AN ABSTRACT OF THE THESIS OF

Deqin Cai for the degree of Doctor of Philosophy in Agricultural and Resource Economics presented on October 20, 1995. Title: The Cyclical Behaviors of Agricultural Farmland Prices

Abstract approved by: Redacted for Privacy

J. Douglas Brodie / Richard S. Johnston

This research studies the cyclical behavior of agricultural farmland prices in the United States with a special emphasis on how agricultural policies contribute to farmland price movement.

The first stage of the study is to have a conceptual understanding of how agricultural policies affect the behavior of farmland prices. A theory is developed to accomplish this goal. It assumes that a farmer maximizes the expected utility generated from production profit subject to an uncertain wealth accumulation process and government policy constraints. The farmer's choice variables are how much input to use and how much land to hold. Based on this framework, the farmland price is endogenously determined from the farmer's optimizing behavior. It shows that in states where the farmer's expected rate of appreciation of land price is higher than the rate of return in off-farm investment, government transfer payment programs can actually increase the variability of the farmland price. On the contrary, in states where the farmer's expected rate of appreciation of land price

is lower than the rate of return in off-farm investment, government transfer payments do stabilize the fluctuation of the prices.

The second stage of the research is to empirically analyze the cyclical behavior of farmland price. Annual land price data were collected from the USDA for the years 1910-1989. The data on total state agricultural cash receipts and government program transfer payments are from *Agricultural Statistics*. The ratio of government transfer payments to total state agricultural cash receipts is formed to measure the relative importance of agricultural programs in each state.

Nonparametric procedures are used to analyze the volatility, persistence, and comovement of agricultural land prices in 48 states. The result indicates that the behavior of farmland prices differs in two groups of states. In group one, which includes almost all of the North Central and Plains states, the empirical results show that the volatility has increased after farm policies were introduced. The movement of the farmland prices turn from stationary to being nonstationary. However, in group two, including almost all of the New England and Mid-Atlantic states, the volatility and persistence of the farmland prices are not statistically significant. In fact, in some of the latter groups, the volatility and persistence actually declined after farm policies have been introduced.

Finally, the empirical findings also show that although the general macroeconomic conditions are important in the forming of farmland prices in each state, specific economic and geographic factors also play an important role in the cyclical behavior of farmland prices.

The Cyclical Behaviors of Agricultural Farmland Prices

By Deqin Cai

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Completed October 20, 1995
Commencement June 1997

Doctor of Philosophy thesis of Deqin Cai presented on October 20, 1995

APPROVED:

Redacted for Privacy

Co-Major Professor, Representing Agricultural and Resources Economics

Redacted for Privacy

C0-Major Professor, Representing Agricultural and Resource Economics

Redacted for Privacy

Head of Department of Agricultural and Resource Economics

Redacted for Privacy

Dean of Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University Libraries. My signature below authorizes release of my thesis to any reader upon request

Redacted for Privacy

Deqin Cai, Author

ACKNOWLEDGMENTS

I would like to thank my previous academic advisor Dr. Allan Love for his support and help in my thesis research. After Dr. Allan Love left the Oregon State University, Drs. Brodie and Johnston served as my major advisor and co-chair of my thesis committee, respectively. Thanks go to them for their continued guidance and encouragement during the final stage of this thesis writing. In addition, I also would like to thank Dr. Perry, Dr. Thomas and Dr. Philbrick who served on my committee.

Finally, the financial support for the Robert F. Johnson Fellowship is highly appreciated.

TABLE OF CONTENTS

LIST OF TABLES

THE CYCLICAL BEHAVIORS OF AGRICULTURAL FARMLAND PRICES

CHAPTER 1

INTRODUCTION

Nonparametric statistics are used to analyze the volatility, persistence, and comovement of agricultural land prices in 48 states for the period 1910-1989. The main focus is on possible changes in the cyclical behavior of land prices after agricultural policies were introduced in 1933. Two important characteristics that are compared across time periods are the volatility and persistence of short-run movements in real land prices. We analyze whether short-run fluctuations have become less extreme and whether the tendency of shocks to have permanent or transitory effects changed after agricultural policies were introduced. Correlation of short-run price movements across states is also investigated to determine if macroeconomic or sectoral shocks dominate or if individual state land price series move in different ways. The methods used in this study were recently applied in Romer (1991) to 38 annual production series to investigate the cyclical behavior of individual production series in the United States from the period 1889-1984..

Two important policy issues can be illuminated by examining how lengthy land prices vary over time. First, because land is the fixed resource used in agricultural production, land prices should be determined by the discounted stream of expected future earnings. Effective agricultural policies should reduce farm income variability and, hence, dampen fluctuations in anticipated land price. If agricultural policies have been effective, we would expect land price fluctuations in each state to become more stable after their introduction[2]. Second, the relative importance of macroeconomic and sector-specific shocks is not well understood. If macroeconomic factors dominate land price movement, price in each state should respond similarly to shocks. If, however, land prices in some states tend to respond to shocks differently than land prices in other states, this would indicate state-specific and possibly sector-specific factors are most important.

This paper is organized as follows: The literature review is given in Chapter 2. Chapter 3 develops a theory to see how government policies enter the land price movement. Chapter 4 describes the data and methodology. The volatility and persistence of land price growth are analyzed in Chapters 5 , 6. Chapter 7 investigates the relationship between states and payment programs. The last chapter provides a summary.

[1]It should be kept in mind that the purposes of agricultural policies are complex and multidimensional. The reduction of farm income variability is only one of them (Boulding, 1983).

[2]The same idea is used by Romer (1986) to study the stabilization of the postwar economy in the United States.

CHAPTER 2

LITERATURE REVIEW

1: Literature Review:

There are many models in the literature to explain land price movements. Among them the following are most widely used:

[a]: Portfolio Equilibrium Model (Feldstein, 1980)

This model assumes that the economic agent holds short-term nominal assets ("bills"), land, and capital. The current price level and inflation rate are known, but the rate of inflation in the future is unknown. The wealth consists of three parts: the return from bills, the value of land, and the return to capital, where return to land and capital are uncertain and returns to bills are riskless. Also, it is further assumed that the economic agent is endowed with a quadratic utility function of wealth. It follows that the expected utility is a linear combination of the mean and variance of wealth. Given this formulation, the model can be used to solve explicitly for the equilibrium asset prices of land and capital. The main purpose of the model is to understand how changes in expected inflation and in its uncertainty affect the real prices of land and capital. It shows that changes in the rate of inflation affect the relative prices of assets. Therefore, an unanticipated jump in the expected rate of inflation leads to a jump in the level of land price. This model emphasizes the importance of inflation in the formulation of land price.

[b]: Land Accumulation and Credit Rationing Model (Shalit and Schmitz, 982)

The idea of this model is to derive the demand for farmland induced by agricultúral production. No speculative motives are involved in this formulation. It is assumed that the farmer maximizes the utility of consumption and bequest, which is the net value of land, and the farmer is a price taker in which all prices of inputs and outputs are known during his lifetime. The difference between consumption and wealth is saved and is used only for the purchase of additional land. When the farmer purchases farmland, credit is allocated on the basis of wealth. To get funds, the farmer has to offer his wealth as collateral. A key assumption in the model is that the farmer will purchase land as soon as the return to land investments is higher than the market rate of interest. The farmer's formal problem is to maximize utility subject to a land constraint, debt constraint, and credit constraint. Under this approach savings and accumulated debt are major determinants of farmland prices. Thus, the farmland price is not only determined by the profit it generates, but also by the debt it carries, which is associated with the banker's willingness to lend money to the farmer. This willingness, in turn, depends on the banker's expectation about the future price of the farmland. Using annual data for the 1950-80 period, Shalit and Schmitz (1982) estimated the price of the land as a function of the debt per acre, the prior year's net income, and factors that contribute to the last year's consumption. The empirical debt equation was estimated as a function of land price, the number of farmers, and the market rate of interest. Finally, they jointly estimated the price and debt equations using a two stage least square method to correct serial correlation in the error in their covariance structure. The correction of serial correlation is necessary since we might expect that a higher farmland price is positively associated with a higher debt level. Their empirical finding supports the hypothesis that the farmland price is positively associated with the debt level, while the farm income's impact on the land price is small.

[c]: Expectation and Capital Gains Model (Castle and Hoch, 1982)

Castle and Hoch argue that expectation plays an important role in the behavior of farmland price movements. The expected land price is determined by two components. The first component is the capitalized value of the current year's net contribution of real estate to agricultural income. The second component is the real capital gains. In their model, they assumed that the rent in the current year is R, having increased by a real amount, C, over the previous year, and it will increase C every year thereafter. Based on this set up, it is shown that the present value of the stream of farm returns to the land can be decomposed into two parts. The first part is the capitalized rent value. The second part is the capital gains. Their empirical testing used the data spanning the period 1920-1978 with the conclusion that the capital rent can only explain half of real estate values, another half can be explained by the capital gains or losses due to the changes in price level.

[d]: Heterogeneous Expectation Model (Brown and Brown, 1984)

This model considers how uncertainty about the future affects farmland price. In this formulation, the land owner's optimal preservation price, i.e., the minimum price at which he would sell the land has a speculative component, resulting from the land owner expectation that other farmers might have higher expectation about land price than he does. Those farmers that have higher land price expectation, therefore, would buy land from the land owner. As a result, lands would go to people who value them most. The land price is therefore bid up. They formulated a model to show how the optimal reservation price is determined from expectations. The result indicates that the sale price of land depends on two factors. The first one is the present value of land, and the second factor is the distribution of expectations about potential offers for land. Using Corn Belt and Lake States data on land prices for 1968-81, they created an extremely preliminary empirical test to support the importance of distribution expectations on the future potential buyer's offer price.

[e]: Nonfarmland Investment Opportunities Model (Robinson, Lin and Ventakaraman, 1985)

This model emphasizes the relationship between agricultural and nonagricultural land markets. They show how the expected growth rate in net cash return to land, inflation expectation, property income, and capital gain taxes affects the formation of land prices. Using data from 24 states from 1960-1981, they show that significant differences exist between states in the land price markets, and in many states, agricultural land prices are altered by nonagricultural demand for land.

[f]: Mixing Rental Income and Inflation Model (Alston, 1986)

In his study, Alston combined the real growth in net rental income to land and inflation into a model. The farmer is assumed to maximize the present value of land. It is shown that the effect of the inflation rate is theoretically ambiguous. Thus, the model favors the hypothesis that the land price is determined by the net rental income. Alston used data from eight states of the United States for various intervals between 1969 and 1982. The results indicate that inflation has only a small effect on the growth of real land price. Most of the growth in real land price can be explained by the real growth in net rental income to land.

[g]: Demand Side Model (Burt, 1986)

Burt argues that the classical supply function of land does not exist. The price of farmland is totally determined by the demand side. The nonexistence of a supply function of land is probably the major reason why the simultaneous equation estimation approach, developed in the 1960's (Herdt and Cochrane, 1966; Tweeten and Martin, 1966; Reynolds and Timmons, 1969), which equated the demand and supply sides of the land market performed very poorly. Moreover, the study by Pope, Kramer, Green, and Gardner (1979) also demonstrated that the performance of such models was quite discouraging. Burt used a distribution lag model to capture the dynamic adjustment process of land price. He argued that the use of aggregated data can exacerbate many problems in analysis of land prices, because of large difference in heterogeneity. Instead, he used the price of high quality grain land from Illinois for 1959-82, imposing an ARMA structure to do empirical testing. His empirical result concludes that the rent is a driving force in land price determination. However, there is little evidence that land price is driven by speculation motives. Also, the effect of the inflation rate on land prices is not significant.

[h]: Rational Bubble Model (Falk, 1991)

Using the statistical method developed in a study of the stock market by Campbell and Shiller (1987), Falk formally tested the validity of the constant discount rate version of the present value model of farmland prices. Using data from Iowa land prices and rents for 1921-86, he concludes that, although there is a positive correlation between land price and rent, land price is much more volatile. A formal testing fails to support the present value model hypothesis. Thus, he proposes that the farmland price is characterized by rational bubbles. The rational bubbles are factors which are fundamentally irrelevant to the determination of an asset's price, such as self-fulfilling expectation. These rational bubbles cause the farmland price to deviate from the value of the asset predicted by the present value model in a non-stationary way.

[i]: Geographically Dispersed Market Model (Benirschka and Binkley, 1994)

The most recently published study of farmland price is the work done by Benirschka and Binkley (1994). Based on the rent theory dating from Ricardo and Von Thunen, they construct a model to show that the farther away from the central market, the more sensitive is land price to boom and bust periods. They argued that investors in less favorably located areas should adapt more flexible plans, and government policy should consider the difference in geographic factors. Their hypothesis was tested using county data from five Corn Belt states for the period of 1969 to 1987.

2. Discussion of Literature Review

Despite the fact that we have many models to explain the behavior of farmland prices, many of them show contradictory results. The following examples will illustrate this point: In their studies, Burt (1986) and Alston (1986) attributed land price changes to movements in returns, and speculative elements play no role. Falk's study (1991) *rejected* the present value model and concluded that land price movements are much more volatile than rent movements. He proposed several possible interpretations, including speculation bubbles. Furthermore, the study by Clark, Fulton and Scott (1993) also rejected the capitalization of land price determination, suggesting a"complete rethinking" of land price models, including future shifts in government policy. A recent study by Just and Miranowski (1993) showed that inflation rate and return to capital are at least as important as income return to land in the formulation of land price. Also, Feldstein (1980) demonstrated that inflation rate is very important in the formulation of land price movement. However, the most recent study by Benirschka and Binkley (1994) showed that land price variation increases with distance to market.

The main sources of differences in the literature to explain farmland price movements are due to two factors:

[1]:The first one is the conceptual view of how farmland price is determined. If farmland price only responds to movements in returns, then the land price fluctuation truly reflects the movement of factors that are fundamental in the

determination of land price, for example, the expected income stream generated in production from a piece of land. Any factors that affect the expected income stream will affect the fluctuation of farmland price. On the other hand, several authors (Falk, 1991; Clark, Fulton and Scott, 1993) have found that empirical farmland price is much more volatile than rent movement. Thus another explanation of farmland price determination is the hypothesis that the land price is expectation-driven. This hypothesis views a piece of farmland as capital asset, then the results in financial economics shows that the price of capital asset could be determined by some factors which are intrinsically unrelated to the fundamental value of the asset, for example, people's expectation about the movement of farmland price. This expectation-driven hypothesis is common in the literature of financial economics to explain the price behavior of trading securities, such as stock (Campell and Mankiw, 1987).

[2]: The second source to cause differences in explaining farmland price movement is due to the way the empirical work is conducted. There are several factors involved. First, different people use data set from different regions in different periods. Benirschka and Binkley (1994) use data set from five Corn Belt states from the period of 1969 to 1987, Falk uses data set from Iowa from the period of 1921-86, whereas Burt uses the price of high quality grain land from Illinois from 1959-82 and Robinson, Lin and Ventakaraman (1985) use data from 24 states from 1960-1981. Second, the empirical data are executed using different econometric procedures, such as simultaneous equation approach (Reynolds and Timmons, 1969), ARMA structure model approach (Burt, 1986), and simple

regression approach (Brown and Brown, 1984).

In short, the literature shows little consensus, characterizing land price movement by numerous methods and models. Most of them deal with the behavior of farm land prices in the time dimension.

Three important things in the literature are missing: First, there is not an explicit and rigorous theoretical formulation on how government policy affects farmland price movement. Filling this gap will provide some useful insights on possible mechanisms in which government policies affect the land price behavior. Second, the literature lacks evidence of how the behavior of agricultural farmland prices changes before and after the introduction of the agricultural policies in 1933. Moreover, most empirical studies draw data from relatively few states, and periods covered are quite arbitrary. The most comprehensive data covered so far in the literature is the work of Robinson, Lin and Ventakaraman (1985), where they use data from 24 states, but the period covered is only from 1960-1981. The arbitrary selection of data from few states is likely to cause bias in the conclusions. Since different regions are heterogeneous in many factors, such as the structure of economy, the degree of urbanization, and the technology used in agricultural production, etc; it is important to have an empirical characterization of farmland price behavior in each state before and after the time when agricultural policies were introduced. In short, there has not been comprehensive use of disaggregate data set in each state to understand the cyclical behavior of the farmland price. If the farmland price moves differently in each state, the use of aggregate data use might provide misleading information on the farmland price movement[3]. Finally, some important questions can only be answered using disaggregate data. For example, does farmland price in each state move together, as would be the case if the aggregate shocks were the dominant source of fluctuations or if the state-specific shocks had large spillover effect. Or do the state farmland prices move differently, as would be the case if isolated and state-specific shocks were more important in explaining farmland price movement? Third, the empirical work in the literature has been carried out using parametric econometric approaches. In general, the parametric approach needs some assumptions on the underlying data generation mechanism. Thus, the robustness of the parametric approach is quite sensitive to assumptions adopted in tests. It is likely that different test procedures will result in different implications.

The current study fills the three gaps mentioned in the above by providing a theoretical framework to gain some insights of how government policies affect farmland price behavior, and using disaggreate data set on agricultural land prices in 48 states from the period 1910-1989 to cover the pre-policy and post-post policy periods. Finally, this study uses a nonparametric approach, and various econometric test procedures are carried out in order to test the robustness of results. Details will be provided in chapter 4.

---

[3]Romer reports (1991) that traditional aggregate measures of production are not consistent over time, where she studies the cyclical behavior of individual production series from 1889-1984.

CHAPTER 3

THE THEORETICAL FORMULATION

It is important to have a deeper understanding of the connection between farmland price movement and government programs. Essentially, farming is a risky business. It is difficult to completely anticipate farm income and land price appreciation since economic environments are not fully predictable. Therefore, it would be crucial to incorporate this stochastic element into our modeling process.

Just (1993) points out that , in addition to the discount rate, the fundamental force in the return to farming is the wealth accumulation process. The wealth accumulation process in farming is characterized by a high degree of risk. Thus, the usefulness of the model developed by Shalit and Schmitz (1982) is severely restricted because it fails to take the stochastic economic environment into account.

Our main modeling effort is to introduce a stochastic component in the wealth accumulation process in a dynamic setting. At the same time, we also want to see how government policies enter the economic environment in which the farmer has to make decisions. The final goal is to understand how government policies affect farmland price movement.

To make the model more concrete, we assume that a representative farmer must take two choices at the beginning of the planning period. The first one is to decide how much land to hold; the second one is how much input to use in the production. Conceptually, we could argue that land is very illiquid, one can not buy and sell land in a short period of time. This criticism can be circumvented by introducing an adjustment factor to penalize a fast holding or selling of land, but this extra introduction will not qualitatively change our main result in this research. It is further assumed that the farmer forms the expectation of the appreciation rate of land price based on currently available information, including general macroeconomic conditions, input and output prices, off farm investment opportunity and earning potential, as well as the perception of income protection due to government programs.

The model will be defined using the following notation:

x: input choice variable

p_x: price of input

g: government payment

p_y: price of product output

y: production output

l: the amount of land held

w: wealth in cash

p_l: the price of land

b_w : rate of the return on off farm investment, which is risk free

b_l: farmer's expected appreciation rate of land price

θ : the percentage of the wealth the farmer decides to consume, which is between 0 and 1.

r: discount factor

The farmer's problem may be formally formulated as follows[4]:

$$\underset{(I,x)}{Max}\, E_t \int_t^{\infty} (p_y y(x) - p_x x) I e^{-rs} ds$$

subject to

$$dw = [b_w w + (b_l - b_w) p_l I + (p_y y(x) - p_x x) I - \theta\,(w + g)]dt + gw\sigma dz \quad (1)$$

$$dg = -\alpha g dt - \beta (p_y y(x) - p_x x) dt, \quad (2)$$

where E is the expectation operator which is conditional on the information available at the time t. Furthermore, the initial data on wealth and government payment are given.

Equation (1) says that wealth accumulation depends on: [1] the return from off farm investment, which is b_w; [2] the real capital gains from investment in land, where $b_l - b_w$ is the premium above the risk free return; [3] the profit from production on land; [4] the farmer's consumption ; [5] a risk term $gw\sigma dz$, where dz is the standard Wiener process. Equation (1) implies that wealth grows with the time horizon, the farmer is certain about the current wealth, but uncertain about future wealth. This formulation is actually a generalized intertemporal capital asset pricing model under uncertainty (Merton, 1990). This modeling approach allows us to incorporate the fact that the longer the planning horizon,

[4]This type of formulation is common in the literature. Our formulation of the total profit function is the same as the one formulated by Hertzler (1991, page 1130), and the formulation of the wealth accumulation is similar to the one proposed by Hertzler (1991, page 1130). But the formulation of equation (2) is our own. It shows how government behaves in the transfer payment program. The success of this formulation can only be judged by whether or not the modeling approach here will give us interesting and important hypotheses to be tested for empirical work.

the greater the degree of uncertainty due to the properties of Browning motion. This formulation also dramatically departs from most commonly used risk analysis, i.e., the mean-variance approach. It is well known that in order for the mean-variance approach to be consistent with the expected utility theory, it is required that the error term should be normally distributed and the utility function is quadratic.There is, however, no reason why we need to restrict ourselves to consider only the first two moments of the probability distributions. More importantly, the mean-variance approach does not deal with the fact that the longer the planning horizon, the higher the degree of uncertainty involved. Moreover, the solution does not allow us to have the Markovian property interpretation, i.e., a rational economic agent makes decisions based on the currently available information. In fact, due to large volumes of mathematical literature on stochastic optimal control and Ito calculus, using this Wiener process approach greatly enhances the need to pose sharper questions without losing its fundamental insight, enabling us to interpret results more clearly and precisely than those obtained by the discrete time approach, giving us richer empirical content (Merton, 1990).

Equation (2) states that the higher the government payment, the slower the rate of change of government payment to the farmer. This idea is captured by the parameter α . Equation (2) also implies that the more profit a farmer earns, the slower the rate of change of government payment to the farmer. This idea is evident through the parameter β . Note that parameters α and β can also be interpreted as a government policy device toward payment and profit, respectively, since the two parameters measure how government changes the rate of growth of the payment program.

In this model, it is assumed that the farmer is risk neutral. In fact, the fundamental conclusion will not change if we model the farmer as risk averse.

To solve the model, let's define J to be the optimal objective function as

$$J = J(w,g,t) = \underset{(I,x)}{Max}\ E_t \int_t^{\infty} (p_y y(x) - p_x x) I e^{-rs} ds = \underset{(I,x)}{Max}\ E_t \int_t^{\infty} \Pi_d(s) ds,$$

where $\Pi_d(s) = (p_y y(x) - p_x x) I e^{-rs}$, and the optimal objective function is, in general, dependent on the two state variables, w, g, and the time t. From the fundamental optimality condition from Ito's stochastic optimal control, we have

$$0 = \max\left[\Pi_d(t) + (\frac{1}{dt}) E_t dJ\right].$$

Note that J(w,g,t) is a function of the random variable w, i.e, wealth whose accumulation process is governed by stochastic differential equation (1). Therefore, we need to use Ito's lemma to expand the term dJ[5].

Thus, the fundamental equation becomes

$$0 = \max\left[\Pi_d(t) + \left(\frac{1}{dt}\right) E_t (J_t + J_w dw + J_g dg + \frac{1}{2} J_{ww} (dw)^2\right],$$

where dw and dg are given by equations (1) and (2) and $(dw)^2 = (g\sigma w)^2$ from

---

[5]Here, the notation J_t means $\partial J / \partial t$, etc. The operator $(1/dt)E_t d(.)$ is Ito's differential generator. For a discussion of the technique, see Merton (1990, page 123, equation 5.3). For a more advanced treatment, see Chung (1991, page 94, equation 5.3). For the technique solving stochastic differential equation using the Lie Algebra, see Krener and Lobry (1981, page 202, equation 2.14)

Ito's lemma. Substituting dw and dg from (1) and (2) into the above equation, we have

$$0 = \max[\Pi_d(t)] + J_t + \left[b_w w + (b_l - b_w) p_l I + (p_y y(x) - p_x x) I - \theta(w+g)\right] J_w$$

$$-\left[\alpha g + \beta(p_y y(x) - p_x x)\right] J_g + \frac{1}{2}(g\sigma w)^2 J_{ww}]. \qquad (3)$$

That is, at each instant, I and x must be chosen to just balance current profits against changes in the expected sum of all discounted future profits.

Maximization with respect to I gives

$$\frac{\partial \Pi_d(t)}{\partial I} + (b_l - b_w) p_l J_w + (p_y y(x) - p_x x) J_w = 0. \qquad (4)$$

Solving for J_w in (4) results in

$$J_w = -\frac{\dfrac{\partial \Pi_d(t)}{\partial I}}{(b \ \ - b_w) p_l + (p_y y(x) - p_x x)} \ . \qquad (5)$$

Maximization with respect to input choice x results in

$$\frac{\partial R(x)}{\partial x} I J_w - \beta \frac{\partial R(x)}{\partial x} J_g = 0, \qquad (6)$$

where R(x) = $p_y y(x) - p_x(x)$.

In principle, we could solve J_w and J_g from (5) and (6), then substitute them back into equation (3) to obtain a partial differential equation for J(w,g,t). Theoretically, one could solve that equation for J and determine the optimal trajectories for I and x explicitly. However, solving such a partial differential equation is usually not feasible, so instead we eliminate J from the system.

To this end, we take the derivative with respect to w in (3), which gives us

$$0=\frac{\partial\Pi_d(t)}{\partial w}+J_{tw}+[b_w w+(b_l-b_w)]p_l I+[p_y y(x)-p_x x)-\theta(w+g)]J_{ww}-$$

$$-[\alpha g+\beta(p_y y(x)-p_x x)]J_g+\frac{1}{2}(g\sigma w)^2 J_{www}+b_w J_w-\theta J_w+w(g\sigma)^2 J_{ww}.$$

Now using the facts that $\partial\Pi_d(t)/\partial w=0$, and $J_{ww}=0$ from (5), and applying Ito's differential operator with respect to J_w again, the above equation can be simplified to

$$(\frac{1}{dt})Ed(J_w)=J_w(\theta-b_w). \tag{7}$$

Inserting equation (5) into (7), we have the following

$$(\frac{1}{dt})E\left[\frac{\frac{\partial\Pi_d(t)}{\partial I}}{(b\ -b_w)p_l+(p_y y(x)-p_x x)}\right]=$$

$$\left[\frac{\frac{\partial\Pi_d(t)}{\partial I}}{(b\ -b_w)p_l+(p_y y(x)-p_x x)}\right](\theta-b_w)$$

which is a stochastic version of the well-known Euler's equation from the calculus of variations.

Recall that $\partial\Pi_d(t)/\partial I=\left[p_y y(x)-p_x x\right]e^{-rt}$, substituting this into the above gives

$$\frac{1}{dt}Ed\left[\frac{(p_y y-p_x x)e^{-rt}}{(b_l-b_w)p_l+(p_y y(x)-p_x x)}\right] \tag{8}$$

$$=\left[\frac{(p_y y-p_x x)e^{-rt}}{(b_l-b_w)p_l+(p_y y(x)-p_x x)}\right][\theta-b_w].$$

To facilitate the analysis, let's define a function

$$f(t, p_l) = \left[p_y y(x) - p_x x\right]e^{-rt} / \left[(b_l - b_w)p_l + (p_y y(x) - p_x x\right]. \qquad (9)$$

Then, equation (8) can be rewritten as

$$\frac{1}{dt} Ed[f(t, p_l)] = f(t, p_l)(\theta - b_w).$$

From the Ito's lemma, we have

$$df(t, p_l) = f_t dt + f_{p_l} dp_l + \frac{1}{2} f_{p_l p_l} (dp_l)^2.$$

where f_t is the partial derivative of f with respect to t. The terms f_{p_l} and $f_{p_l p_l}$ have similar interpretations. Thus, we have

$$f_t = \frac{-rR(x)e^{-rt}}{(b_l - b_w)p_l + R(x)},$$

$$f_{p_l} = \frac{-R(x)e^{-rt}(b_l - b_w)}{[(b_l - b_w)p_l + R(x)]^2},$$

$$f_{p_l p_l} = \frac{R(x)e^{-rt}(b_l - b_w)^2}{[(b_l - b_w)p_l + R(x)]^3}.$$

Since farm land price is dependent on the two state variables w and g, it follows that $p_l = p_l(w, g)$. Expanding p_l (w,g) using Ito's lemma yields

$$dp_l = p_{lw} dw + p_{lg} dg + \frac{1}{2} p_{lww} (dw)^2,$$

which implies $(dp_l)^2 = \left\{\frac{\partial p_l}{\partial w}\right\}^2 \{g\sigma w\}^2 dt$, where dw and dg are governed by differential equations (1) and (2).

respectively. Plugging f_t, f_{p_l} *and* $f_{p_l p_l}$ into (8) results in

$$\frac{1}{dt}E\left\{f_t dt + f_{p_l} dp_l + \frac{1}{2} f_{p_l p_l} (dp_l)^2\right\}$$

$$= \frac{1}{dt}E\left\{\begin{array}{l} \dfrac{-rR(x)e^{-rt}}{(b_l - b_w)p_l + R(x)}dt - \dfrac{R(x)e^{-rt}(b_l - b_w)}{[(b_l - b_w)p_l + R(x)]^2}dp_l \\ +\dfrac{1}{2}\dfrac{2R(x)e^{-rt}(b_l - b_w)^2}{[(b_l - b_w)p_l + R(x)]^3}\left(\dfrac{\partial p_l}{\partial w}\right)^2 (g\sigma w)^2 dt \end{array}\right\}$$

$$= \left[\frac{R(x)e^{-rt}}{(b_l - b_w)p_l + R(x)}\right][\theta - b_w].$$

Further simplification yields the following dynamics of expected land price movement

$$\frac{1}{dt}E(p_l) = \frac{(b_l - b_w)}{(b_l - b_w)p_l + R(x)}c_1 g^2 + c_2 + c_3 \tag{10}$$

where

$$c_1 = (\frac{\partial p_l}{\partial w})^2 \sigma^2 w^2,$$

$$c_2 = -\frac{r\{(b_l - b_w)p_l + R(x)\}}{(b_l - b_w)},$$

$$c_3 = -\frac{(\theta - b_w)\{(b_l - b_w)p_l + R(x)\}}{(b_l - b_w)},$$

and $R(x) = p_y y(x) - p_x(x)$.

Equation (10) is the farmland price fluctuation equation under government intervention. It reveals some important information about how government programs contribute to the stabilization of farm land price.

The effect of government payment (g) on the stability of land price fluctuation depends on the sign of Q, where $Q = (b_l - b_w)/[(b_l - b_w) + (p_y y(x) - p_x x)]$. If the farmer's expected appreciation rate of land prices is greater than the rate of returns on off farm investment, which is risk free, i.e., $b_l - b_w \geq 0$, then the payment (g) tends to increase the fluctuation of land price. Since b_l is the expectation of land price appreciation, it uses the information in the general economic conditions, such as interest rate, the amount of debt the farmer holds, as well as the farmer's perception of the potential income gain from policy programs.

On the other hand, if farmer's expected appreciation rate of land price is less than the rate of return on off farm investment, then there are two possible outcomes. The first outcome is that the denominator of Q is positive with the negative numerator, i.e., the profit per acre of land production (p_y y(x) - p_x x) can offset the loss from investment in land (b_l - b_w)p_l. If this happens, the government payment tends to decrease the land price fluctuation. The second case is that if the land price p_l is sufficiently high, the loss from investment in land is large, such that the profit earned in land production is not high enough to cover this investment loss. If this happens, the denominator and numerator of Q are both negative, so Q is still positive. In this case the government payments increase the fluctuation of farm land price.

In our model, we set up b_l as the farmer's expected appreciation rate of land prices. This future expectation depends on a lot of possible factors, such as the general macroeconomic conditions, export percentage, perceived technological change, and even the farmer's attitude toward land. Thus, by introducing the two kind of rates of returns, our result is able to show explicitly how government payment affects the behavior of farm land price, thus providing a mechanism through which government payment affects the movement of farmland price.

Another finding from equation(10) is that a high interest rate exerts a dampening influence on land prices. The economic intuition of this is very simple. One way to reason this is to take the interest rate as the off farm investment returns. As the interest rate is expected to increase, the farmer has more incentive to do off farm investment, thus reduces the investment on farmland. Consequently, this reduction on investment on farmland lowers the expectations about the appreciation of land prices, and increases off-farm investment, thus causing land prices to drop. The higher interest rate also discourages the farmer from borrowing money and purchasing land, resulting in lowering demand for land and lower land prices. The general message here is that macroeconomic conditions, such as the interest rate, matter a great deal in terms of affecting the variability of the farmland price movement..

It should be pointed out that the above model is not intended to be the only explanation of the contribution of government programs to the stability of land price fluctuation. Instead, it is only one of several alternative theoretical models to explain what we observe in reality. Like any scientific knowledge, there may exist more than one theory to explain the same observed phenomenon. In fact, this model puts a great emphasis on people's expectation on the behavior of land price fluctuation.

The rest of the paper is an empirical study of the cyclical behavior of farmland price. It should be kept in mind that according to the theoretical formulation, the same government payment program will cause the farmland price to behave differently, depending on whether the expected appreciation rate of land prices is greater or smaller than the rate of return on off-farm investment, which is risk free. Thus, if the model developed so far has any empirical significance, we could expect that the empirical data of the farmland price will reveal at least two different behavior patterns. The first pattern is the case where the price fluctuation tends to increase when government payment program is made. The second pattern is the case where land price fluctuation tends to decrease with government payment program. Thus, the empirical data set should classify the farmland price movement in 48 states into at least two categories, i.e., those states where farmland price fluctuation tends to increase, and the states with actually declining fluctuation in farmland price. Also, we need the empirical evidence to support the hypothesis that government payment program help to explain farmland price fluctuation.

Since the modeling process involves the concept of expectation and since there are a lot of empirical proxies for expectation, and arbitrary selection of them will easily introduce bias. Also, as we pointed out in chapter 2, parametric econometric procedures popular in the literature so far actually need some assumptions on the data generating mechanism, for example, the stationary assumption is needed for most classical econometric techniques to be applicable. On the other hand, we might expect that the farmland price series is not stationary, which is quite common in most economic time series data (this indeed is the case which will be verified later in chapter 6). Finally, different parametric test procedures will also likely end up with different implications, since each different procedure usually has some particular assumptions concerning the way how the data is generated. As we explained in the literature review part, one source for the diverse views of the farmland price movement is due the use of different parametric estimators. To avoid the above three problems, and to increase the robustness of our empirical tests, we adopt the nonparametric test approach in our empirical study. More on this point will be discussed in chapter 4.

In the chapters that follow the detailed procedures to do the empirical tests will be explained and documented.

CHAPTER 4

DATA AND METHODOLOGY

Annual land price data are available from the USDA from the year 1910-1989. In the analysis that follows, data are divided into the pre-agricultural policy period 1910-1933 and the post-agricultural policy period 1947-1989. The years 1934-1946 are influenced by depression and wartime price controls. These periods are delineated as period one and period two, respectively. Land prices are deflated by the Consumer Price Index available from the Bureau of Labor Statistics. Following Cochrane (1989), Campbell and Mankiw (1987), and Romer (1991), we use the log difference of price data in our analysis. This insures data stationarity but does not *a priori* force trend-reverting behavior on the data as would detrending (Campbell and Mankiw, 1987). Price data used in the analysis can be interpreted as growth rates. The total state agricultural cash receipts and government program transfer payments are from the *Agricultural Statistics*. We then form the ratio of government transfer payments to total state agricultural cash receipts to measure the relative importance of agricultural programs in each state.

The standard deviation is used to measure price volatility. This standard deviation measures the dispersion of price movements around the mean. The standard deviation does provide some useful information about price movements, but it is a short-run concept. It contains no information about how long it takes for the deviation to revert to the mean. It does not answer some important questions such as , is the deviation temporary or permanent? That is, is there tendency for the time series not to be trend-reverting after an innovation in land prices occurs?

If the deviation is transitory, we would expect that price movements will eventually be trend reverting. Therefore, the innovation today has no permanent impact in the long run. The impact is transitory. This observation is also important from the econometric point of view. If the responses of land prices to shocks are temporary, the land price movements are dominated by temporary deviations from the trend. Thus, the innovation in land price today should not substantially change one's forecast of land prices, say, ten or twenty years later. The forecast value of land prices should be dominated by the discounted value of expected future returns. On the other hand, if the responses of land prices to shocks have a permanent impact on land price fluctuations, then if real land price falls one percent lower than one would have expected from its past history, this change in real forecast of land prices should change one's forecast of land prices over a long horizon by over 1 percent. This is essential to understand the dynamics of land price movement, and to provide a better design of policies.

The real problem is how to estimate the shock persistence econometrically. It is obvious that there are at least two ways to do it. The first approach is to run regressions on the current value of prices over the previous residual error terms, estimating the relevant coefficients. Then, we check to see if the coefficients become smaller when the time lag becomes longer. The problem is that the innovation is not identifiable in time series analysis. It also suffers some fundamental problems from the econometric point of view. The first one is that there is a model specification problem since it is well known that the pure autogressive model and pure moving average model are highly restrictive. (Nelson, Kang, 1981). We might even use autoregressive and moving average approaches, but there is another problem associated with that, namely, what is the proper order of lags for the model. Then we have to do model diagnostics and verification.

Another source of problems is associated with the design of an appropriate test procedure. It is well known that in classical statistics hypothesis testing, we first partition the sample space into rejected and accepted regions. A nonrandom test maps the value of a random variable into these dichotomized regions. By doing so, we can have three possible outcomes: [1] we make a correct decision; [2] we falsely reject the true null hypothesis (type I error); [3] we fail to reject the false null hypothesis (type II error). Of course, one wants to reduce both of these errors to be as small as possible. Unfortunately, it can be shown that it is impossible to reduce both types of errors simultaneously by designing an appropriated test procedure. In practice, we usually fixed the type I error as some predetermined level, say, 1%, or 5%, then we choose a particular test method which can minimize the type II error among all other test procedures given this prespecified type I error. The purpose of designing a good test procedure is to minimize the type II errors or maximize the test power. To appreciate this, let us prespecify the type I error we are willing to bear, say, 5%, i.e., on the average we allow ourselves to reject the true hypothesis five percent of time. Of course, this number (5%) also reflects the decision maker's attitude toward risk, reflecting the fact that the decision maker does not want to commit this false rejection error about 5 percent of time. Instead, he is willing to trade for the type II error. This behavior also reveals important information, that is the decision maker thinks that committing type I error is a more serious mistake than committing type II error.

This raises another interesting question, that is, how to specify the null hypothesis? Now, if the type I error is 5%, after using a test procedure, suppose that we know the power of this test is also only 5%, then it follows immediately that the rejection of the null hypothesis contains zero information. Also, in parametric hypothesis test, we have to have knowledge about the underlying data generating mechanism, either by previous knowledge, or by assumptions. Whatever the underlying data generating mechanism might be, when we reject the null hypothesis, we either reject the null hypothesis we specify, or we reject the underlying data generating mechanism, in some cases, we might reject them both.

It is also well known that a lot of econometric modeling is based on the stationarity assumption. If land price series are not stationary, this raises a question how robust our econometric modeling is. Indeed, in our study, we found that land price series are not stationary, and follow a random walk. This might help to explain the question why some large scale and sophisticated econometric models of land prices have lower predicative power than a single regression model (Burt, 1986). Burt (1986) argues that the lack of clear understanding of interactions of land prices and other economic variables, inappropriate model specification, and nonexistence of a classical supply function for land might be very important reasons for this failure.

Due to the reasons outlined in the above and the reasons mentioned at the end of chapter 3 a nonparametric test is adopted in our study. Specifically, we use the recently proposed nonparametric estimator (Cochrane,1989; Campbell and Mankiw, 1987) to measure persistence. Cochrane's estimator is based on the weighted average of the first several sample autocorrelations

$$V^k = 1 + 2\sum_{j=0}^{k}(1 - \frac{j}{j+k})p_j ,$$

where p_j is the jth sample autocorrelation. Campbell and Mankiw show that a simple transformation of Cochrane's estimator (V^k) allows interpretation of the transformed statistics as A^k (L) in the following equation:

$$\Delta y_t = \beta + A^k(L)e_t ,$$

where A^k (L) is the lag operator in the order of lag L. If A^k (1) =0, then an innovation in the land price growth is completely dissipated in later periods. If A^k (1) = 1, then the growth in land prices is a random walk. And if A^k (1) > 1, then the trend growth rate in land prices is permanently changed. Campbell and Mankiw's transformation is given by

$$A^k = \sqrt{\frac{V^k}{(1 - p_1^2)}} ,$$

where p_1^2 is the square of the first sample autocorrelation of the series. Campbell and Mankiw give the standard error of V^k as

$$SE[V^k] = \frac{V^k}{\sqrt{\frac{3}{4}\frac{T}{k+1}}}.$$

The standard error for A^k can be computed using the delta method[6].

[6]There is another part of the empirical work using the methodology from factor analysis. However, it is used to answer different types of empirical questions. Thus, it is delegated to chapter 7.

CHAPTER 5

VOLATILITY

The standard deviation of the growth rate of land price series is used to measure the volatility of land prices. This standard deviation measures the dispersion of the growth rate around the mean, and is an unconditional summary statistic. Thus, it contains the full information about the volatility of land prices. We divide the time horizon into two periods. The first period is from 1910 to 1933. The second period is from 1947 to 1989. We are interested in seeing if there is any significant change in the measurement of volatility since farm policies were introduced. There has been much research in macroeconomics discussing the postwar economic stabilization policies[7]. The conventional belief is that the postwar policies do stabilize the economy as indicated by statistically significant decline in the volatility of virtually all macroeconomic series (Delong and Summer 1984). However, in a recent study done by Romer (1986), she is unable to reject the hypothesis that the postwar volatility of aggregate macroeconomic variables are declining or the same, thus casting a great doubt on the role of economic stabilization policies.

---

[7]According to the conventional view, if the postwar economic stabilization policies are effective, then the fluctuation in aggregate macroeconomic variables should decline significant in the post-war period (Romer, 1986). In fact, this view is empirically supported by Delong and Summers (1984)

The empirical results for volatility in our study are reported in table 1 (Appendix). Several features of this table need to be discussed.

The first obvious finding is that for each period, there is a significant difference in the magnitude of volatility in each state. For example, in the first period, Arizona has volatility level 0.101, while Kentucky has volatility 0.048, which is about half as large as Arizona. In the second period, Connecticut has volatility level 0.038, and Iowa has volatility level 0.106, which is about two and half times higher than that in Connecticut.

The second feature is that even starting with the same volatility level in different states, their respective volatility levels in the post-policy period are quite different. For example, both Idaho and Missouri have volatility 0.058 in the pre-policy period, but volatility levels during the postpolicy period are quite different. Idaho has volatility 0.059, essentially no change in magnitude while Missouri has a significant increase with the magnitude of 0.077 in the post-policy period. This vast difference in the level of the volatility in states implies that either each state is subject to different sources of shocks (state specific shocks), or they respond differently to the common shocks (general macroeconomic shocks).

The more important pattern that is immediately apparent in Table 1 is that the volatility behavior in each states can be characterized by two types: The first type is the states where the volatility has increased after the farm policies have been introduced, particularly those in the mid-west and great plains. For example, Nebraska's volatility level increases from 0.059 in the pre-policy period to 0.091 in the post-policy period.

The second type is the states where the volatility level has indeed decreased in the post-policy period. For example, the volatility in Massachusetts has decreased from 0.062 to 0.039. This important finding has at least two implications. First, if the agricultural policies are indeed effective[8], they should reduce farm income variability and, hence, dampen fluctuations in anticipated land price. If government intervention in the agricultural sector has been really successful, it is hard to conceive why the volatility in some states is much higher after agricultural policies were introduced while some states do experience the lower volatility of the growth rate of land prices. Indeed, the recent study by Romer shows that the volatility level has changed very little in the postwar period where she examines 38 annual production series of the United States economy from the period 1889-1984. world. Our finding is even stronger in the sense that, instead of not declining, the volatility level of farmland price in some states has actually increased. The fact that some states have actually achieved a decline in the volatility of farmland prices, while other states have experienced an increase in the volatility of the farmland prices also indicates that each state might respond differently to general macroeconomic shocks, and some factors which are state-specific, such as the degree of urbanization, the industry structure of the state economy, such as the degree of urbanization, the industry structure of the state economy, the production technology used in a particular state, etc., might be

[8]Again, we should always keep in mind that the purposes of agricultural polices are complex and multidimensional. To protect farmers and reduce their income variability is only one of several purposes of the farm program.

important in the formation of land price movements. If this is not the case, it is hard to conceive why some states experience a decline in the volatility, while the others see an increase.

The stylized concept that government payment programs to farmers have the tendency to stabilize farm land price (Burt, 1986; Tweeten and Martin 1966) leads to the general consensus that the volatility difference between the pre-policy and post-policy periods should be important. But if this difference is not statistically significant, then our general belief about the roles of government agricultural policies in stabilizing farm land prices is put on shaky ground. Since there is a 15 year time lag between two periods, it is reasonable to assume that the two data sets are independent. Thus a test for the equality of the standard deviation of the growth rate in the two periods results in the standard F ratio statistics with the degree of freedom corresponding to the size of the two samples. To do the test, we form the ratio of the standard deviation of the two periods which is displayed in the third column in table 1 (Appendix). A ratio number larger than one indicates an increase in volatility. The null hypothesis is that there is no difference in the volatility level between the two periods, the alternative is that the null hypothesis is false. We expect that completely effective agricultural policies should reduce land price volatility. It is conceivable, however, that macroeconomic conditions have destabilized agricultural land prices even though policy has had a dampening effect. The test F statistics $F(23, 42)$ indicates that for some states, such as Indiana, Ohio, and Nebraska, the volatility in the second period has significantly increased. On the other hand, the volatility for other states, such as Massachusetts and New Hampshire has significantly decreased during the second period. In table 1, the states marked with * indicate that volatility levels have been significantly changed during the two periods.

Another important question we are interested in is what information we can get if we pool each individual state data to obtain the aggregate indicator of a general national volatility level? How reliable is this information? It is very obvious that in the first period, each state shows a different volatility level with the range being 0.064, ranging from 0.112 in South Carolina to 0.048 in Kentucky; while in the second period, each state also shows a versatile volatility level with the range being 0.068, ranging from 0.038 in Connecticut to 0.106 in Iowa. With this kind of data structure in the two periods, there does not seem to be too much hope that aggregate data can tell the true story. This can be further clarified by this simple observation. The mean volatility across 48 states in the first period is 0.069 with the standard deviation 0.016, and the mean volatility across 48 states in the second period is 0.0651 with the standard deviation 0.0143. A very simple test will lead anyone to conclude immediately that there is not a significant difference in the volatility level in the two periods. Thus, the use of aggregate indicator might be misleading in this case. This also supports the use of disaggregate data in our analysis. This is a paradox in the aggregation and disaggregation of land price data. Thus, we must be careful in selecting appropriate data sources, since an indicator for the general volatility is quite misleading. Instead, the information in the change of the volatility in each state would be more useful in terms of providing the aggregate land price fluctuations. In fact, it is quite likely that the aggregate land price volatility indicator becomes less volatile, while each state actually experiences continued increasing volatility. This will happen if there is a fundamental correlation structure change in the data set. For example, the relationship in each state changes from reinforcing each other in period one to canceling out each other in period two. Economically, this implies that there is a fundamental structure change in the economy, since the relationship between each state changes dramatically from one extreme to the other. But our empirical finding using factor analysis reported in chapter 7 indicates that this structure change does not seem to be likely.

CHAPTER 6

PERSISTENCE

In chapter 5, the volatility of the growth rate of land price series was analyzed. Results indicate that in some states, volatility has increased significantly in the second period, while the opposite happens in other states. It is well known that one of the purposes of introducing agricultural policies is to stabilize farmers income (Boulding, 1983). Since land price is associated with the discounted present value of future income returns, then the stabilized income stream yields stabilized land prices. Therefore, if agricultural policies are really effective, it is difficult to perceive the opposite land price movements in these two sets of states. If volatility indeed increases, then the next important question is how long this volatility will stay in the trend? Putting it another way, is this price series movement transitory or permanent?
More importantly, we are interested in investigating if the persistence level in farmland price series changes over time, especially between the two different time periods. The answers to these questions are important for better understanding of land price fluctuations, consequently for the better design of government policies. These questions are also important from the statistical point of view, since the properties of transitory or permanent movements of land price growth rate have very different implications for statistical estimation and hypothesis testing (Campbell and Mankiw 1987), and help us to understand the nature of different

shocks and how shocks affect land price movements. In fact, one of the important motivations behind the recent development in nonstationary time series analysis is due to the presence of the permanent component in a lot of time series data (Davison 1981; Nelson and Kang 1981).

How can we measure this persistence of the growth rate of land prices statistically? To illustrate the idea, we consider the following very simple example

$$y_t - y_{t-1} = b_t + a_t e_t + a_{t-1} e_{t-1} + a_{t-2} e_{t-2} + \ldots\ldots + a_{t-k} e_{t-k}, \quad (11)$$

where a_t is the mean growth rate, y_t is the log of the original land prices, and their difference can be interpreted as the growth rate of land prices. To simplify the discussion, let's us define the backward lag operator L as

$$Ly_t = y_{t-1},$$

Applying this lag operator successively, we have

$$L^k (y_t) = L(L^{k-1} (y_t)) = y_{t-k}.$$

Thus, we can rewrite equation (11) as

$$y_t - y_{t-1} = b_t + a_t e_t + a_{t-1} L e_t + a_{t-2} L^2 e_t + a_{t-3} L^3 e_t + \ldots\ldots$$

$$= b_t + (a_t + a_{t-1} L + a_{t-2} L^2 + a_{t-3} L^3 + \ldots\ldots) e_t$$

$$= b_t + A(L) e_t,$$

where A(L) is equal to $a_t + a_{t-1}L + a_{t-2}L^2 + \ldots\ldots\ldots$ Therefore, A(L) is a polynomial in the lag operator, and e_t is white noise[9].

[9]Notice that here, we treat the lag operator L as if it were a number, since we add, multiply, and factor them. The validity of doing this rests in a deep and beautiful theorem in functional analysis. It is called the Riesz-Fisher theorem, one of the remarkable achievements of human minds. For an economic discussions of its significance, see Sargent (1979). For a mathematical discussion, see Riesz and Nagy (1955).

Persistence is illustrated in the following questions: if there is a shock at time t, will this shock affect the growth rate of land price after a long period of time, say, 10 or 20 years later? If this shock eventually dies out with time, then we can see that the growth rate of land price reverts to the trend. If this is indeed the case, then we say that the shock has only a transitory effect on the growth rate. If the effect of this shock to the growth rate of land price will not fade away as time goes, this shock becomes a permanent part of the growth rate of land price, then we say that this shock has a permanent impact on the growth rate of land price. Now how can we measure this persistence statistically? What is a good indicator of this persistence? We would expect that if the effect of shock to the growth rate will eventually die out, then we would see that the coefficients of a_{t-k} will become smaller and smaller as the time k increases, since these coefficients measure the impact of shock e_{t-k} to the growth rate at the time t. Therefore, the sum of coefficients of A(L) is a good indicator to measure this shock. If A(L) is equal to 0, then a shock does not affect the growth rate at all. If $A(L) > 0$, then a shock does affect the growth rate in the next period movements. Especially, if A(L) is equal to 1, we have what the literature calls a random walk phenomenon. If this happens, the impact of shock to the growth rate of land price will not die out with the passage of time.

The above reasoning indicates that an estimate of A(L) is a good indicator of the persistence of shock to the growth rate of land price. One way we can estimate A(L) is to parameterize the above integrated moving average process with the proper specification of the order of lags in the model, then estimate accordingly. The limitations of this parametric approach are well known (Cochrane 1989; Campbell and Mankiw 1987). The first one is that the white noise term is not identifiable in time series. The second one is the proper selection of the order of lags. This requires different diagnosis procedures, such as the plotting of an autocorrelation function, and the Box-Jenkens method. Also, estimation and hypothesis testing in this model is very sensitive to the lag order. Considering these potential pitfalls, Cochrane (1988) proposed the following estimator as one indicator of persistence, which is based on the weighted average of the first several sample autocorrelations

$$V^k = 1 + 2\sum_{j=0}^{k}(1 - \frac{j}{j+k})p_j ,$$

where p_j is the jth sample autocorrelation. In fact, the estimator V^k is a weighted average of sample autocorrelation, with linearly declining weights. Campbell and Mankiw show that a simple transformation of Cochrane's V^k allows interpretation of the transformed statistics as $A^k(1)$ in the following equation

$$y_t - y_{t-1} = b + A^k(L)\, e_t.$$

If $A^k(1) = 0$, then a shock in the land price growth rate is completely dissipated in the later periods. If $A^k(1) = 1$, then the growth in land price is a random walk. Finally, if $A^k(1) > 1$, then the trend growth rate in land price is permanently changed. Technically, if $A^k(1) > 1$, the land price growth series is called nonstationary (Campbell and Mankiw 1987). The idea is that shocks become a permanent part of the growth rate of land price, and the land price movements are not trend reverting. Since both A^k and V^k measure the persistence of the growth rate of land price, it is, therefore, natural to expect that there is a relationship between these two. This indeed is the case as illustrated by Campbell and Mankiw. Campbell and Mankiw's transformation is given by

$$A^k = \sqrt{\frac{V^k}{1-p_1^2}},$$

where p_1^2 is the square of the first sample autocorrelation of the series. A result in spectral analysis (Prestley, 1983) gives the asymptotic standard error of V^k as

$$S.E[V^k] = \frac{V^k}{\sqrt{\frac{3}{5}\frac{T}{1+k}}},$$

where T is the sample size and k is called the Barnet's window size. In this paper, the window size 8 is used. This choice is based on Campbell and Mankiw's (1987) Monte-Carlo study result, and also consistent with Romer's (1991) research result where she used the same methodology to study the persistence of disaggregate data of GNP in 38 industries in the U.S.

Table 2 (Appendix) reports the nonparametric estimates of A(1) for the two periods. In the first period, before agricultural policies were introduced, innovation in land price growth appears to dissipate quickly. A^k is less than one for 29 states. After agricultural policies were introduced, innovation in land price growth appears to permanently shift trend growth. Persistence estimates in states such as Illinois, Iowa and Idaho, increase to about two after agricultural policies were introduced. In other states, such as Massachusetts, New Jersey, and New York, persistence estimates actually decline in the second period. To formally test the hypothesis that the persistence has not changed between period one and period two, we used the asymptotic t test, where we first calculate the standard deviation of the estimated A^k using the delta method, then we build a t test statistic based on the estimated persistence and their corresponding standard error for the two periods in each state. The hypothesis that persistence has not changed between the two periods can be rejected for states marked with a * at the 15% significance level in table 2 (Appendix).

The results have two important implications. First, increased persistence measures in the post-policy period suggest that permanent shocks have become more important. Alternatively, the ability to recover from external shocks has diminished in states where persistence has significantly risen. One possibility is that farm programs have made shocks more persistent by reducing down-side profit risks while maintaining upward revenue flexibility. When economic conditions worsen, farm programs protect farmers from economic loss, but as conditions improve, farmers benefit. Second, persistence estimated greater than one in the post-policy period indicates that the price series is not stationary, characterizing a series that will continue to grow from its previously forecast value following a shock (Campbell and Mankiw, 1987).

As in the case of volatility, another question we are interested in is: can we infer some aggregate persistence level based on the disaggregated data from each state? If yes, how reliable is this aggregation?

To answer these questions, we observe that in the pre-policy period, the persistence level in 28 states is less one, indicating the stationary time series movement in those states, whereas in another 10 states the persistence level is greater than 1. In the post-policy period, there are only 17 states which are statistically significant in terms of increasing the persistence level. In some states, the persistence actually declines. Thus, it is still misleadingto conclude that the aggregate persistence level has changed from being stationary to being nonstationary. Here, we face a paradox similar to the case of volatility. The paradox results from inadequate aggregation of data without taking the internal structure of the data into account.

CHAPTER 7

COMOVEMENTS

Existing literature has dealt with the linkages of macroeconomic conditions and the agricultural sector (Rausser, Chalfant, Love and Stamoulis,1986). The empirical results in chapters 5 and 6 focus on the volatility and persistence of farmland price in each state during the pre-policy and post-policy periods. There are, however, several other unanswered important questions. For example, how important are the general macroeconomic conditions in causing this observable movement in each state? How does each state respond to the general macroeconomic conditions? Do they respond to macroeconomic conditions similarly or separately? When each state responds to the general macroeconomic conditions, do they have spillover effects between states? Do state specific factors, such as the degree of urbanization, the adoption of technology, the structure of each state's economy contribute to the observable movements of the growth rate of land price? If yes, how important are they? How do government agricultural programs contribute to the movements? Tweeten and Martin (1966), and Herdt and Cochrane (1966) argue that the capitalized benefits from the farm program tied to land ownership and pressures for farm enlargement from technological advances in production are the most significant factors contributing to the rise in farm prices despite constant or declining per acre farm income. In her recently published paper, Romer studies the cyclical behavior of individual production series from 1889-1984. In the paper, she raises the similar kind of questions, and uses factor analysis to tackle them. In what follows, following Romver, we also use factor analysis to answer the questions that are raised above.

If factor analysis indicates the predominance of the general macroeconomic shocks, then the conventional thoughts that the interest rate is a driving force in causing the land price elevation may gain support. It would also indicates that there is a strong spillover effect between states. If state specific shocks are more important, then the conventional view that technological advances elevate land price may gain support. More importantly, if the factor pattern of the growth rate of land price is consistent with the factor pattern of the government payment programs, then the hypothesis that the government programs help explain shock persistence in the second period gains support.

Factor analysis is used to gain more insight to the above relevant questions. Briefly speaking, factor analysis is a multivariate statistical method which can decompose the cross-correlation of data into two parts. The first part can explain the structure of the cross-correlation of data due to the common, but unobservable factor, the second part can explain the structure of cross-correlation of data due to factors which are particular to the individual series. By this decomposition, we can see how important the common factor is in explaining the fraction of variance of growth rate of the farmland price in data, and how strong the specific individual factors contribute to the comovement of data.

Factor analysis results from SAS's (1989) initial factor method are presented in table 3 (Appendix) for land price growth and for the ratio of government transfer payments to total state agricultural cash receipts. The second data set measures relative agricultural program importance in a state, and is included for factor loading comparisons. Government payment and agricultural cash receipt data are from *Agricultural Statistics*. Both analyses are done for the post-policy period, 1947-1989. The factor pattern for the growth rate of land price is fairly obvious. First, a single factor accounts for a large part of the total variation in land price growth. This is indicated by the first factor loading coefficient for each state. Each of them is positive and close to each other in magnitude. The magnitude contains the information about how strongly each state responds to the common but unobservable factor. The interest rate is a very likely candidate for this unobservable common factor.

The second factor loading coefficients divide states into two categories. The first one is states with positive factor loading coefficients; the second one is states with negative factor loading coefficients. states. The factor pattern for government payment ratio shows a close similarity, thus matching the factor pattern obtained from the growth rate of land prices. This second factor-loading coefficient can be called the state specific factor. The finding is consistent with those reported in the last two chapters. In chapter 5, we observe that the volatility has decreased in some states and this coincides with the positive factor loading for the state specific factor both in the growth rate of land price and government payment ratio. The characterization of states by positive and negative second factor loading coefficients is also consistent with finding in chapter 6, where in those states which are basically associated with negative second factor loading coefficient in factor analysis experience an statistically significant increase in the persistence level. On the other hand, in those states which are basically associated with a positive second factor loading coefficient, the persistence level has actually declined or has not increased significantly.

So far, we have empirically demonstrated that the behavior of volatility, persistence and factor analysis of farmland price classifies the states into two group. The group classification by each empirical method is virtually the same. Moreover, the factor analysis performed in the above also supports the hypothesis that the government payment program helps to explain the behavior of the cyclical behavior of farmland price, since both factor loading patterns virtually match each other.

How do these empirical finding relate to the conceptual framework developed in chapter 3? In chapter 3 we developed the hypothesis that government payments tend to decrease fluctuation in land price if farmers expect land price to appreciate at a rate slower than the rate of return from off-farm investment. This appears to the case for almost all of the new England and Mid-Atlantic States. Possible explanations for this result lie in the role of agricultural in the state with respect to either its share in state produce or the expected change in that share. This may, in turn, reflects the conditions of future demand for agricultural products of those states..

In contrast, almost all of the North Central and Plains States were characterized by increasing volatility in land prices and a negative sign in the state-specific factor loading coefficient. The results are consistent with farmers expectations in those states that land price would appreciate at the rate higher than the rate of return in off-farm investment. This, in turn, also reflects the expectation about future demand for agricultural products in those states, and income protection due to farm programs. It should be emphasize that whether this is a correct interpretation of the results is not clear at this stage, it is only the interpretation linked to the theoretical model developed in chapter 3. It seems to me that more detailed conceptual and empirical work need to be done to shed more light on this topic.

CHAPTER 8

CONCLUSIONS

This study investigates the cyclical behavior of agricultural farmland prices in 48 states from the period 1910-1989. We divide the data into two subperiods - pre-policy period from 1910-1933 and post-policy period from 1947-1989. The years 1934-1946 are taken out because of the depression and wartime price controls. The main focus is the possible change on the pattern of cyclical behavior of agricultural farmland prices after the agricultural policies were introduced in 1933.

We approach the problem both theoretically and empirically. On the theoretical side, the main effort is to understand through what kind of mechanism government policies affect the farmland price movement. Based on a representative farmer's profit maximization problem, plus an uncertain wealth accumulation process and government policy constraint, we derived an explicit formula showing how government payment program affects the farmland price movement. It shows that the same government payment program will affect the farmland price in two different ways- either increase the fluctuation of land price or decrease the fluctuation of land price, depending on whether the expected rate of appreciation of farmland price is higher or lower than the risk-free return on cash. Thus, the same government policy will generate two different kinds of outcomes.

The second part of study is to empirically test if farmland price behavior can indeed be categories into two different groups, which is predicted from the theoretical modeling. Our empirical work indicates that the behavior of volatility of farmland price can classify states into two different groups. In group one, the volatility level has increased after the agricultural policies were introduced. This group includes almost all of the North Central and Plains states. In group two, the volatility level has decreased after the farm policies were introduced. In addition, shocks had a more persistent influence on agricultural land price since farm policies were introduced. The group two states include almost all of the New England and Mid-Atlantic states. The behavior of agricultural land prices differ between these two groups. In first group, the land price turns from stationary into nonstationary. This evidence is not statistically significant in group two states. In fact, in some of the latter states, persistence actually declines, maintaining land price series stationary. Moreover, factor analysis also indicates that general macroeconomic conditions play affect the formation of farmland price in each state equally. On the other hand, the state specific factors also play roles. Finally, the factor analysis also indicates that the government payment program helps to explain the cyclical behavior of the farmland price. From a policy point of view, the results indicate the possibility that agricultural programs may have had a destabilizing effect on the agricultural sector. Moreover, the results also reveal that agricultural policies design may have to consider heterogeneous nature of state-specific factors. Among factors that may differentiate the two groups of states are the location, the degree of urbanization, the percentage of export share of agricultural products, etc. Future research may want to explore these issues, together with state-specific - or, perhaps, regions-specific - policies, including land use policies that help form expectations and, in the process, affect land prices. As to what extent the each state specific factors or region-specific factors has to be considered in the design of agricultural policies remains an important and open question for future research.

APPENDIX

Table 1: Standard Deviation of Growth in Land Prices

Region	State	Period 1	Period 2	Ratio (2/1)
New England	Connecticut	0.069	0.038	0.563*
	Maine	0.058	0.049	0.840
	Massachusetts	0.062	0.039	0.635*
	New Hampshire	0.074	0.048	0.658*
	Rhode Island	0.078	0.057	0.734
	Vermont	0.066	0.048	0.729
Mid-Atlantic	Delaware	0.061	0.059	0.975
	Maryland	0.055	0.060	1.089
	New Jersey	0.074	0.058	0.776
	New York	0.057	0.044	0.780
	Pennsylvania	0.061	0.058	0.959
North Central	Illinois	0.064	0.090	1.414
	Indiana	0.056	0.087	1.556*
	Iowa	0.086	0.106	1.242
	Michigan	0.060	0.062	1.028
	Minnesota	0.067	0.094	1.411
	Missouri	0.058	0.077	1.324
	Ohio	0.051	0.078	1.513*
	Wisconsin	0.054	0.063	1.168
Plains	Kansas	0.064	0.071	1.112
	Nebraska	0.059	0.091	1.524*
	North Dakota	0.050	0.078	1.356
	Oklahoma	0.064	0.068	1.058
	South Dakota	0.069	0.072	1.040
	Texas	0.068	0.061	0.889
Southeast	Alabama	0.068	0.059	0.861
	Arkansas	0.069	0.071	1.038
	Florida	0.109	0.078	0.720
	Georgia	0.084	0.060	0.713
	Kentucky	0.048	0.055	1.159
	Louisiana	0.064	0.081	1.256
	Mississippi	0.094	0.072	0.762
	North Carolina	0.077	0.051	0.663*
	South Carolina	0.112	0.055	0.497*
	Tennessee	0.054	0.051	0.943
	Virginia	0.059	0.050	0.863
	West Virginia	0.048	0.065	1.363
Northwest	Colorado	0.073	0.063	0.870
	Idaho	0.058	0.059	1.013
	Montana	0.058	0.064	1.116
	Oregon	0.076	0.057	0.747
	Washington	0.063	0.058	0.916

	Wyoming	0.105	0.067	0.640
Southwest	Arizona	0.101	0.072	0.715
	California	0.083	0.065	0.793
	Nevada	0.073	0.080	1.020
	New Mexico	0.089	0.070	0.780
	Utah	0.055	0.067	1.219

Table 2: Persistence Measures

Region	State	Period 1	Period 2	T-Ratio
New England	Connecticut	1.547	1.755	0.17
	Maine	1.129	1.401	0.34
	Massachusetts	1.681	1.339	-0.29
	New Hampshire	1.135	2.061	0.77
	Rhode Island	1.703	1.075	-0.51
	Vermont	0.856	2.380	1.08
Mid-Atlantic	Delaware	1.309	1.748	0.40
	Maryland	0.929	1.663	0.86
	New Jersey	1.643	1.168	-0.41
	New York	1.528	1.368	-0.15
	Pennsylvania	1.255	1.426	0.19
North Central	Illinois	0.891	1.918	1.017
	Indiana	0.903	2.042	1.10*
	Iowa	1.188	2.037	0.76
	Michigan	0.694	1.918	1.25*
	Minnesota	1.252	2.159	1.36*
	Missouri	0.889	1.752	0.95
	Ohio	0.809	1.797	1.11*
	Wisconsin	0.614	2.320	1.36*
Plains	Kansas	0.703	2.109	1.33*
	Nebraska	0.689	1.547	1.31*
	North Dakota	0.918	2.058	1.07
	Oklahoma	0.720	1.950	1.23*
	South Dakota	0.974	1.447	0.67
	Texas	0.837	1.194	0.69
Southeast	Alabama	0.823	1.634	0.99
	Arkansas	0.967	1.854	0.89
	Florida	1.097	2.001	0.084
	Georgia	0.756	1.786	1.11*
	Kentucky	0.919	1.987	0.98
	Louisiana	0.732	1.799	1.22*
	Mississippi	0.521	1.777	1.50*
	North Carolina	1.142	1.587	0.48
	South Carolina	0.675	1.692	1.23*
	Tennessee	0.830	2.019	1.10
	Virginia	0.610	1.418	1.33*
	West Virginia	0.937	1.737	0.86
Northwest	Colorado	0.673	1.755	1.27*
	Idaho	0.694	2.607	1.33*
	Montana	1.054	1.795	0.74
	Oregon	0.821	2.139	1.16*
	Washington	0.912	1.884	1.02

	Wyoming	0.688	1.932	1.22*
Southwest	Arizona	1.783	1.456	-0.23
	California	1.029	2.037	0.96
	Nevada	1.002	1.233	0.38
	New Mexico	0.987	1.225	0.39
	Utah	1.018	2.310	0.97

Table 3: Factor Analysis		Land Price		Govt.Pay/Revenue	
Region	**State**	**Factor1**	**Factor 2**	**Factor 1**	**Factor 2**
New England	Connecticut	0.884	0.430	0.142	0.889
	Maine	0.915	0.380	0.604	0.394
	Massachusetts	0.591	0.591	0.190	0.901
	New Hampshire	0.834	0.513	0.701	0.262
	Rhode Island	0.882	0.427	0.076	0.312
	Vermont	0.916	0.373	0.148	0.910
Mid-Atlantic	Delaware	0.980	0.059	0.862	0.144
	Maryland	0.984	0.063	0.923	0.100
	New Jersey	0.933	0.220	0.886	-0.062
	New York	0.936	0.224	0.946	0.093
	Pennsylvania	0.984	0.108	0.869	0.030
North Central	Illinois	0.905	-0.364	0.853	-0.028
	Indiana	0.930	-0.326	0.950	-0.042
	Iowa	0.875	-0.434	0.880	-0.024
	Michigan	0.981	-0.139	0.966	-0.031
	Minnesota	0.935	-0.321	0.915	-0.033
	Missouri	0.974	-0.183	0.930	-0.084
	Ohio	0.944	-0.272	0.975	-0.039
	Wisconsin	0.979	-0.134	0.86	0.012
Plains	Kansas	0.927	-0.339	0.927	-0.088
	Nebraska	0.952	-0.262	0.639	0.648
	North Dakota	0.982	-0.148	0.940	-0.106
	Oklahoma	0.982	-0.138	0.928	-0.055
	South Dakota	0.978	-0.161	0.924	0.033
	Texas	0.947	0.168	0.304	-0.191
Southeast	Alabama	0.993	0.081	0.778	-0.189
	Arkansas	0.982	-0.079	0.841	-0.217
	Florida	0.964	0.191	0.593	-0.018
	Georgia	0.988	0.023	0.902	-0.049
	Kentucky	0.996	-0.041	0.923	0.146
	Louisiana	0.973	-0.107	0.688	-0.168
	Mississippi	0.984	-0.081	0.848	-0.262
	North Carolina	0.991	0.065	0.913	-0.081
	South Carolina	0.990	0.012	0.893	-0.162
	Tennessee	0.997	0.029	0.892	-0.182
	Virginia	0.982	0.166	0.930	-0.064
	West Virginia	0.966	0.033	0.884	0.122
Northwest	Colorado	0.933	-0.025	0.648	-0.020
	Idaho	0.976	-0.176	0.944	-0.011
	Montana	0.992	-0.075	0.886	-0.107
	Oregon	0.976	-0.098	0.946	0.019
	Washington	0.975	-0.077	0.933	-0.111

	Wyoming	0.989	-0.046	0.762	0.288
Southwest	Arizona	0.952	0.096	0.749	-0.299
	California	0.834	-0.048	0.875	-0.267
	Nevada	0.960	0.011	0.752	0.063
	New Mexico	0.985	0.002	0.843	0.038
	Utah	0.957	-0.070	0.828	0.272

BIBLIOGRAPHY

Alston, J.M. 1986. "An Analysis of Growth of U.S. Farmland Prices, 1963-82", *American Journal of Agricultural Economics*, 68:1-9.

Benirschka, M, and J.K. Binkley. 1994. "Land Price Volatility in a Geographically Dispersed Market", *American Journal of Agricultural Economics*, 76: 185-195.

Boulding, K. 1983. "Review of P. Balogh, The Irrelevance of Conventional Economics", *Journal of Economics Literature*, 21: 554-555.

Brown, K.C., and D.J. Brown. 1984. "Heterogeneous Expectations and Farmland Prices", *American Journal of Agricultural Economics*, 66: 164-69.

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

Campell, J.Y. and N.G. Mankiw. 1987. "Are output Fluctuations Transitory?", *Quarterly Journal of Economics*, 102: 857-880.

Campbell, J.Y., and R.J. Shiller. 1987. "Cointegration and Tests of Present Value Models", *Journal of Political Economics*, 95: 1062-88.

Castle, E.N., and I. Hoch. 1982. "Farm Real Estate Price Components, 1920-78", *American Journal of Agricultural Economics*, 64: 8-18.

Chung, K.L., and R. J. Williams. 1990. *Introduction to Stochastic Integration*, Second Edition, Birkhauser.

Clark, J.S., M. Fulton, and J.T. Scott. 1993. "The Inconsistency of Land Values, Land Rents, and Capitalization Formulas", *American Journal of Agricultural Economics*, 75: 147-55.

Cochrane, J.H. 1989. "How Big is the Random Walk in GNP?", *Journal of Political Economy*, 96: 893-920.

Davison, J.E.H. 1981. "Problems with the Estimation of Moving Average Process", *Journal of Econometrics*, XVI (1981): 295-310.

Delong, J.B. and Lawrence Summers. 1984. "The changing Cyclical Variability Economic Activity in the United States," NBER Working Paper No. 1450, September 1984.

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

Feldstein, M. 1980. "Price Inflation, Portfolio Choice, and Prices of Land and the Corporate Stock", *American Journal of Agricultural Economics*, 62: 910-16

Harvey, A.C. 1981. *Time Series Models*, Oxford Publisher.

Herdt, R.W., and W.W. Cochrane. 1996. "Farmland Values in Illinois", *Journal of Farm Economics*, 48: 243-203.

Hertzler, G. 1991 "Ito Stochastic Control", *American Journal of Agricultural Economics*, 73: 1126-1137.

Krener, A.J., and C. Lorby. 1981. "The Complexity of Stochastic Differential Equations", *Stochastics*, 4: 193-203.

Johnson, R.A., and D.D. Wichern. 1988. *Applied Multivariate Statistical Analysis*, Second Edition, Prentice Hall, Englewood Cliffs.

Just, R.E., and J.A. Miranowski. 1993. "Understanding Farmland Price Changes", *American Journal of Agricultural Economics*, 75: 156-68.

Merton, R.C. 1990. *Continuos Time Finance,* Blisss Balckwell.

Nelson, C., and H. Kang. 1981. "Spurious Periodicity in Inappropriate Detrended Time Series", *Econometrica*, XLIX (1981): 741-51.

Pope, R. D., A. Randall, D. R.D. Green, and B.D. Gardner. 1979. "An Evaluation of Econometrics Models of U.S. Farmland Prices", *West Journal of Agricultural Economics*, 4: 107-19.

Prestley, E. G. ` 1983. *Time Series Analysis,* Denver Publisher

Rausser, G.C., J.A. Chalfant, H.A. Love, and K. Stamoulis. 1986 "Macroeconomic Linkages, Taxes, and Subsidies in the U.S. Agricultural Sector", *American Journal of Agricultural Economics*, 68: 399-412

Reynolds, J.E., and J.F. Timmons. 1969. *Factor Affecting Farmland Values in the United States*. Iowa Agricultural Experimental Station Research Bulletin, Number 566.

Riesz, F. and B. Nagy. 1955. *Functional Analysis,* Denver Publications.

Robinson, L.J., D.A. Lind, and R. Venkataraman. 1985. "Cash Rents and Land Values", *American Journal of Agricultural Economics*, 67: 794-805.

Romer, C.D. 1986. "Is the Stabilization of the Postwar Economy a Figment of the Data?", *American Economic Review*, LXXVI, 314-34.

Romer, C.D. 1991. "Behavior of Individual Production Series, 1889-1984", *Quarterly Journal of Economics*, 106: 1-31.

Sargen T.J,1979. *Macroeconomics Theory,* Academic Press.

Shalit, H., and A. Schmitz. 1982. "Farmland Accumulation and Prices", *American Journal of Agricultural Economics*, 64: 710-19.

Tweeten, L.G., and J.E. Martin. 1996. "A Methodology for Predicting U.S. Farm Real Estate Price Variation", *Journal of Farm Economics*, 48: 478-93.

U.S.D.A. 1989. *Agricultural Land Prices*, 1910-1989. Economic Research Service U.S.D.A, Washington, D. C..

U.S.D.A. *Agricultural Statistics*, U.S.D.A, Washington, D.C., Various Issues.

U.S. Bureau of Labor Statistics, Department of Commerce, Washington, D.C., Various Issues.