.19)	0.57 (0.63)
ACRE	2.25 (0.09)	971.00 (0.00)	0.83 (0.48)	1.31 (0.28)	0.17 (0.91)
RETURN	1.41 (0.25)	2.59 (0.06)	1.01 (0.39)	0.88 (0.45)	1.04 (0.38)
D/A RATIO	0.34 (0.79)	0.26 (0.85)	0.07 (0.97)	39.52 (0.00)	0.64 (0.59)
INTRATE	15.84 (0.00)	3.90 (0.01)	0.68 (0.56)	3.98 (0.01)	11.06 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (54). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

[13] All abbreviations and acronyms are provided in Appendix A

Table B.11. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in New York, 1950-2003[14]

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	72.92 (0.00)	1.57 (0.21)	0.41 (0.74)	3.51 (0.02)	1.24 (0.30)
ACRE	2.43 (0.08)	166.56 (0.00)	0.55 (0.64)	1.52 (0.22)	0.31 (0.81)
RETURN	3.04 (0.04)	0.47 (0.70)	0.76 (0.52)	3.43 (0.02)	1.86 (0.15)
D/A RATIO	1.31 (0.28)	0.68 (0.56)	1.20 (0.32)	48.20 (0.00)	3.45 (0.02)
INTRATE	2.75 (0.05)	0.64 (0.59)	0.86 (0.46)	4.32 (0.01)	13.30 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (54). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

Table B.12. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in Ohio, 1950-2003

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	140.71 (0.00)	4.48 (0.009)	2.54 (0.07)	1.43 (0.24)	1.22 (0.31)
ACRE	0.02 (0.99)	1806.97 (0.00)	0.54 (0.65)	0.34 (0.79)	0.84 (0.47)
RETURN	3.24 (0.03)	0.28 (0.83)	0.19 (0.90)	1.09 (0.36)	2.14 (0.11)
D/A RATIO	1.67 (0.18)	5.04 (0.005)	4.72 (0.007)	78.21 (0.00)	2.17 (0.10)
INTRATE	11.55 (0.00)	5.05 (0.005)	0.55 (0.64)	2.62 (0.06)	21.04 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (54). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

[14] All abbreviations and acronyms are provided in Appendix A

Table B.13. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in Texas, 1950-2003[15]

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	43.36 (0.00)	0.74 (0.53)	0.45 (0.71)	1.91 (0.14)	1.50 (0.22)
ACRE	0.80 (0.50)	635.96 (0.00)	0.20 (0.89)	0.67 (0.57)	0.96 (0.42)
RETURN	0.73 (0.53)	0.69 (0.55)	0.27 (0.84)	1.83 (0.15)	1.88 (0.15)
D/A RATIO	2.26 (0.09)	1.26 (0.30)	1.73 (0.17)	33.89 (0.00)	0.37 (0.77)
INTRATE	2.25 (0.09)	1.22 (0.31)	0.15 (0.92)	1.70 (0.18)	15.80 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (54). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

Table B.14. *F* test (*P* value) of levels VAR on Farmland Values, Farmland Acreage, Real Returns to Farm Assets, Debt-to-Asset Ratio and Interest Rates in USA, 1960-2003

Dependent variable (current values)	Lagged variables				
	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE	131.57 (0.00)	1.40 (0.26)	0.27 (0.84)	0.25 (0.85)	0.75 (0.52)
ACRE	3.57 (0.02)	1676.29 (0.00)	24.13 (0.00)	1.14 (0.34)	3.55 (0.02)
RETURN	1.14 (0.34)	0.95 (0.42)	0.23 (0.87)	0.71 (0.55)	1.49 (0.24)
D/A RATIO	0.47 (0.70)	1.33 (0.28)	0.08 (0.96)	6.24 (0.002)	2.27 (0.10)
INTRATE	6.02 (0.003)	3.26 (0.03)	0.44 (0.72)	3.52 (0.02)	12.18 (0.00)

Note: The *F* statistics is calculates as follows: $F=[(SSE_{reduced}-SSE_{full})/k]/[SSE_{full}/(T-5k-1)] \sim F_{k, T-5k-1}$
The null hypothesis is that the variable listed in the column heading does not influence variables in the left-hand-most column. SSE_{full} is refers to sums of squared residuals from the ordinary least squares regression, where variables under the headline 'Dependent Variable (current values)' are regressed on all the variables listed under the headline of 'Lagged Variable'. $SSE_{reduced}$ refers to sums of squared residuals from OLS regression, where variables under the headline of 'Dependent Variables' are regressed on all the variables under the headline of 'Lagged Variables' except for the variable that is listed in the associated row of each column. K refers to the number of lags used in the regression (k=3) and T is number of observations used (44). P values for each F statistics are provided in parentheses; null hypothesis is rejected for p-value <0.05.

[15] All abbreviations and acronyms are provided in Appendix A

Table B.15. Forecast error variance decomposition on farmland values, farmland acreage, real returns to assets, Debt-to-Asset Ratio and Interest Rates in California 1950-2003[16]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.13	71.06	0.00	0.00	27.40	1.54
1	0.23	75.32	0.29	0.07	22.71	1.62
2	0.31	75.86	0.44	0.24	18.84	4.62
3	0.37	77.51	0.53	0.37	14.81	6.79
4	0.40	78.68	0.47	0.48	12.55	7.83
5	0.43	77.21	0.52	0.49	13.16	8.62
6	0.45	72.67	1.15	0.45	16.84	8.90
ACRE						
0	0.03	0.00	100.00	0.00	0.00	0.00
1	0.06	0.10	97.86	0.79	0.24	1.00
2	0.08	0.19	94.82	3.43	0.23	1.34
3	0.10	0.17	95.79	2.96	0.16	0.92
4	0.11	0.17	96.65	2.17	0.12	0.89
5	0.13	0.15	95.92	2.17	0.13	1.64
6	0.14	0.16	94.57	2.62	0.12	2.52
RETURN						
0	0.37	0.00	0.00	95.94	0.00	4.06
1	0.45	2.10	2.53	89.71	1.00	4.67
2	0.49	6.14	4.53	79.51	1.30	8.52
3	0.50	6.40	5.51	75.82	2.40	9.87
4	0.55	5.64	4.79	68.56	6.27	14.75
5	0.58	5.33	4.22	61.66	11.41	17.37
6	0.61	5.73	3.91	57.07	15.16	18.12
D/A RATIO						
0	0.24	0.00	0.00	0.00	94.67	5.33
1	0.37	0.06	0.82	0.31	92.88	5.93
2	0.47	0.77	1.49	0.59	88.85	8.30
3	0.53	2.53	1.79	0.52	84.70	10.46
4	0.57	6.37	1.90	0.48	80.69	10.57
5	0.60	11.17	1.84	0.43	76.53	10.03
6	0.63	15.56	1.74	0.41	72.84	9.45
INTRATE						
0	0.24	0.00	0.00	0.00	0.00	100.00
1	0.31	8.39	0.54	0.64	1.07	89.36
2	0.35	21.60	1.49	6.52	2.12	68.27
3	0.39	30.78	1.68	9.03	1.92	56.59
4	0.42	37.36	1.68	8.65	2.03	50.28
5	0.45	40.03	1.65	7.82	4.94	45.56
6	0.49	39.06	1.51	6.91	11.39	41.14

Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying "Bernanke factorization" to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[16] All abbreviations and acronyms are provided in Appendix A

Table B.16. Forecast error variance decomposition on farmland values, farmland acreage, real returns to farm assets, Debt-to-Asset Ratio and Interest Rates in Georgia 1950-2003[17]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.10	80.17	0.56	2.28	13.67	3.33
1	0.16	72.52	0.44	2.92	6.34	17.78
2	0.20	66.60	0.30	1.98	4.23	26.89
3	0.23	57.13	0.55	3.13	4.09	35.10
4	0.26	48.34	1.27	4.46	5.10	40.83
5	0.29	40.77	2.32	6.54	5.36	45.02
6	0.31	34.71	3.48	8.65	5.11	48.05
ACRE						
0	0.05	0.00	100.00	0.00	0.00	0.00
1	0.08	5.36	93.76	0.32	0.29	0.27
2	0.09	3.43	89.40	5.81	0.47	0.89
3	0.11	2.70	90.18	5.66	0.45	1.02
4	0.12	3.21	89.74	4.69	1.10	1.25
5	0.13	3.41	89.42	4.10	1.35	1.72
6	0.14	3.26	88.88	3.61	1.60	2.65
RETURN						
0	0.53	0.00	0.00	100.00	0.00	0.00
1	0.56	5.03	0.95	92.48	1.48	0.07
2	0.58	8.02	1.73	84.92	4.83	0.50
3	0.59	8.56	2.61	83.02	4.81	1.00
4	0.61	9.18	3.36	78.10	6.42	2.94
5	0.62	8.88	3.94	75.66	8.57	2.95
6	0.64	9.90	4.31	73.01	9.58	3.20
D/A RATIO						
0	0.14	0.00	2.83	11.47	68.91	16.79
1	0.22	0.80	1.69	9.32	49.93	38.27
2	0.30	19.53	0.98	6.62	38.42	34.46
3	0.38	31.58	0.66	8.02	27.62	32.12
4	0.48	43.69	0.57	8.69	19.77	27.29
5	0.56	49.24	0.67	9.86	15.45	24.78
6	0.63	53.80	0.80	10.55	12.68	22.17
INTRATE						
0	0.23	0.00	0.00	0.00	0.00	100.00
1	0.31	8.24	0.10	3.89	0.44	87.32
2	0.41	33.19	0.57	6.81	2.29	57.14
3	0.47	42.29	0.91	8.33	1.73	46.74
4	0.52	44.14	1.02	11.14	1.84	41.86
5	0.56	47.43	1.05	11.43	2.62	37.47
6	0.60	49.47	1.08	11.36	4.01	34.08

Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying "Bernanke factorization" to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[17] All abbreviations and acronyms are provided in Appendix A

Table B.17. Forecast error variance decomposition on farmland values, farmland acreage, real returns to assets, Debt-to-Asset Ratio and Interest Rates in Iowa 1950-2003[18]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.19	50.01	0.00	0.00	37.99	12.00
1	0.32	44.05	0.13	6.53	33.39	15.91
2	0.45	45.86	0.15	11.32	25.87	16.81
3	0.57	48.59	0.34	17.52	18.47	15.08
4	0.66	50.16	0.49	21.55	13.72	14.08
5	0.74	51.07	0.70	23.77	11.04	13.42
6	0.79	51.07	0.97	25.38	9.86	12.73
ACRE						
0	0.13	0.00	100.00	0.00	0.00	0.00
1	0.18	0.28	98.25	0.61	0.21	0.65
2	0.23	0.25	97.77	0.53	1.03	0.42
3	0.28	0.18	96.97	0.90	1.64	0.31
4	0.32	0.19	96.06	1.24	2.01	0.51
5	0.37	0.14	95.29	1.38	2.45	0.75
6	0.42	0.12	94.48	1.32	3.21	0.87
RETURN						
0	0.77	0.00	0.00	96.46	0.00	3.54
1	0.81	0.93	3.86	91.12	0.87	3.23
2	0.86	10.76	3.56	80.57	0.90	4.22
3	0.89	13.62	3.33	75.35	3.74	3.97
4	0.90	13.66	3.63	73.05	5.60	4.07
5	0.91	13.51	4.12	72.37	5.67	4.33
6	0.92	13.65	5.32	71.01	5.65	4.37
D/A RATIO						
0	0.25	0.00	0.00	0.00	96.05	3.95
1	0.42	0.99	0.26	1.01	89.19	8.55
2	0.50	0.80	0.22	2.44	86.90	9.63
3	0.53	2.13	0.25	5.23	82.78	9.62
4	0.54	3.37	0.40	6.43	79.96	9.84
5	0.54	3.49	0.94	6.77	79.14	9.67
6	0.56	3.98	1.54	6.48	78.63	9.39
INTRATE						
0	0.21	0.00	0.00	0.00	0.00	100.00
1	0.25	0.09	8.00	2.11	5.42	84.38
2	0.29	3.20	9.92	1.72	21.66	63.50
3	0.33	11.97	9.09	4.04	25.06	49.85
4	0.37	24.77	8.74	6.15	21.27	39.06
5	0.43	36.93	7.81	8.59	16.69	29.99
6	0.49	43.83	6.90	11.75	13.24	24.29

Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying "Bernanke factorization" to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[18] All abbreviations and acronyms are provided in Appendix A

Table B.18. Forecast error variance decomposition on farmland values, farmland acreage, real returns to assets, Debt-to-Asset Ratio and Interest Rates in Kansas 1950-2003[19]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.17	36.80	0.00	2.32	57.11	3.77
1	0.30	27.50	5.61	5.56	57.17	4.15
2	0.41	32.32	11.04	5.17	46.21	5.27
3	0.50	35.16	15.98	7.09	35.56	6.22
4	0.57	37.86	20.01	8.00	27.44	6.69
5	0.64	38.93	22.79	9.47	21.95	6.86
6	0.70	39.49	24.74	10.37	18.79	6.62
ACRE						
0	0.06	100.00	0.00	0.00	0.00	0.00
1	0.09	3.31	94.65	0.67	0.12	1.25
2	0.12	3.19	91.19	4.63	0.09	0.91
3	0.15	3.60	88.78	6.94	0.06	0.62
4	0.18	3.84	85.43	10.22	0.06	0.45
5	0.20	4.31	83.51	11.72	0.06	0.40
6	0.22	4.69	81.97	12.79	0.10	0.45
RETURN						
0	0.67	0.00	0.00	100.00	0.00	0.00
1	0.75	1.95	6.36	86.22	2.49	2.98
2	0.77	2.06	6.95	83.96	3.93	3.10
3	0.79	2.43	6.61	80.85	5.05	5.06
4	0.81	2.55	7.19	76.98	6.43	6.85
5	0.83	2.49	9.24	74.25	6.14	7.87
6	0.85	2.59	11.13	71.72	6.15	8.40
D/A RATIO						
0	0.23	0.00	0.00	3.91	96.09	0.00
1	0.37	0.57	0.59	4.54	93.35	0.96
2	0.43	0.68	1.27	5.32	91.12	1.61
3	0.44	1.36	1.89	5.82	89.10	1.82
4	0.45	2.32	1.94	5.85	87.75	2.14
5	0.45	3.71	1.93	5.76	86.29	2.31
6	0.46	5.50	2.10	5.66	84.49	2.26
INTRATE						
0	0.18	0.00	0.00	0.00	0.00	100.00
1	0.25	0.59	5.06	0.05	20.94	73.35
2	0.33	2.59	4.65	0.49	51.96	40.31
3	0.38	5.17	3.88	0.38	59.27	31.30
4	0.41	9.19	3.86	0.47	58.39	28.09
5	0.43	14.76	3.84	0.54	55.57	25.29
6	0.46	21.22	4.90	0.81	50.50	22.58

Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying "Bernanke factorization" to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[19] All abbreviations and acronyms are provided in Appendix A

Table B.19. Forecast error variance decomposition on farmland values, farmland acreage, real returns to assets, Debt-to-Asset Ratio and Interest Rates in New York 1950-2003[20]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.12	86.05	7.92	0.00	0.00	6.03
1	0.19	69.50	15.84	0.08	1.50	13.08
2	0.24	62.45	18.35	1.24	0.95	17.02
3	0.29	53.86	19.09	2.05	0.76	24.24
4	0.32	45.62	17.75	2.35	0.62	33.66
5	0.35	39.32	16.09	2.86	0.56	41.17
6	0.37	34.36	14.35	3.14	0.56	47.60
ACRE						
0	0.06	0.00	93.30	0.00	0.00	6.70
1	0.09	1.36	88.62	0.15	3.80	6.08
2	0.11	1.76	84.98	0.16	4.99	8.12
3	0.12	2.10	79.66	0.56	4.88	12.80
4	0.14	2.43	73.99	1.51	5.18	16.89
5	0.15	2.39	69.30	2.32	4.94	21.05
6	0.15	2.23	65.15	2.85	4.66	25.11
RETURN						
0	0.58	0.00	0.00	100.00	0.00	0.00
1	0.60	0.00	0.38	93.77	1.58	4.27
2	0.64	1.84	2.69	85.58	6.13	3.77
3	0.70	2.96	5.62	75.00	13.01	3.41
4	0.74	4.47	8.42	66.15	16.29	4.67
5	0.79	4.85	10.42	58.12	19.72	6.89
6	0.83	4.52	11.43	52.66	23.59	7.81
D/A RATIO						
0	0.18	0.00	0.00	0.00	91.91	8.09
1	0.23	0.78	3.19	1.17	89.33	5.53
2	0.30	1.68	3.18	0.67	85.47	9.01
3	0.37	3.85	2.83	0.77	85.25	7.30
4	0.43	9.82	2.05	0.58	81.67	5.88
5	0.48	14.93	1.93	0.69	77.09	5.36
6	0.53	19.52	2.43	0.99	72.45	4.60
INTRATE						
0	0.25	0.00	0.00	0.00	0.00	100.00
1	0.35	0.42	0.79	3.73	6.86	88.20
2	0.43	5.66	0.91	7.08	18.80	67.56
3	0.51	11.69	0.66	6.14	22.82	58.69
4	0.58	15.85	0.65	4.86	25.31	53.33
5	0.65	19.43	0.79	4.17	29.29	46.33
6	0.70	22.48	1.11	3.60	31.63	41.19

Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying "Bernanke factorization" to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[20] All abbreviations and acronyms are provided in Appendix A

Table B.20. Forecast error variance decomposition on farmland values, farmland acreage, real returns to assets, Debt-to-Asset Ratio and Interest Rates in Ohio 1950-2003[21]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.17	35.97	0.00	0.00	55.78	8.26
1	0.29	40.82	3.06	2.60	38.69	14.83
2	0.39	45.40	7.21	3.36	28.01	16.02
3	0.47	45.54	11.38	8.42	20.53	14.14
4	0.54	46.88	14.19	10.46	16.57	11.90
5	0.60	48.23	16.52	10.51	14.35	10.39
6	0.64	48.79	18.90	10.19	12.76	9.35
ACRE						
0	0.04	100.00	0.00	0.00	0.00	0.00
1	0.05	0.06	97.52	1.02	0.81	0.58
2	0.06	0.11	95.99	2.81	0.59	0.50
3	0.07	0.10	94.60	3.99	0.73	0.59
4	0.08	0.25	93.53	4.17	1.52	0.53
5	0.09	0.37	92.12	5.09	1.88	0.55
6	0.09	0.36	90.86	5.90	1.90	0.99
RETURN						
0	0.74	0.00	0.00	100.00	0.00	0.00
1	0.78	4.16	1.15	88.14	0.53	6.02
2	0.82	7.87	1.41	82.44	2.69	5.59
3	0.83	8.23	2.34	78.92	4.03	6.48
4	0.87	7.80	2.35	72.13	5.82	11.91
5	0.90	7.97	2.52	67.85	5.77	15.90
6	0.92	7.68	3.42	65.63	5.53	17.76
D/A RATIO						
0	0.21	0.00	0.00	0.00	87.11	12.89
1	0.32	0.09	0.27	2.26	68.27	29.11
2	0.37	0.87	0.23	3.40	60.49	35.01
3	0.42	4.62	0.22	14.38	48.57	32.21
4	0.45	8.90	0.99	18.33	43.01	28.77
5	0.47	13.11	2.11	18.42	39.89	26.47
6	0.49	18.35	3.11	17.21	36.87	24.46
INTRATE						
0	0.21	0.00	0.00	0.00	0.00	100.00
1	0.28	1.77	2.19	1.76	6.34	87.95
2	0.33	5.01	6.06	1.23	24.79	62.91
3	0.37	13.00	5.01	1.29	29.64	51.05
4	0.40	20.17	4.45	2.65	28.76	43.97
5	0.45	27.55	4.03	6.14	25.81	36.47
6	0.50	35.56	3.95	6.82	23.18	30.49

Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying "Bernanke factorization" to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[21] All abbreviations and acronyms are provided in Appendix A

Table B.21. Forecast error variance decomposition on farmland values, farmland acreage, real returns to assets, Debt-to-Asset Ratio and Interest Rates in Texas 1950-2003[22]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.19	48.73	3.16	2.03	32.19	13.90
1	0.29	62.12	4.97	1.01	24.59	7.32
2	0.36	69.21	4.19	0.69	19.08	6.82
3	0.42	72.47	3.19	0.65	14.17	9.52
4	0.47	75.06	2.58	0.63	11.32	10.41
5	0.50	76.77	2.25	0.60	9.86	10.52
6	0.53	77.83	2.08	0.55	9.15	10.40
ACRE						
0	0.08	0.00	100.00	0.00	0.00	0.00
1	0.11	1.10	98.13	0.20	0.19	0.39
2	0.14	0.73	97.15	0.21	0.17	1.73
3	0.16	0.57	95.88	0.31	0.13	3.11
4	0.18	0.76	95.48	0.40	0.16	3.20
5	0.20	1.41	95.06	0.39	0.35	2.80
6	0.21	2.24	94.25	0.37	0.70	2.44
RETURN						
0	0.80	0.00	0.00	100.00	0.00	0.00
1	0.82	0.01	2.76	96.49	0.00	0.74
2	0.84	0.54	2.74	93.05	0.01	3.66
3	0.90	3.92	3.67	80.11	5.80	6.50
4	0.93	3.79	3.85	75.07	6.89	10.41
5	0.94	4.41	3.81	74.34	6.98	10.47
6	0.95	5.37	3.75	73.45	7.12	10.31
D/A RATIO						
0	0.30	0.00	8.17	5.26	83.37	3.20
1	0.37	1.95	10.77	4.58	80.59	2.12
2	0.41	12.52	9.14	4.19	72.26	1.90
3	0.44	20.51	7.69	4.05	63.57	4.18
4	0.47	24.78	6.78	3.70	60.80	3.95
5	0.50	29.41	6.04	3.29	57.79	3.49
6	0.53	31.46	5.58	3.03	56.72	3.21
INTRATE						
0	0.28	0.00	0.00	0.00	0.00	100.00
1	0.40	4.21	0.77	0.01	0.00	95.00
2	0.44	4.35	2.50	0.02	0.11	93.03
3	0.46	4.49	3.54	0.17	0.12	91.68
4	0.48	6.46	4.38	0.42	0.11	88.63
5	0.49	10.83	5.22	0.43	0.17	83.35
6	0.51	17.07	5.61	0.40	0.20	76.72

Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying “Bernanke factorization” to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[22] All abbreviations and acronyms are provided in Appendix A

Table B.22. Forecast error variance decomposition on farmland values, farmland acreage, real returns to assets, Debt-to-Asset Ratio and Interest Rates in USA 1960-2003[23]

Horizon	ST. ERROR	LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
LVALUE						
0	0.16	21.06	0.00	0.00	51.22	27.73
1	0.29	18.39	0.77	1.02	39.87	39.94
2	0.41	22.39	0.73	1.83	29.17	45.89
3	0.51	24.18	0.87	5.03	22.10	47.81
4	0.59	24.65	0.80	8.16	17.22	49.17
5	0.66	25.26	0.77	10.48	14.17	49.32
6	0.71	25.88	0.78	11.95	12.55	48.84
ACRE						
0	0.02	0.00	100.00	0.00	0.00	0.00
1	0.03	4.55	59.34	0.04	31.88	4.19
2	0.05	6.21	31.49	41.03	18.84	2.42
3	0.06	8.66	18.91	55.54	14.90	1.99
4	0.07	7.93	16.58	60.68	13.09	1.72
5	0.07	7.26	16.19	60.77	13.21	2.58
6	0.08	6.89	15.74	58.07	13.89	5.42
RETURN						
0	0.72	0.00	0.00	100.00	0.00	0.00
1	0.75	0.13	1.95	94.71	3.12	0.09
2	0.80	5.70	2.03	83.63	6.36	2.28
3	0.84	6.65	2.00	78.55	6.10	6.70
4	0.87	6.21	1.86	74.16	5.66	12.12
5	0.89	6.29	1.82	71.62	6.10	14.17
6	0.91	6.19	1.81	68.14	7.36	16.49
D/A RATIO						
0	0.23	0.00	0.00	0.00	95.01	4.99
1	0.34	0.86	0.44	0.28	79.42	19.01
2	0.37	0.87	0.53	1.71	70.36	26.52
3	0.39	0.95	0.69	7.45	63.95	26.96
4	0.43	1.31	0.59	10.86	62.64	24.60
5	0.47	1.75	0.49	11.12	66.11	20.53
6	0.52	3.75	0.42	8.93	67.14	19.77
INTRATE						
0	0.22	0.00	0.00	0.00	0.00	100.00
1	0.32	1.53	0.46	2.70	24.76	70.55
2	0.40	2.79	0.30	2.35	49.04	45.52
3	0.45	7.37	0.47	2.12	53.95	36.09
4	0.48	11.10	0.48	1.82	54.80	31.80
5	0.53	15.34	0.46	2.89	50.61	30.70
6	0.58	19.73	0.43	4.24	45.70	29.90

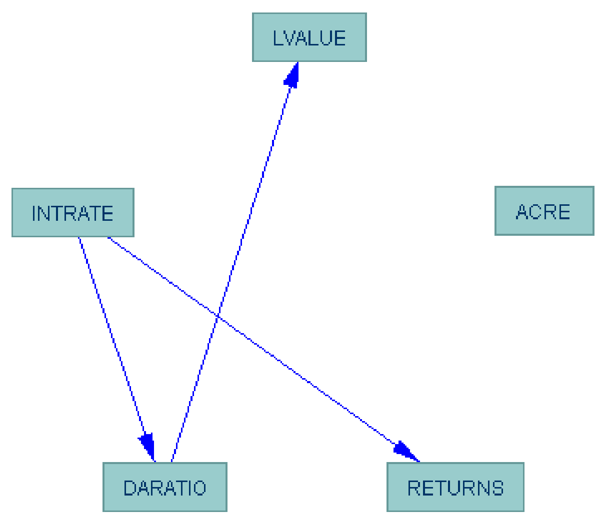
Note: * Error Variance Decompositions are based on observed innovations from the VAR model after applying "Bernanke factorization" to the innovation correlation/covariance matrix. The entries in each row sum to one hundred.
The interpretation of each row is as follows: different time horizons are listed in the first column. Uncertainty in the variable heading horizons (0-6) is decomposed into shares of variables listed at headings of each column.

[23] All abbreviations and acronyms are provided in Appendix A

APPENDIX C

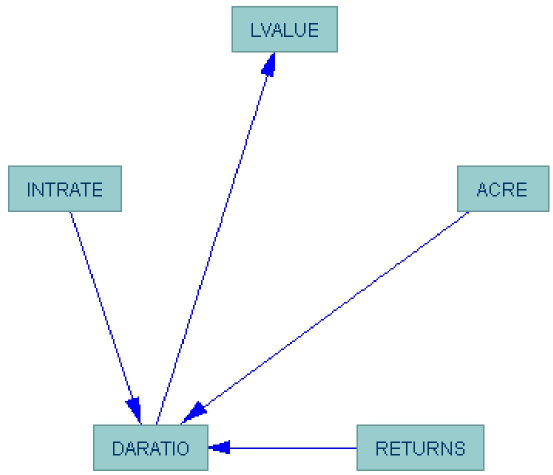
DIRECTED ACYCLIC GRAPHS

Figures C.1.-C.8. represent the contemporaneous causal relationship between farmland values, farmland acreage, Net Returns to Farm Assets, Debt to Asset Ratio, Interest Rates (10Year Treasury Bond Rate) for seven US states as well as United States as a whole. PC Algorithm results are presented at the 20% significance level.

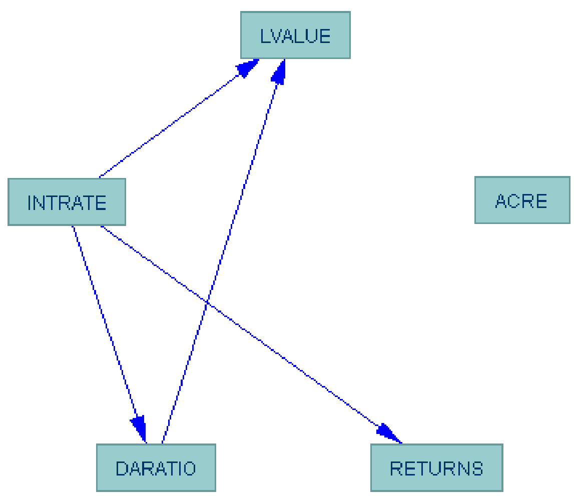


C.1. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in California (1950-2003)[24]

[24] All abbreviations and acronyms are provided in Appendix A

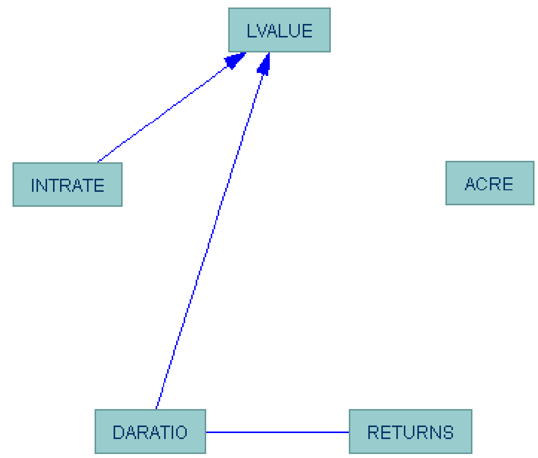


C.2. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in Georgia (1950-2003)

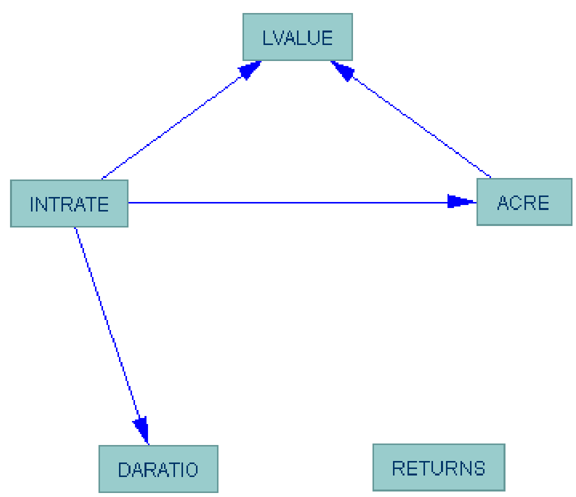


C.3. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in Iowa (1950-2003)[25]

[25] All abbreviations and acronyms are provided in Appendix A

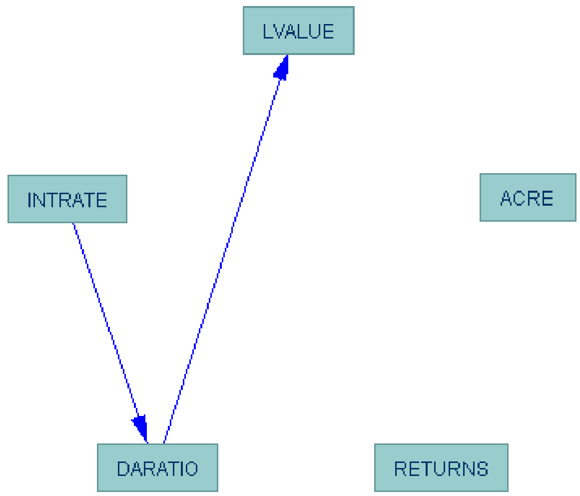


C.4. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in Kansas (1950-2003)

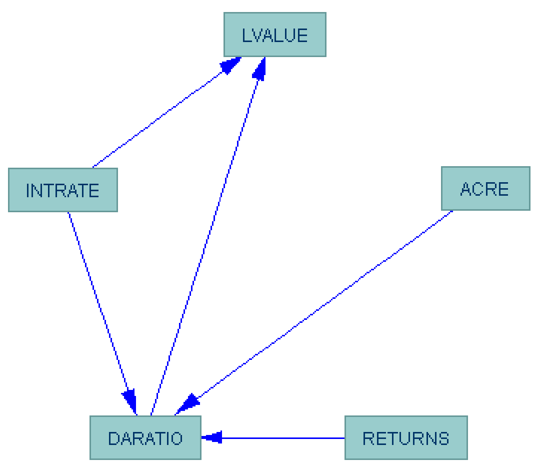


C.5. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in New York (1950-2003)[26]

[26] All abbreviations and acronyms are provided in Appendix A

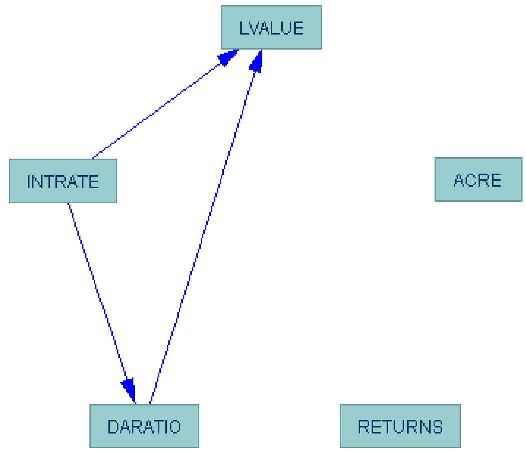


C.6. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in Ohio (1950-2003)



C.7. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in Texas (1950-2003)[27]

[27] All abbreviations and acronyms are provided in Appendix A

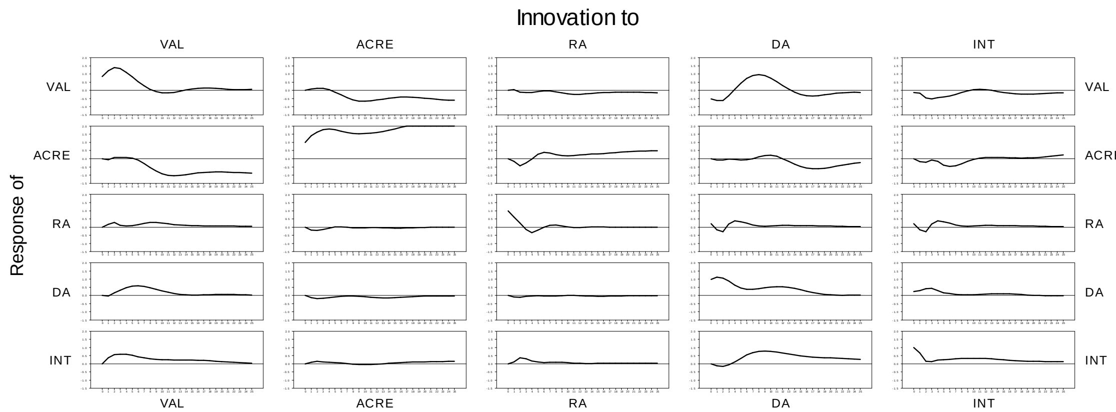


C.8. Farmland values, acreages, returns to Farm assets, Debt to Asset Ratio and Interest Rates in USA (1960-2003)[28]

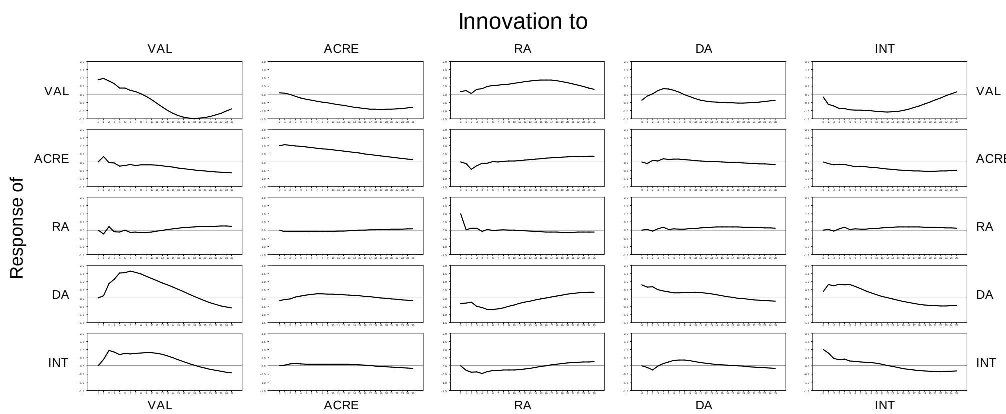
[28] All abbreviations and acronyms are provided in Appendix A

IMPULSE RESPONSE GRAPHS

Impulse Response Graphs (C.9.-C.16.) depict the response of one series to a one time shock (positive) in the other variables listed at the top of each column.

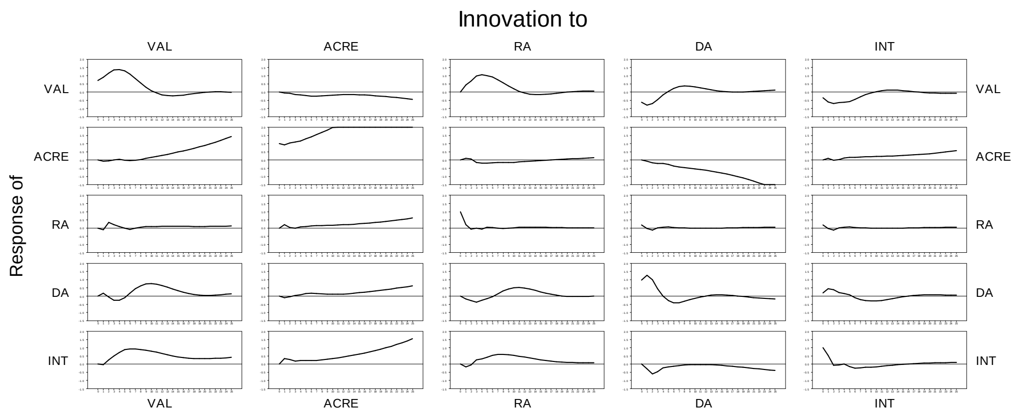


C.9. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in California

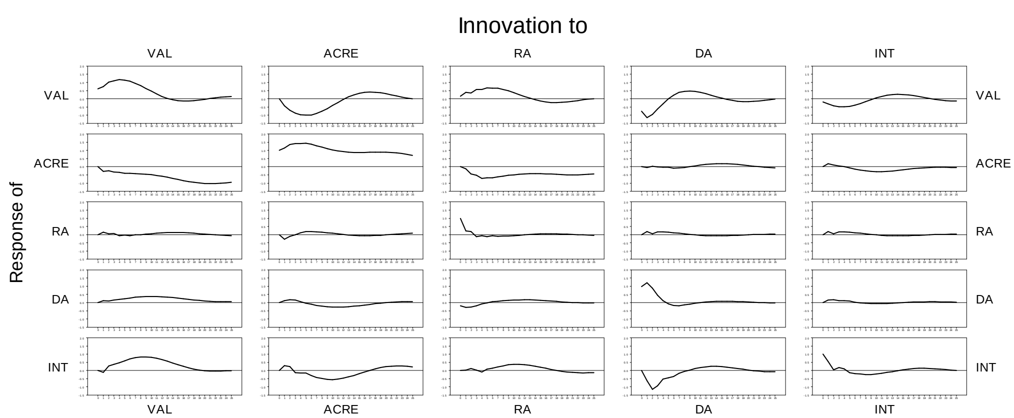


C.10. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in Georgia[29]

[29] All abbreviations and acronyms are provided in Appendix A

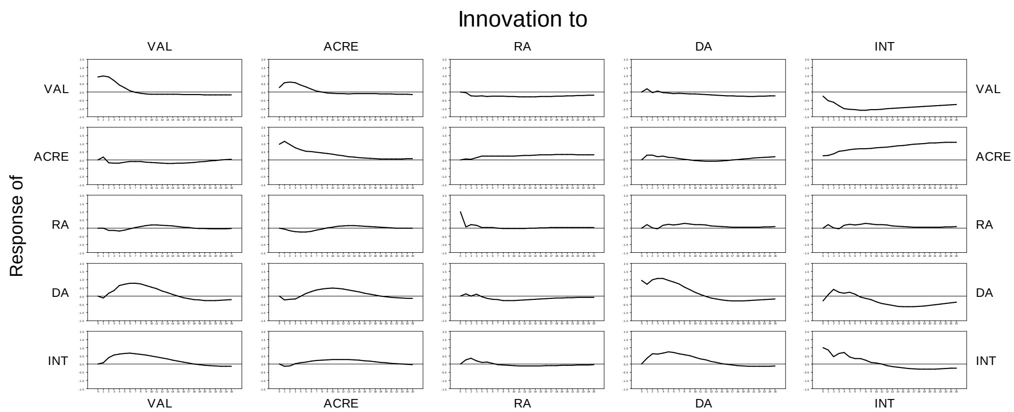


C.11. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in Iowa

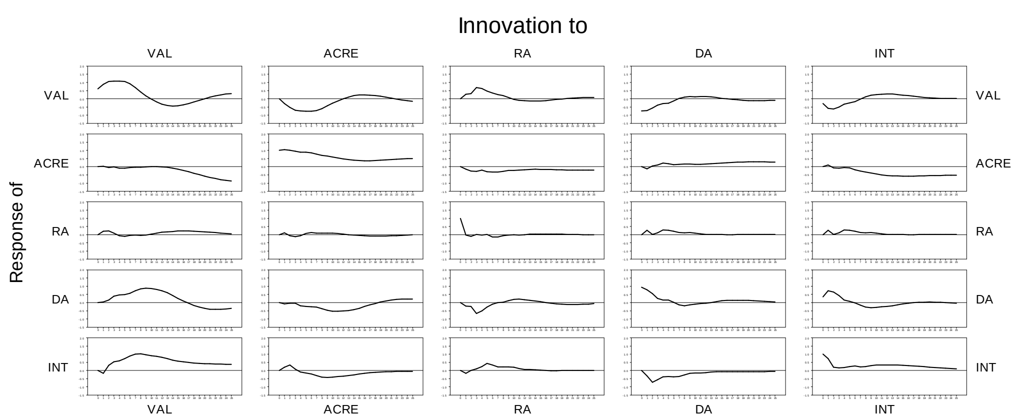


C.12. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in Kansas[30]

[30] All abbreviations and acronyms are provided in Appendix A

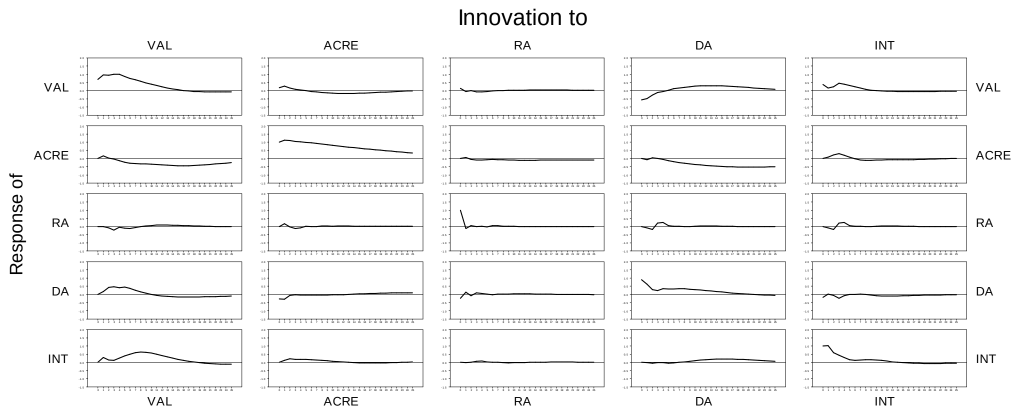


C.13. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in New York

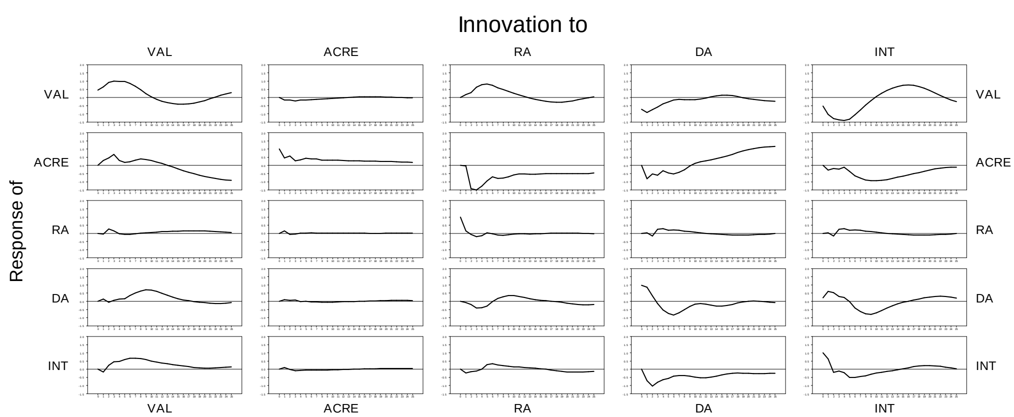


C.14. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in Ohio[31]

[31] All abbreviations and acronyms are provided in Appendix A



C.15. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in Texas



C.16. Normalized responses of Farmland Values, Farmland Acreage, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates (10-Year Treasury Bond Rate) to a one time only shock in every other series over horizon of 26 years in USA[32]

[32] All abbreviations and acronyms are provided in Appendix A

APPENDIX D

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in California

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
9.35669678	37500	13231.60957	15.01017556	2.40
10.31274746	37800	23554.3427	14.77477887	2.40
11.67682593	38200	23827.8187	14.31751095	2.40
11.90800836	38600	18034.2737	13.86272864	2.40
11.74023204	39100	16478.2758	14.52883272	2.40
12.25400631	39200	18554.6273	15.24216001	2.82
12.96856553	39200	19664.62012	14.74971725	3.18
13.79071016	39200	15694.77987	14.51353777	3.65
14.75151717	39100	14625.51936	14.42597247	3.32
16.13034744	39000	12920.50036	14.82847888	4.33
18.1524425	38800	35311.77487	13.4569528	4.12
18.60814811	38600	31529.70077	13.9376244	3.88
18.86704988	38400	35454.29596	14.96148268	3.95
20.04495207	38200	34467.4761	15.08156372	4.00
21.18912081	38000	41745.33589	14.91615553	4.19
21.60795102	37800	36146.44498	16.37899531	4.28
20.36238136	37600	40688.06366	18.07799549	4.93
20.29543457	37400	34558.7546	17.92046176	5.07
19.54567346	37200	40097.27867	17.80614703	5.64
18.31529844	37000	35194.37479	18.90330879	6.67
17.10363861	36600	31446.66694	19.44918438	7.35
17.08396735	36200	29350.97635	20.12794484	6.16
16.87050479	35800	45607.63166	21.64977704	6.21
17.89414202	35400	74755.71754	22.6030494	6.85
18.80706201	35000	76463.42514	23.11721259	7.56
18.70708027	34300	56059.14101	22.73611924	7.99
18.87965773	34200	51409.25579	23.96752794	7.61
21.37611675	34100	51524.22305	23.27604671	7.42
25.91669944	34000	57540.35309	20.60158333	8.41
28.73690796	33900	77485.42215	20.85241506	9.43
32.03729052	33800	79988.23041	19.56252556	11.43
32.13367609	33600	74361.12472	20.55403543	13.92
30.77134994	33400	60425.58182	21.91582416	13.01
30.59450558	33100	50435.49816	22.69456853	11.10
27.41955651	32800	63375.78466	24.5671544	12.46
25.01992166	32500	63990.51915	24.6266131	10.62
22.00005074	32200	64769.62827	23.64087684	7.67
21.72018869	31900	79161.87606	21.52425109	8.39
23.01006525	31300	76404.46736	19.74955186	8.85
23.97892298	30800	70218.73258	18.65595561	8.49
25.44906511	30500	68619.4363	18.07878962	8.55
25.53962371	30200	49995.04081	17.54659536	7.86
25.61283304	29900	57656.8847	17.34676505	7.01
25.00282837	29600	62243.95288	17.92924579	5.87
24.59425026	29300	65569.59041	18.83942948	7.09
26.05438854	29000	47383.52735	18.33652213	6.57
26.63569823	28700	62096.1778	18.21312538	6.44
27.35418959	28500	60889.25639	18.65576333	6.35
28.71210158	27800	48443.78701	19.09426883	5.26
29.12085666	27800	43503.0346	19.20721885	5.65
32	27800	42621.61141	20.24037779	6.03
33.20247651	27800	27014.44058	20.41021842	5.02
34.55126544	27600	37934.17416	20.94926627	4.61
35.74452074	27100	62928.67115	20.68433525	4.01

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in Georgia

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
2.623490618	26000	7189.423735	9.814860716	2.40
2.706977096	25800	11261.75335	9.973280641	2.40
3.121269226	25600	7059.754269	10.11931576	2.40
3.287315237	25400	9281.707974	9.748399505	2.40
3.203190791	25200	1955.168528	10.41414053	2.40
3.254428178	24800	6558.447724	11.41398791	2.82
3.399776453	24400	3748.09883	11.28116586	3.18
3.671412175	23800	2933.23088	11.3230999	3.65
3.965298698	23200	6946.440729	11.38368439	3.32
4.389813756	22600	3539.739651	12.20543588	4.33
4.846987265	22000	4710.886629	13.70610209	4.12
5.403881397	21400	7077.076333	13.7164841	3.88
5.33098461	20500	5732.160295	15.7858403	3.95
5.871290308	19800	9285.1951	16.2444997	4.00
6.415469414	19200	6263.843193	17.01236365	4.19
6.877273937	18900	8503.989442	17.57311952	4.28
7.37704918	18700	9434.673582	18.17869502	4.93
7.741557518	18400	8382.415329	18.3853326	5.07
8.588858565	17900	6453.588041	17.73119434	5.64
8.947348297	17600	9008.819826	18.53826858	6.67
9.259931731	17400	7735.412212	18.38945744	7.35
10.02904966	17200	9733.384427	18.05307561	6.16
10.90451095	17200	10128.71066	18.43173722	6.21
13.31073021	17000	19523.5831	17.63313398	6.85
13.65168054	17000	13100.23801	18.68043803	7.56
13.33964796	15000	10583.57305	21.76653366	7.99
14.45201731	15000	9639.194766	21.26732687	7.61
16.02039384	15000	3160.128315	22.44539172	7.42
16.97915301	15000	8329.603623	21.62798356	8.41
18.08164995	15000	8942.42196	22.7024933	9.43
17.96085975	15000	-641.5280485	24.39798294	11.43
15.66093898	14500	8875.315989	27.62335522	13.92
14.96414423	14000	12258.52276	28.06339677	13.01
14.28951799	13700	9221.182632	28.35459289	11.10
13.26458	13500	14782.20834	27.95284037	12.46
12.40764996	13500	11135.49773	27.90610163	10.62
12.66531645	13300	9634.459197	23.95680395	7.67
12.77458852	13000	10285.32795	22.72489112	8.39
13.60526246	12600	12832.66011	20.30961767	8.85
13.73315175	12500	14883.07758	17.66181594	8.49
13.41681574	12100	12405.19789	16.92963882	8.55
12.13635341	12100	15499.08654	17.65838491	7.86
13.08997477	11700	17016.79373	16.87319924	7.01
13.01052155	11600	12301.74389	16.47116398	5.87
13.9588988	11500	18078.13638	16.28530323	7.09
14.7641535	11400	16278.34108	17.07749513	6.57
15.23561939	11300	19221.13763	16.82820345	6.44
15.82560394	11300	16458.85052	16.8778895	6.35
16.8955688	11200	15258.84567	16.52461984	5.26
19.20954755	11100	16337.30007	15.08843556	5.65
19	11100	14709.78784	14.67495954	6.03
20.01914025	10850	18390.02039	14.52827965	5.02
21.11466221	10800	10827.20972	14.1483361	4.61
22.10516414	10800	22392.5319	13.70388566	4.01

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in Iowa

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
9.744642624	34800	41669.98179	10.38984937	2.40
10.62672134	34900	36338.87468	10.27593483	2.40
11.08010146	34900	40991.28041	10.84228764	2.40
10.6475896	34900	24854.84994	10.98791762	2.40
10.43605422	34900	37689.75541	11.65337762	2.40
10.87382519	34900	12918.67543	12.40897092	2.82
10.80566672	34900	15863.01304	12.54579526	3.18
11.0416871	34800	29026.61593	12.83578614	3.65
11.2577779	34800	27048.86778	13.1704456	3.32
11.9625563	34700	12168.40757	14.20485455	4.33
11.49971488	34700	20873.73564	15.23685361	4.12
11.79455853	34700	26656.71253	15.44691094	3.88
11.86723531	34700	27247.68049	16.64948915	3.95
12.15540572	34600	32784.18921	18.02396301	4.00
12.60504202	34600	29314.48615	18.77620129	4.19
13.75454787	34600	43553.73117	18.30135167	4.28
14.92666091	34500	46412.32946	18.53540841	4.93
15.27388375	34500	33949.77922	19.89206501	5.07
15.33151389	34400	30732.98444	19.98292588	5.64
14.98872022	34400	37647.22477	20.3705473	6.67
14.23487544	34400	34921.92535	20.73381969	7.35
14.31733296	34400	26828.61683	21.21827106	6.16
15.44529515	34300	47289.4627	19.88525764	6.21
18.74175928	34300	92653.77001	17.64686146	6.85
20.70792892	34300	48429.69009	17.11917986	7.56
24.2060673	34100	45961.62802	15.97945766	7.99
31.31684991	33900	22856.06584	14.48706058	7.61
31.12867767	33800	22589.27113	16.02336828	7.42
33.87089725	33800	48013.6894	15.57140121	8.41
37.13195972	33800	38502.0455	16.05529942	9.43
36.97606452	33800	22869.88294	15.96158882	11.43
31.94763902	33700	41886.32061	17.85626122	13.92
26.98711183	33700	29310.7878	20.98083154	13.01
23.41388428	33700	12517.39777	23.21806212	11.10
16.22577249	33600	39021.52053	29.06533722	12.46
12.60562137	33600	40489.0293	31.64364937	10.62
11.10826937	33600	39024.36069	29.63084832	7.67
13.03557373	33500	40592.21689	22.25066391	8.39
14.46384699	33500	28341.21651	18.97915499	8.85
13.87315608	33500	32171.86535	18.73369282	8.49
13.95593893	33500	32766.99264	17.99811293	8.55
13.65191754	33400	21837.94363	18.38856575	7.86
14.02745307	33100	30744.20728	17.84375574	7.01
14.48127616	33100	3937.832126	18.30525828	5.87
14.955963	33000	32452.9036	18.23824201	7.09
15.74119307	33000	21716.01682	17.52281545	6.57
17.04684687	33000	46879.22948	16.93188899	6.44
17.8169051	33000	39287.49348	16.80417025	6.35
18.34672195	33000	24949.33233	17.33504714	5.26
18.59647689	32800	16261.87654	17.31556898	5.65
18.5	32800	22554.30887	17.88849897	6.03
18.7496338	32000	22404.58	18.13626034	5.02
19.2911232	31800	17744.38952	18.16617854	4.61
20.69419622	31700	16647.31442	17.25805066	4.01

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in Kansas

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
3.989691396	50500	16406.08	9.65798361	2.40
4.153405242	50500	9984.57807	9.978540447	2.40
4.42792905	50500	17821.09831	10.29306533	2.40
4.441332291	50500	1807.437155	9.963233051	2.40
4.271057463	50500	7863.056823	10.70416041	2.40
4.319498213	50400	-1052.283452	11.61109546	2.82
4.351551227	50400	-461.6050692	11.57111108	3.18
4.362268924	50300	1458.55412	12.0229245	3.65
4.535290973	50200	16402.49494	12.29685625	3.32
4.712766934	50200	7579.602967	13.44307511	4.33
4.846987265	50200	10344.44691	13.46094412	4.12
5.027959212	50200	11411.4002	13.83635877	3.88
5.191915446	50200	10712.94737	14.61682935	3.95
5.274987386	50200	9530.411149	16.23218744	4.00
5.557061534	50200	7484.151808	16.68868576	4.19
5.989883752	50200	11896.94877	17.07828704	4.28
6.212251941	50100	13395.14833	17.55566391	4.93
6.528016069	50100	9430.433992	18.01686931	5.07
6.501846203	50000	8388.866651	18.27136466	5.64
6.079608458	50000	11471.20435	18.93645461	6.67
5.882780158	49900	16026.37695	18.9507412	7.35
6.017429797	49700	19041.38699	19.20005891	6.16
6.595737629	49500	29377.51532	18.36256283	6.21
7.9424876	49300	50374.97406	16.15872306	6.85
8.525100084	49000	28076.44132	16.42372095	7.56
8.998342411	48700	16715.40682	16.49479105	7.99
9.900004975	48600	8190.704922	17.10983782	7.61
9.775948361	48400	7855.028106	18.70654623	7.42
10.94794808	48300	6674.492115	17.22552041	8.41
11.84590237	48300	15996.97195	16.86041165	9.43
11.44981688	48300	-1697.507826	17.09821657	11.43
10.62102557	48300	7258.925919	18.4112883	13.92
9.64141781	48300	14865.58029	19.77674881	13.01
9.21872341	48300	9704.138322	20.3543855	11.10
7.266773405	48000	14593.42993	23.119822	12.46
6.000527117	48000	18148.23356	25.2518829	10.62
5.279318932	47900	15670.13481	23.90948204	7.67
5.694204306	47900	18707.14232	20.22714895	8.39
5.666657861	47900	16442.61878	19.02242851	8.85
5.727449758	47900	10991.69881	18.33806021	8.49
5.501507094	47900	19285.68905	18.69280334	8.55
5.446558604	47800	10975.10723	18.33349363	7.86
5.358672253	47700	16694.08887	18.20856258	7.01
5.690688992	47600	13458.48076	18.05743308	5.87
5.926992744	47600	19202.10744	17.9051373	7.09
6.003365359	47500	8089.005249	18.10295973	6.57
6.0196678	47500	19938.71914	18.28384971	6.44
6.047267201	47500	16538.51442	18.68142657	6.35
6.011920187	47500	13128.57618	19.51269535	5.26
6.028528222	47500	12011.75983	19.16134127	5.65
6.45	47500	5342.427685	19.30948673	6.03
6.494013789	47300	6274.246836	19.92905449	5.02
6.574338007	47300	-2436.59279	20.77018484	4.61
6.725613771	47200	9761.863908	20.17168441	4.01

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in New York

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
5.5567246	17000	-408.6862419	8.217347904	2.40
5.548486273	16800	1873.887119	8.51999384	2.40
6.040340263	16400	1804.84966	9.019693581	2.40
6.010270241	16100	519.1115506	8.992938646	2.40
5.689129745	15800	-802.7301183	9.794615674	2.40
5.975459501	15600	-1673.096065	10.54866764	2.82
5.973623484	15400	-606.9929735	10.64404234	3.18
6.295670462	15100	588.5020047	10.84137275	3.65
6.370694017	14800	1837.564143	11.25661529	3.32
6.868638534	14500	-1302.638016	12.37152696	4.33
6.890325033	14300	619.41416	14.17687877	4.12
7.189511771	14000	1728.866219	15.02767043	3.88
7.463378454	13700	-1478.188069	15.97682246	3.95
7.843676896	13400	1215.633361	16.67867298	4.00
8.31300262	13200	734.2582822	16.99071358	4.19
8.56331529	13000	2867.086004	17.75390919	4.28
9.145815358	12600	5572.597115	17.25325449	4.93
9.582792819	12000	3141.820506	17.86999888	5.07
10.03371328	11500	2529.451809	17.58990119	5.64
10.43857301	11200	3748.470307	17.62938108	6.67
10.42196238	11200	2667.698254	17.72768997	7.35
11.17028635	11000	2058.603923	17.96799816	6.16
11.79941003	11200	-13.58756753	18.42057553	6.21
13.96998807	11500	3026.48564	17.99061263	6.85
14.68851704	11700	-1255.193659	17.58949039	7.56
14.54995132	10600	-3664.00914	18.13397952	7.99
14.60126362	10200	-3045.392839	18.60205149	7.61
14.03246176	10000	-4885.193021	20.72370895	7.42
14.64096849	9800	-1886.611075	20.88081637	8.41
14.52989728	9600	571.3780058	22.05976075	9.43
14.29839814	9400	504.7191721	23.85217101	11.43
13.88513056	9700	1880.535236	22.86961937	13.92
13.22886928	9500	1846.42133	24.72878754	13.01
13.21239966	9500	-1035.187986	26.31596303	11.10
12.31617411	9400	682.6754685	22.94392498	12.46
12.29010061	9100	1031.553405	23.88435882	10.62
13.69521342	8900	389.1502359	21.18610045	7.67
13.79425822	8700	1473.145813	19.23392924	8.39
13.80339735	8400	-358.2160512	17.57237145	8.85
12.90585345	8400	826.9463629	18.39103288	8.49
13.41681574	8300	39.54483299	17.19386703	8.55
13.48615272	8200	-1348.04452	15.81357509	7.86
14.31679822	8100	279.0678188	15.6813113	7.01
14.25500622	7900	-1854.78615	16.17681603	5.87
14.18046862	7900	-2805.608306	16.32173654	7.09
13.67855398	7800	-4521.708034	17.08736949	6.57
13.31784911	7800	-1342.902352	17.59300487	6.44
13.41508149	7800	-5571.728182	18.40754358	6.35
13.88960871	7800	-3885.058424	17.88924655	5.26
14.40716067	7700	-4600.841623	17.77332392	5.65
15.2	7700	-2534.662938	17.96050463	6.03
15.72234917	7660	-214.2680893	17.95040008	5.02
16.31587535	7660	-4319.832971	18.43958808	4.61
16.74348603	7650	-1935.615173	17.11465317	4.01

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in Ohio

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
8.265947689	21800	6513.084785	7.795110256	2.40
9.167637867	21400	6720.851294	7.726807779	2.40
9.939474707	21000	8095.497227	8.027196805	2.40
9.717454869	20700	5689.975346	8.173209427	2.40
9.735314328	20400	8505.370225	8.633009097	2.40
10.16083221	20200	380.8943127	9.22236766	2.82
10.58367769	20000	115.4734658	9.11620486	3.18
11.87331169	19800	-1692.051196	8.758819836	3.65
11.36716387	19600	3607.142953	9.461484227	3.32
11.7180243	19400	-2705.756189	10.40671117	4.33
11.7373123	19200	2690.290216	11.50890893	4.12
12.12349044	19000	4866.85066	11.80607195	3.88
12.2844428	18800	3291.602077	12.64805717	3.95
13.16453374	18600	3469.032295	13.04195052	4.00
13.55380862	18400	2363.441033	13.88821044	4.19
14.19824297	18200	5166.94584	14.61846887	4.28
14.88352028	18000	10932.30087	14.4905299	4.93
15.23203749	17900	3304.772736	15.05165444	5.07
15.17097447	17800	4949.8879	14.90188428	5.64
15.25637594	17700	4113.529182	14.67871808	6.67
15.10639843	17600	3846.151894	14.52159241	7.35
15.18190621	17500	3108.543195	14.90263488	6.16
16.73792715	17400	6519.381201	14.06267589	6.21
19.68355623	17300	12010.78561	13.2513099	6.85
20.33351574	17200	12688.64359	13.41724947	7.56
22.25905754	16700	9063.950856	13.07842981	7.99
27.33694841	16500	5900.076756	11.99682265	7.61
28.62622199	16400	4094.199217	12.81327802	7.42
32.4068004	16300	4623.516156	12.22187794	8.41
34.9121143	16300	6811.126723	12.15286947	9.43
33.86852133	16200	3650.778533	12.56985011	11.43
27.55039913	16100	-5435.405616	15.2905434	13.92
24.20721355	16000	-1076.312907	16.38349258	13.01
23.25606242	15900	-5379.959446	16.10307128	11.10
18.17851978	15800	7622.757152	17.98443124	12.46
16.51528488	15800	8389.185986	17.84213506	10.62
15.62219756	15800	1595.16754	16.72340479	7.67
16.64419122	15600	2410.905302	14.17311309	8.39
17.1452725	15700	6983.707748	13.11214404	8.85
16.20231898	15600	10961.75429	12.84039647	8.49
16.21045409	15500	9496.645977	12.15147877	8.55
16.52912133	15300	-1444.420806	11.86552027	7.86
16.85146177	15200	5847.829792	11.45157107	7.01
17.64905532	15100	2751.557315	10.68588072	5.87
19.38735944	15000	5748.343949	10.81207526	7.09
19.75791131	14900	1015.508503	10.93868595	6.57
20.13658786	14900	7924.483726	11.14972999	6.44
21.38028612	14900	9960.463444	11.25430042	6.35
23.01114278	14900	2545.801066	11.24832643	5.26
23.50104222	14900	-3291.541356	11.15706479	5.65
24.7	14900	3376.722007	11.00089871	6.03
25.3901291	14680	2359.17753	10.98134635	5.02
26.29735203	14610	-11516.34534	11.35500784	4.61
27.56090678	14600	931.7638732	10.98582477	4.01

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in Texas

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
2.801996807	150000	22512.16702	9.655667674	2.40
3.131286337	151000	27485.37659	9.428340664	2.40
3.367833627	152000	18742.35324	9.590203882	2.40
3.336056645	153000	11458.80413	9.465485442	2.40
3.289024093	154000	15440.46292	9.963496542	2.40
3.340638196	154000	12391.5446	10.73767364	2.82
3.283983578	154000	8669.641567	10.97018108	3.18
3.498048934	154000	-9632.811888	10.8444969	3.65
3.397124521	154000	28581.36751	11.5819247	3.32
3.650368134	154000	20012.27965	12.23253423	4.33
4.229233986	153000	14553.05782	11.22892439	4.12
4.417085663	151500	22302.22358	11.46109569	3.88
4.681995179	150000	15686.95352	11.85217959	3.95
4.862162286	149000	12932.52105	12.97589726	4.00
5.150447276	148000	8915.288002	13.78478713	4.19
5.279971604	147000	16824.25561	14.36547205	4.28
5.349439172	146000	19174.91789	14.70026364	4.93
5.565552161	145000	11068.7456	14.77508883	5.07
5.699149141	144000	15517.80001	14.5491965	5.64
5.659006615	143000	15498.44575	14.73026322	6.67
5.664899412	142800	24402.76769	14.12407474	7.35
5.982846867	142500	17905.35252	14.19206156	6.16
6.496304398	142000	27194.20883	13.9660577	6.21
7.56576882	141800	65051.94856	12.89118587	6.85
6.998646352	141800	19265.11421	14.50491039	7.56
7.209198306	140000	22537.24642	14.15128869	7.99
7.437440923	139700	17721.49036	13.97188288	7.61
7.881566023	139300	14932.32033	13.79044845	7.42
8.434946025	139000	16472.87434	13.58224464	8.41
8.798660021	138600	29893.41726	13.32000244	9.43
8.656727461	138200	3674.001941	13.85863077	11.43
9.115816534	137600	28554.90216	13.42265167	13.92
8.728661446	137200	18934.88454	13.5235615	13.01
9.455378025	137000	22475.70753	12.74609174	11.10
10.3432168	136800	24528.58726	12.10472093	12.46
8.598845388	135500	26116.05796	13.97481584	10.62
7.739390115	134000	13345.95608	13.7114745	7.67
7.513707681	133200	30131.0004	12.91683478	8.39
6.881885187	132000	25374.71598	12.53652021	8.85
6.452926727	132000	22104.70559	12.01344472	8.49
6.101894283	131000	31804.07045	11.84424842	8.55
5.778088258	130000	25040.76192	12.30788503	7.86
5.775329275	133000	34172.20354	11.35677302	7.01
5.826450956	133000	36536.16373	11.49406194	5.87
5.816207832	132000	32991.19817	11.76356401	7.09
5.862237421	132000	15987.47262	12.06400033	6.57
5.902470727	131500	11856.70364	12.24672114	6.44
6.21495572	131500	18562.31219	11.99808452	6.35
6.322881576	130500	14410.55925	12.20581056	5.26
6.437241999	130000	25935.54195	12.14019459	5.65
7.3	130000	8896.43785	12.14729013	6.03
7.568211558	130700	18527.94932	12.05441723	5.02
7.774034724	130500	23946.81708	12.09500221	4.61
8.042517167	130500	26581.23103	11.90263041	4.01

Annual data of Farmland Values, Returns to Farm Assets, Debt to Asset Ratio and Interest Rates in USA

LVALUE	ACRE	RETURN	D/A RATIO	INTRATE
5.646401963	1175646	188928.296	12.87386088	4.12
5.868305411	1167699	244647.4116	13.28963066	3.88
6.057285426	1159383	249449.6527	14.11842557	3.95
6.360743877	1151572	264080.9739	15.02882555	4
6.652047671	1146106	214043.463	15.74496303	4.19
7.037719076	1139597	319622.6685	16.21742639	4.28
7.270063984	1131844	361212.9551	16.76032984	4.93
7.503427384	1123456	277496.6097	17.15191742	5.07
7.592862963	1115231	253245.0314	17.07937462	5.64
7.49318859	1107811	308570.3297	17.33559438	6.67
7.396145144	1102371	292989.0133	17.39490806	7.35
7.595554266	1096863	304046.6481	17.50562249	6.16
8.155194625	1092065	448249.9191	17.09149896	6.21
9.49813616	1087923	917735.1254	15.95450822	6.85
9.812862797	1084433	568161.7413	16.62415784	7.56
10.45531999	1059420	457355.9803	16.34807866	7.99
11.79407899	1054075	288849.9281	15.9361331	7.61
12.42259206	1047785	256355.7037	16.63899982	7.42
13.71982757	1044790	366987.6603	15.92626328	8.41
14.86959778	1042015	427635.0306	16.12802788	9.43
15.13614592	1038885	208889.7013	16.23634304	11.43
13.92738563	1034190	380404.9755	17.80618586	13.92
12.70204283	1027795	339030.5782	19.11326855	13.01
12.42628152	1023425	189906.398	19.40769596	11.1
10.67164535	1017803	431032.9635	21.0304047	12.46
9.310696413	1012073	423054.5594	22.18749613	10.62
8.556580173	1005333	330075.3364	20.95626114	7.67
8.771681588	998923	425322.8442	18.30949251	8.39
8.848322874	990723	399126.6475	16.88446628	8.85
8.708755134	986850	451124.3252	16.10242114	8.49
8.636633837	981736	414007.7142	15.5977241	8.55
8.466141365	978503	297183.4146	15.62163606	7.86
8.59099341	968845	407744.4581	15.16149457	7.01
8.981569801	965935	315144.1919	14.77291021	5.87
9.289790875	962515	384193.2948	14.8631051	7.09
9.581381633	958675	226520.916	14.805755	6.57
9.800218796	956010	432860.3631	14.81407441	6.44
10.15284667	953500	319000.2754	14.92535211	6.35
10.51342249	947440	266686.8542	15.19597261	5.26
10.99850492	942990	208579.5436	14.72534082	5.65
11.46328332	945080	232595.2158	14.76354467	6.03
11.82324171	942070	237896.2227	14.78611854	5.02
12.22345541	940300	80511.03177	14.82394318	4.61
12.76003833	938650	283464.5918	14.36062622	4.01

VITA

Meri Davlasheridze was born and raised in the country of Georgia. In 1998 she obtained her diploma in Production Economics, Organization and Management from Tbilisi State University of Georgia. The same year she continued her post graduate study in Agricultural Economics at Agrarian State University of Georgia, Tbilisi.

From 1997 up to 2005 she has worked for various international companies dealing with rural and agribusiness development. She was a coordinator for USAID funded ACDI/VOCA Farmer to Farmer Project for couple of years before pursuing her degree at Texas A&M University.

Address:

Department of Agricultural Economics

Texas A&M University

2124 TAMU

College Station, TX 77843-2124