2011

OPPORTUNITY COST OF LAND AND URBAN GROWTH

Bo Jiang
University of Kentucky, ukbojiang@gmail.com

STUDENT AGREEMENT:

I represent that my thesis or dissertation and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained and attached hereto needed written permission statements(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine).

I hereby grant to The University of Kentucky and its agents the non-exclusive license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless a preapproved embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's dissertation including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Bo Jiang, Student

Dr. William H. Hoyt, Major Professor

Dr. Christopher R. Bollinger, Director of Graduate Studies

OPPORTUNITY COST OF LAND AND URBAN GROWTH

DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Business and Economics at the University of Kentucky

By
Bo Jiang
Lexington, Kentucky

Director: Dr. William H. Hoyt, Professor of Economics
Lexington, Kentucky
2011

ABSTRACT OF DISSERTATION

OPPORTUNITY COST OF LAND AND URBAN GROWTH

This study examines the impact of the opportunity cost of urban land on urban growth. Based on prices, costs and productivity data on agricultural commodities at county levels, the opportunity cost of land was measured by the weighted revenue, cost, and government payment per acre of farm lands. Aggregating county data to metropolitan area levels, a panel data for 269 metropolitan areas from 1978-2000 were constructed. This study found that, as predicted by the theory, cities grow slower when revenue increases or cost decrease in the area. The impact of commodity program payment was also examined. Our results show that price shocks and agricultural subsidies do have an instantaneous impact on urban growth by affecting the opportunity cost of urban land.

KEYWORDS: land supply, opportunity cost, urban growth, agricultural price, spatial equilibrium

Author's Signature: Bo Jiang

Date: November 12, 2011

OPPORTUNITY COST OF LAND AND URBAN GROWTH

By
Bo Jiang

Director of Dissertation: Dr. William H. Hoyt

Director of Graduate Studies: Dr. Christopher R. Bollinger

Date: November 12, 2011

ACKNOWLEDGMENTS

The dissertation would not be possible without the help of my advisor, William H. Hoyt. Prof. Hoyt encouraged me to focus on this study when the idea first came to me, lent his knowledge on relative fields, made me realize the importance of the literature reading, and helped me with the editorial work. Other than the advising work for the dissertation, I am also indebted to his coordination with other committee members, the department, and graduate school which had enabled me focus better on my dissertation. I am also grateful to my dissertation committee members: Glenn Blomquist, Alison F. Davis, and David Wildasin. Prof. Blomquist suggested me to consider the livestock. I am also thankful to his editorial help. Prof. Wildasin helped me examine the topic thoroughly from all angles. Prof. Davis lent me her knowledge on the agricultural sector.

I thank Prof. J.S. Bulter for making me notice the issue of cointegration in my panel data, and Prof. Albert Saiz for helping me create buffers for MSAs. I would also like to thank my department, especially DGS Prof. Christopher Bollinger, for organizing the workshop for my dissertation. I would also like to thank Yu You for helping me copying the agricultural census books, and Longjin Chen for sharing his idea and knowledge in various fields.

Finally, I thank Tian Yanfang, my wife, for taking care of everything of my family in China so that I could focus. I also thank Jiang Fan, my brother, for taking care of my mother for the last two years of her life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1 Introduction

1.1 Issues to Be Addressed

My objective in this dissertation is to offer some empirical evidence on the extent that metropolitan growth is, in fact, influenced by agricultural land rents as suggested by the traditional spatial equilibrium model. As agricultural land rents in an area, or more specifically, changes in these land rents, should be determined by the changes in the value of agricultural commodity grown in the area, my empirical work addresses how changes in the agricultural prices affects land uses bordering metropolitan areas and growth of those areas.

Therefore, the main hypothesis of this dissertation is that populations of metropolitan areas decline as the prices of agricultural products produced on lands bordering those areas increase. To accomplish this goal, I use county level data on agricultural products, including the prices, yields, costs, government payments, and lands used, to measure the value of agricultural land. The county level data is then aggregated into MSA levels and combined with data on population to examine the relationship.

The focus on how agricultural commodity prices rather than agricultural land values influence growth is done for several reasons. First, data on agricultural prices and production at the county level are more available and reliable than data on land values as most property value data are. In fact, the value of land and capital are based on assessed or self-reported value. Second, focusing on the value of agricultural products reduces concerns about endogeneity because the value of agricultural land is based both on agricultural productivity and on its value in alternative use such as residential or commercial development. Finally focusing on prices of agricultural commodities allows for more obvious and direct consideration of a number of interesting policy implications. A particular interest is the consideration of how agricultural pricing policies including price supports, export subsidies and biofuels might affect metropolitan growth in those areas with a significant and affected agricultural fringes.

1.2 The Relationship between Agricultural Prices and Urban Growth

While economic theory clearly predicts the impact of the opportunity cost of land on metropolitan growth, which is usually called the agricultural rent, little evidence has been provided. Figure 1.1 shows one example of such a relationship during 1980s. Led by a group unfavorable factors such as increased international farm products output, an overvalued dollar, and high U.S. interest rates[1], U.S. farms experienced their most severe stress since the 1930s. From 1980 to 1984, the average real value of U.S. farmland dropped by 29 percent[2]. The decline had been most pronounced in the Corn Belt and Northern Plains. Meanwhile, as Figure 1.1 shows, the population growth rate of these regions began to climb. Such a change in growth rate was not observed in other regions. Considering the long trend that U.S. population migrates from the North to the South and West, such a change in growth patterns was unusual. No studies, however, document this change, neither is any explanation provided for it.

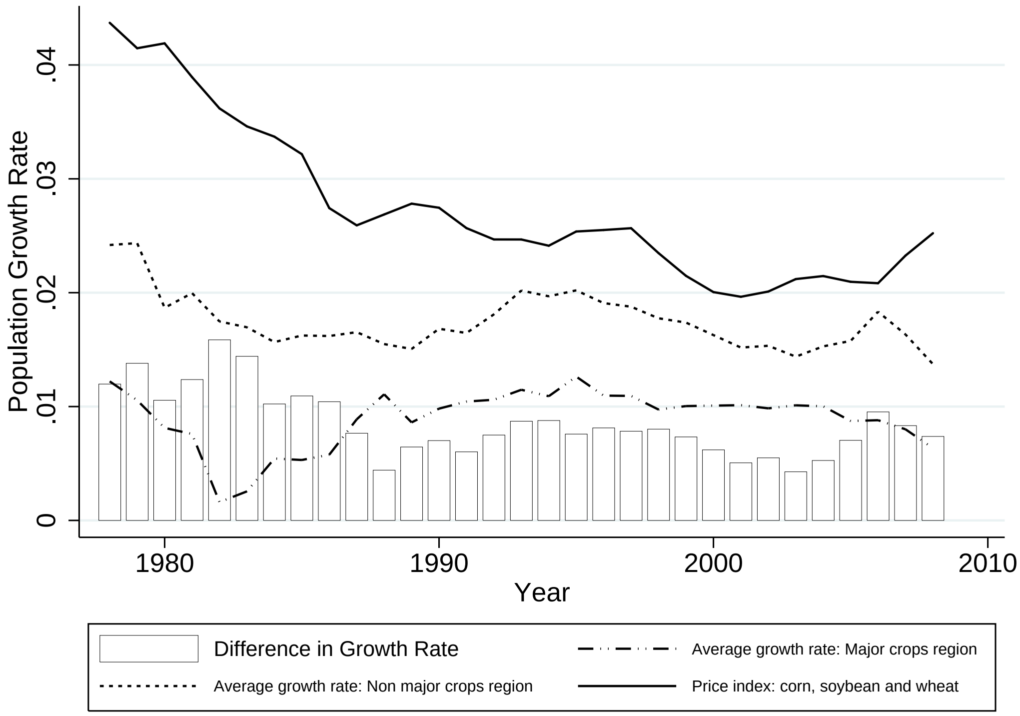
As Figure 1.2 shows, the changes in agricultural land use during and after the crisis are also consistent with this correlation between land value and population growth. Figure 1.2 plots lagged corn price and average corn acreage, from 1978 to 2000, for counties within and out of metropolitan areas respectively. In most years, the corn acreage fluctuates with the lagged price synchronously, suggesting that farmers adjusted planted acreage according to the price of the previous year.[3] The period of 1989-1993 is an exception, where the corn price declined while the acreage increased. This was mainly because the cost of corn production also decreased, faster than the

[1] Calomiris et al. [1986].

[2] Ibid.

[3] In 1985, the corn acreage peaked after the lagged price peaked in 1984, which suggests further lags of prices may also affect farmers' decision.

Figure 1.1: The Impact of Farm Crisis on the Population Growth Rate in 1980s

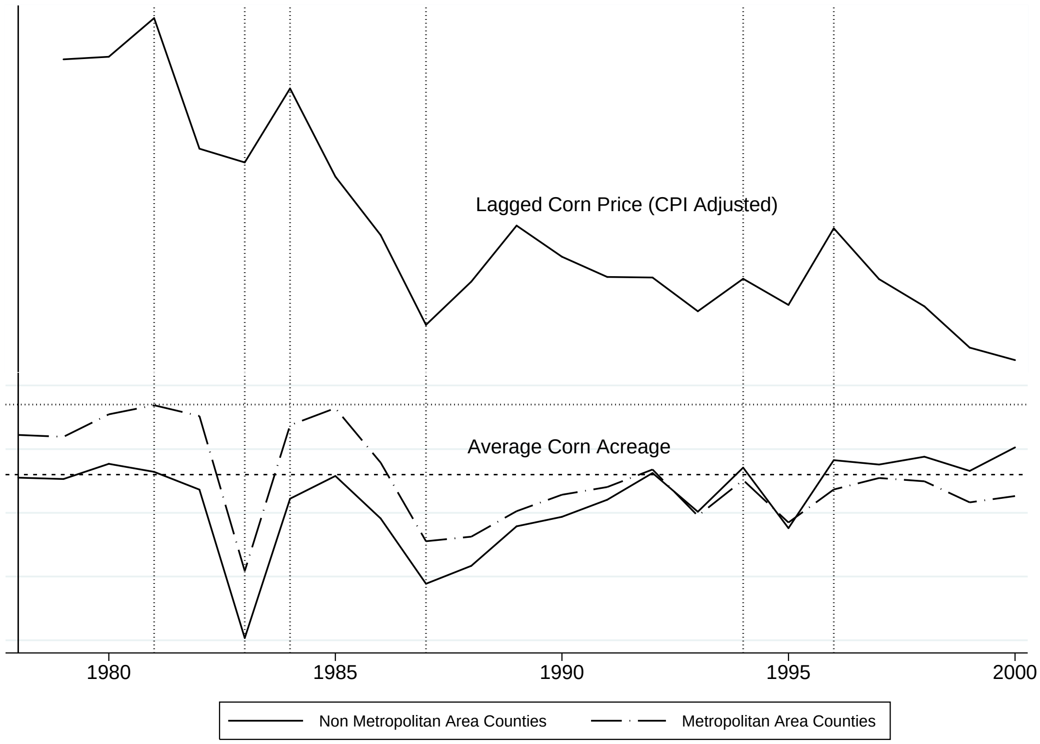


price, in this period. In 1993, the acreage in non metropolitan area resumed it pre-crisis level, but this did not happen for metropolitan counties. The corn acreage in metropolitan areas was actually lower than its pre-crisis level and remained at this lower level ever since, suggesting a permanent loss. One explanation is that farmers had converted their crop land into urban uses during the crisis, which was irreversible in the short run. Such a change in land use is not only for corn. As Figure 1.3 shows, while the crop land out of metropolitan areas recovered from the crisis during 1990s, crop land within metropolitan areas never did.[4]

The price spike in grain prices from 1994 to 1996 provides another example. Beginning in 1994, the prices for crops experienced a rapid escalation driven by economic growth in newly industrialized Asian countries and the depreciation of the U.S. dollars. The corn and wheat price peaked in 1995, while the soybean price peaked in

[4]The change of crop land acreage in Figure 1.3 is smoother than that of corn acreage because the data are from the agricultural census which is conducted every 5 years.

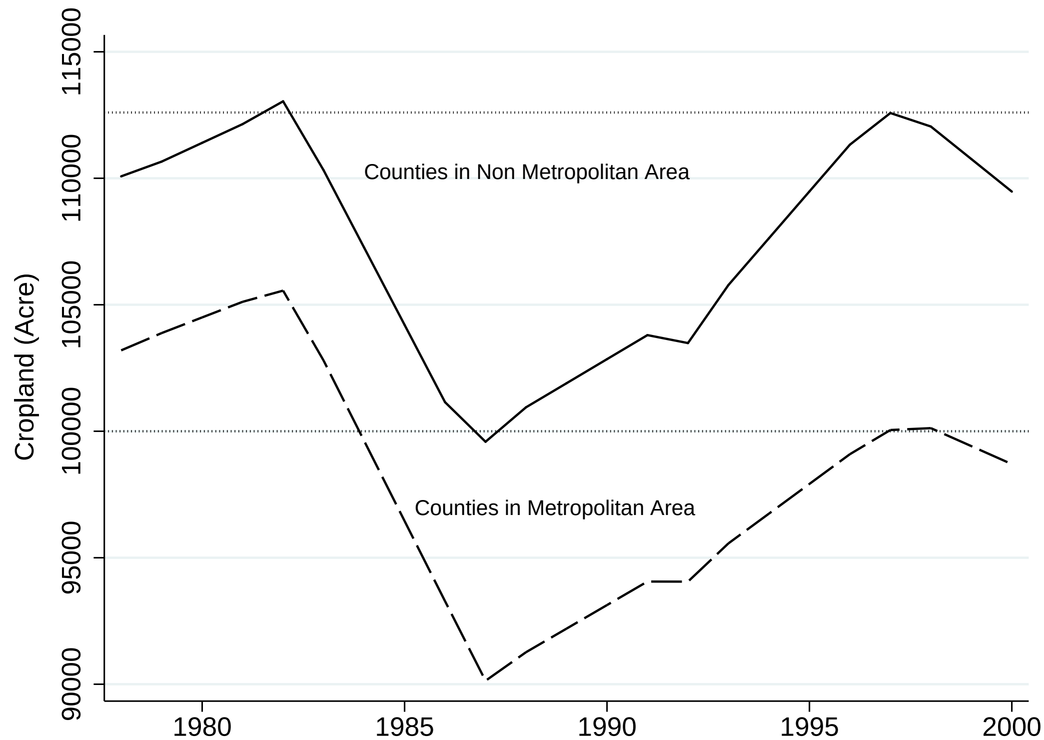
Figure 1.2: The Change of Corn Acreage: 1980-2000



Data Source: Annual County Crop Survey of NASS

1996. The stock to use ratio of these crops hit a historical low (Peters et al. [2009]). Beef prices, however, did not rise during this period. Figure 1.4 compares the growth rate of MSAs in agricultural areas major in crops and major in beef productions. It can be seen that the average population growth rate in crop areas went down during the period of spike, while no such pattern was found for either the beef region or nationwide. The synchronized moves in agricultural prices and urban growth show the correlation between agricultural prices and urban growth is indeed instantaneous. Again, no attention has been placed on such a phenomenon during this period.

Figure 1.3: The Change of Crop Land: 1980-2000



`Data Source: Agricultural Census 1978-2000`

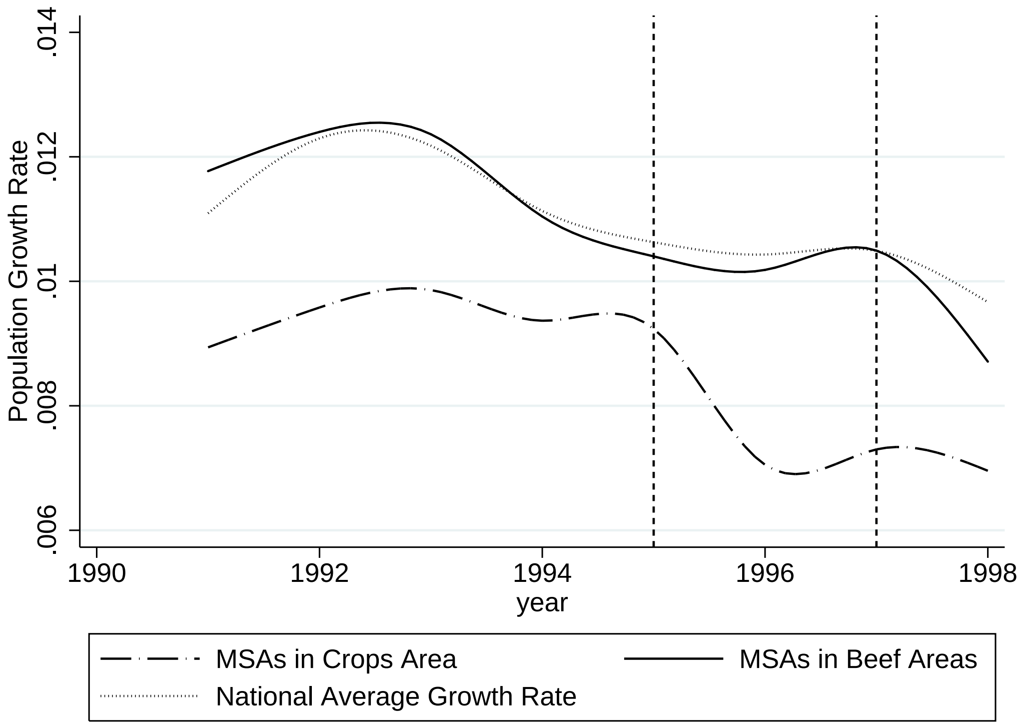
1.3 Policy Implications and Academic Contributions

Policy Implications

A direct policy implication of this study is the influence of government commodity payments on urban growth. It is well accepted that agricultural subsidies will be capitalized into land values via changes in agricultural rents [see Barnard et al. [1997], Gardner [2002], Roberts et al. [2003], Lambert and Griffin [2004] and Kirwan [2009]][5]. Agriculture subsidies have accounted for a large proportion of farm net income, 38.2% between 2000 and 2002 as an example, so the value of lands in these areas will be affected greatly if the payment policy changes. Studies on government payments focus mainly on policy incidence, but urban growth will also be affected by subsidy

[5]The recent ethanol subsidies also raised the food commodity prices, which will be passed to land rents as well [CBO [2009] and Mitchell [2008]].

Figure 1.4: The Price Spike and Population Growth in 1990s



policies. A complete analysis should definitely consider this factor.

Apart from the agricultural policies, this study provides another view of evaluating fiscal policies. As has mentioned earlier, one of the triggering factor of the farmer crisis in 1980s was the sharp increase in interest rates led by the controversial fiscal policy of the federal government. Just as the fiscal policy is not neutral to all industries, it is not neutral to all urban areas as well.

This study can also help governments better understand growth policies, for example, to adjust the timing of these policies according to agricultural price changes. It is cheaper to enact growth policies when the price of land is lower, and vice versa. When making growth policies, local government should not focus on factors within urban areas only, but should also pay attention to current agricultural prices. This is especially important in this era of rising commodity prices fuelled by burgeoning demand of food and biofuel.

Scholarly Contributions

This study provides a direct test for the canonical Alonso–Mills-Muth model that population will decrease with agricultural rent. Little work has been done for testing this implication of the AMM model. Studies on urban sprawl typically treat the opportunity cost of lands as a control but not an academic concern. Moreover, as is discussed in Chapter 2, their measures of the opportunity cost are problematic.

This study can also serve as a complement for the series of studies on the impact of urban growth on urban growth. As documented by Glaeser and Gyourko [2005], Glaeser et al. [2005], Saks [2007], and Glaeser et al. [2006] among others, the supply side of housing market is an important factor determining urban growth. The agricultural rents, or the opportunity cost of land, is one important aspect of supply conditions of the housing market, but it has not received sufficient attention.

1.4 Outline of The Dissertation

Chapter 2 reviews the literature on the impact of the agricultural rent, or, more generally, the opportunity cost of land, and urban growth. The literature of urban sprawl, which focuses mainly on land use patterns in urban areas, generally consider the agricultural rent as a control, but it never treat the rent as a primary academic concern. Findings regarding the influence of the agricultural rent are also limited. Furthermore, measures of agricultural rents in the sprawl literature are problematic because of issues of endogeneity.

The review of the growth literature discusses a recent development focusing on the housing supply. The role of housing supply in urban growth has not gained sufficient attention until the past decade. Empirical studies have recognized the importance of land use policies and local geographic characteristics in determining housing supply, but no attention has been paid to the opportunity cost of land.

Chapter 3 provides a conceptual model based on the Rosen–Roback framework.

The idea of this model is that, as the opportunity cost of urban lands rises, local wages will increase to compensate individuals, which in turn will decrease the local labor demand and the local population. A more detailed model for multiple county MSA is also discussed in this chapter.

Chapter 4 deals with data issues. Details about the data on selected agricultural products[6] are discussed in this chapter, including the process of the data on costs, revenues, government payments, and land used for each product. Based on these data, three variables, the weighted revenue, cost, and government payments were created to measure the agricultural land value for each county. The weight for each product is the ratio of land used for producing this product to the total farmland. To examine the validity of the imputation of these three variables, I regressed farmland values on these variables with a sample of non metropolitan counties. The results confirm that those variables are capable of measuring farmland values. To account for spillover effects, a set of MSA buffers was created to determine which counties to be included for each MSA to aggregate the county level data. Data on the dependent variable, population in urban areas, and other determinants of growth are discussed at the end of this chapter.

Chapter 5 discusses the empirical methodology. Alternative measures of the agricultural variables, together with the reasons and the expected consequences of using them, are discussed first in this chapter. Subsamples that will be used in the empirical analysis, together with the purposes of using them and the power of each subsample, are also discussed. At the end of this chapter, the necessity of a dynamic regression model is discussed, which calls for the use of the Arellano–Bond estimator.

Chapter 6 presents and analyses the empirical results. Results for two subsamples, the 1978-1990 subsample and the 1990-2000 subsample, are analyzed first. The first

[6]Eight crops,soybean, corn, wheat, barley, cotton, oats, rice, and sorghum, were selected. The cropland used for these crops covers about 90% of the total cropland nationwide. Two livestock products, beef and milk, were also included. The market value of these two products accounts for over 65% of the total value of all livestock products.

subsample is featured with a drastic price decline, while the second is featured with a price spike. Results for these two periods are as expected: both population level and the growth rate decline as the agricultural revenue and government payments increase, and the impact of the agricultural cost is the opposite. These results have passed a series of robustness checks. Because the estimation results are more stable in areas with more agricultural lands, to provide a final estimation, a subsample of "agricultural" MSAs was drawn. The results show that as the 3–year agricultural revenue doubles, the population level will be 1.5% lower, while the population growth rate will decrease by 1.22 percent point. Using the estimation results above, I simulated the impact of agricultural subsidies for selected MSAs and a hypothesized price shock of corn for Des Moines.

Chapter 7 summarizes findings and policy implications of this study, together with caveats of this study and suggestions for future works.

Chapter 2 Literature Review

Section 2.1 reviews the studies based on the classic Alonso–Mills–Muth (AMM) model. The AMM model provides a powerful tool to analyze the role of the agricultural rent in urban development. Although the empirical studies based on the AMM model generally considered the value of land in agricultural uses, it is almost always treated as exogenously determined and outside the model. Evidence regarding the influence of the agricultural rent on urban growth is very limited. Moreover, as is shown at the end of this section, measures of agricultural rent of these studies are problematic because of issues of endogeneity. Section 2.2 reviews the studies of urban growth under the Rosen–Roback framework.[1] These studies have recognized a group of determinants of urban growth that are always controlled. In the past decade, a series studies has been conducted on the influence of housing supply on urban growth. This development of the growth literature is not only required by the logic completeness of the theory, it is also a response to the findings that the supply side of housing market is important in practice.

2.1 The Intra–City Spatial Equilibrium

The key idea of the AMM (Alonso [1964], Mills [1967], and Muth [1969]) model is that the city is in equilibrium when individuals can not increase utility by changing locations within a city. The crucial necessary condition for this intra–city spatial equilibrium to exist is that relocation is costless within the city. The equilibrium is then reached via the adjustment of land price. The comparative statics of the model were first completely analyzed by Wheaton [1974]. Brueckner [1987] integrated housing capital into the model and analyzed on the intensity of urban land use.

[1] Rosen [1979] and Roback [1982].

According to the AMM model, the city border is at the point at which the rent for residential use and for agricultural use are equal. In a closed city with a fixed population, the city will shrink as agricultural rent increases, with both the population density gradient and the urban land rent gradient shifting upward, and urban lands will be used more intensively. Because land is more expensive, the utility of urban residents will decrease. In an open city where individuals are perfectly mobile so that the utility level is constant over cities, the city will be truncated on the fringe when the agricultural rent increases. People will move out of the area with high agricultural rent to avoid the decease in utility. The population density gradient and the land price gradient, however, do not shift. Whether and how population is affected by agricultural land values, therefore, depends on whether the city is closed or open. In a modern world with low transportation costs, the open city model is definitely more realistic.

Two approaches are used to test the predictions of the AMM model. One is to compare estimates for a specific city over time. Using historical population data, McDonald [1997] examines the population density gradient for 1870-1990 in Chicago.[2] McMillen [1996] examines the land gradient of Chicago for 1836-1928, using data from Hoyt [1933], and 1960-1990, using data from *Olcott's Land Values blue Book of Chicago*. Both results show that as commuting costs fell incomes increased over time in Chicago, both population gradients and land value gradients decreased. I do not follow this approach because the cross sectional variation of the agricultural rents cannot be used.

An alternative approach is comparing the urbanized land area while controlling for population, transportation cost and income. Brueckner and Fansler [1983] was one of the first studies using this approach. With census data, they examined the spatial

[2] Because historical population data are only available for larger geographical areas, such as municipalities and counties, McDonald [1997] applies a two–point method to estimate the population gradient. Details about this two–point method can be found in Mills [1972].

area of 40 single-county MSAs in 1970. The opportunity cost of land was measured by the 1969 median agricultural land value per acre for the county containing the urbanized area. Their results showed that high-priced farmland was more resistant to urban expansion than poor–quality land. More recent studies include McGrath [2005] and Spivey [2008], which expanded their observations to multiple-county MSAs. McGrath [2005] pooled 33 largest metropolitan areas from the decennial census from 1950 to 1990 to examine the pattern of urban sprawl over the post-war years. The agricultural land value was proxied by state level agricultural land value, which was very imprecise of course. Spivey [2008] updated the study of Brueckner and Fansler [1983] by using 2000 census data. He also redefined key variables with new measures, e.g., the observation unit was Urbanized Areas (UAs) instead of MSAs, the agricultural rents were measured by weighted agricultural farmland value from the Agricultural Census, and two new measures of transportation cost provided by the Texas Transport Institute were introduced. The results of these studies are consistent with the prediction of the AMM model that the spatial size of urban areas decrease with agricultural rent.

Using the second approach, a group of studies also examines the impact of the "fiscal- social" factors (Mieszkowski and Mills [1993]), rather than the "natural evolutionary" factors, on the demand for urban land and urban sprawl. These fiscal–social factors include, central city amenities and disamenities as address by the "flight from blight" hypothesis(Mills and Lubuele [1997] and Brueckner et al. [1999]), local land planning and development polices (Burchfield et al. [2006] and Wassmer [2008])[3], and property taxes (Song and Zenou [2006])[4] It is worth to note that Song and Zenou [2006] used income adjusted by the differences n the cost of living to avoid the heterogeneity in labor markets across metropolitan areas in their studies. An influential

[3]Such policies may be motivated by the fiscal revenue associated with land uses (Lewis [2001]), or by urban residents' intention to maximize property values (Glaeser et al. [2005])

[4]Brueckner and Kim [2003] among others argues that property tax will cause inefficient land use patterns.

study by Burchfield et al. [2006] used the unique data from high altitude aerial photographs of 1976 and 1992 examines a wide range of factors that may encourage urban sprawl. Their findings show that following factors would increase urban sprawl: specialization in sectors with weaker agglomeration economies (measured by the degree of employment decentralization), the historical city center being automobile friendly (so the transportation costs are low, as measured by passengers per capita in 1902), the uncertainty about future urban growth (measured by the standard deviation of decennial percentage population growth rates 1920-70), ground water availability, topography (whether close to mountains or hills, for example), favorable temperature climate, and fragmented local governments where incorporated growth control or zoning is less likely. The opportunity cost of land, however, was not examined in their study.

Most of these studies do consider agricultural land values, but treat it as a control rather than a focus of their studies. All of these studies measured the agricultural rent by using the reported market value of farm lands within metropolitan areas. The observed market value of farm lands, however, is affected by urban growth because farmers will consider the likelihood of those land being converted to urban uses in the future when selling their lands (Capozza and Helsley [1989]). This issue of endogeneity is less problematic when the dependent variable is the spatial size of urban areas and the population is controlled, but will be far more serious if the dependent variable is population or population growth, as is the case in the present study.

2.2 The Inter–City Spatial Equilibrium

As people become more footloose and locational choices are not restricted to individual cities, the idea of spatial equilibrium can also be applied to inter–city analyses. However, while a single urban area can be deemed as a labor market, the analysis of a system of urban areas need to address the heterogeneity in labor markets. By endogenizing the the local labor market, Rosen [1979] and Roback [1982] first developed a model addressing the interaction of locational choice, labor market and housing markets.[5] An important insight of this model is that real wages, netting out local cost–of–living, will be compensated by local amenities or disamenities. The reason is that workers will flow into cities with higher amenities, which will increase both the local labor supply and local housing demand so that local wages and housing prices will respond. Therefore the value of amenities, or quality of life, can be measured by an index combining local wages and housing prices with proper weights. Roback [1982] used this framework to evaluate people's willingness to pay to avoid a variety of disamenities. Based on this framework, Blomquist et al. [1988] provided an estimation of quality of life of U.S. cities; Gyourko and Tracy [1991] expanded the list of local amenities to include a wide range of government–related local characteristics; Albouy [2008] fine–tuned the measure of quality of life by adjusting the weights for income and housing prices with the federal taxes and non-labor income.

Urban Growth

In an system of open cities, because factor mobility is high so that income (adjusted by cost of living) and profit are equal spatially, urban growth is usually measured by employment or population rather than local income or output(Roberts and Setterfield [2006]). Thererfore, studies on urban growth is always associated with the locational choices of individuals, which makes the Rosen-Roback framework a natural choice for analyzing growth. Glaeser et al. [1995] put forward the inter–city spatial equilibrium framework by integrating Mill's (1967) formulation of aggregating production at the city level. Cities are assumed to be in a spatial equilibrium where individual utility and the returns to capital are equalized across space. Populations, local wages, and housing prices are determined simultaneously by local productivity and amenities.

[5] This model was further extended by Hoehn et al. [1987]

Empirical studies based on the inter–city spatial equilibrium framework highlight the importance of productivity and amenities. A host of research documents a strong positive correlation between the skill level of a city's population and city growth in recent decades, e.g., Glaeser et al. [2004] and Moretti [2004] among others. Another line of literature show that various aspects of amenities or disamenities also encourage growth, such as air quality (Kahn [2000]), city crimes (Cullen and Levitt [1999]), favorable climate (Graves [1980]), and consumption amenities such as bars and restaurants (Glaeser et al. [2001]). Moreover, Shapiro [2006] finds that one-third of the employment growth effect of college graduates can be explained by the improvement in the quality of life.

Urban Growth and Housing Supply

The role of housing supply in urban growth has not gained sufficient attention until the recent decade. In previous studies, the housing price was assumed to be determined by the demand side only, i.e., individuals' willingness to pay for a specific location. The supply side of housing market had been ignored. But the supply condition of the housing market is always an important factor determining housing prices, which in turn affects further growth. Several studies confirm the correlation between housing supply and growth in this decade. Glaeser and Tobio [2008] shows that the growth of Sun Belt in 1980s and 1990s may have little to do with local amenities or productivity improvement but more likely to do with favorable development policies; Glaeser and Gyourko [2005] finds that durable housing can explain the asymmetry of population changes in growing and declining cities; Saks [2007] finds that employment growth is lower in places where the housing supply is more constrained; Gyourko et al. [2006] argues scarce land leads to bidding-up of land prices and sorts high-income households into "superstar cities".

These findings of the correlation between housing supply with urban growth suggest the spatial equilibrium framework should include the supply side of the housing market. Glaeser [2008] and Glaeser and Gyourko [2006] integrate the housing market into the inter–city spatial equilibrium framework by introducing an additional equilibrium condition that the expected profit of housing developers equals zero. The introduction of the forward looking behavior of developers into the analysis has made the model dynamic.

Realizing the importance of housing supply in determining urban growth, urban economists have conducted a series of studies on the heterogeneity in the supply conditions of housing markets across cities. Using cost data from commercial developers, Gyourko and Saiz [2006] estimates an elastic supply for physical structure and conclude differences in construction activities across markets do not explain the variation in costs. Their findings lead subsequent researches to focus on supply shifters such as local regulatory environments and local topographies. Using the Wharton Regulatory Index, Glaeser et al. [2006] examines how growth is affected by local regulatory policy on land uses[6]; using satellite-generated data on terrain elevation and presence of water bodies, Saiz [2010] finds geography is a key factor in determining housing supply inelasticities by directly reducing land availability and indirectly inducing anti-growth regulations via high land values.[7]

The opportunity cost of urban land is definitely another source of the heterogeneity in land supply. The productivity of agricultural lands are different according to their climate and geographic characteristics. Even in areas with similar climate and geographic characteristic, the inter temporal changes in land values may still differ because of different crops grown there. Using the information on agricultural prices,

[6] Glaeser et al. [2005] provide a political economic explanation for the heterogeneity in regulatory polices

[7] Saiz [2010] does not find any correlation between the land availability and population by using his cross–sectional data. He explains that the restriction of land availability will be compensated by productivity and amenity shocks. He further shows that the shocks drawn from a Pareto distribution will completely offset the restriction of land. However, there is no mechanism to guarantee that the agricultural price shocks should follow a Pareto distribution at any time, so the population can still be correlated with agricultural prices intertemporally.

we can get a measure of agricultural land value which captures the heterogeneity in land supply across spaces. The volatility of agricultural commodity prices, moreover, provides changes in land values over time, which enables us to observe whether spatial equilibrium would hold in the short run.

2.3 Implications for My Research

The review of previous studies provides several implications for my research. First, the AMM model provides a clear and intuitive prediction for the impact of opportunity cost of land, or agricultural land values, on urban growth, i.e., in open cities, the population of urban areas decreases with the opportunity cost of land. Second, measures of agricultural land values in previous studies were either imprecise or endogeneous, which explains their limited results regarding the opportunity cost of land. A measure based on agricultural prices is presumably more superior because they are exogeneous. Moreover, the volatility of agricultural commodity prices can also provide short term changes in land values, which enables us to observe the response of urban growth in the short run. Third, recent studies of housing supply and urban growth have found that housing supply is an important determinant for urban growth. As an aspect of supply conditions of housing supply, we do expect the opportunity cost of land will also affect the growth. Finally, studies based the inter city spatial equilibrium point out other determinants that should be controlled in this study, i.e., local amenities and productivities.

Chapter 3 The Conceptual Framework

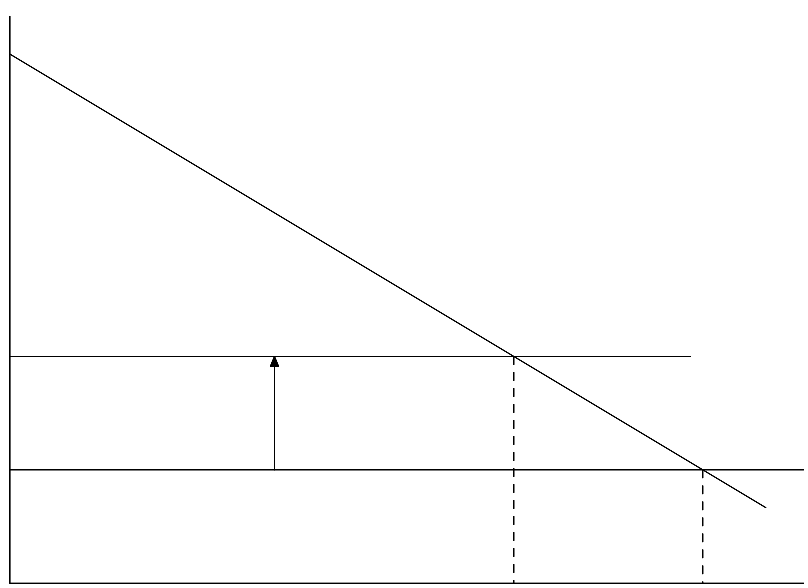
Section 3.1 briefly discusses the comparative static results of the traditional Alonso–Mills–Muth model regarding the opportunity cost of land. The "open–city" version of this model has an explicit prediction on the impact of agricultural rent that urban population will be smaller in areas with higher agricultural rent. In Section 3.2, a model based on the intercity spatial equilibrium framework is presented to analyze how population is distributed among a system of metropolitan areas. The idea of this model is that, as the opportunity cost of urban lands rises, local wages will increase to compensate individuals, which in turn will decrease the local labor demand and the local population. Unlike Saiz [2010] or Glaeser [2008] where the behavior of developers are modeled, my model assumes developers are absent so that individuals consume land directly. No generality will be lost when the opportunity cost of land is exogeneous.[1] Section 3.3 presents a model allowing for multiple-county MSAs. Counties within a MSA differ in the opportunity cost of land but share the same labor market. The increase in the opportunity cost of land within a single county has two effects. First, similar to the result in Section 3.2, local wages must rise to compensate such an increase in land price, which in turn reduces the population of the entire MSA. Second, urban residents will be reallocated across counties. These results together suggest that the population of a single county is also affected by the agricultural rent in other counties.

[1] For example, we can model the cost function of developers as the sum of construction cost and opportunity cost of land, and, as in Saiz [2010] or Glaeser [2008], introduce an additional equilibrium condition for the housing market that the expected profit equals zero. But as long as developers are price taking, any exogeneous change in the opportunity cost of land will be passed to the housing price instantaneously and completely, so the analytical results regarding the cost of land will not change with or without developers in the model.

3.1 The Implication of the Canonical Alonso-Mills-Muth Model

Although the traditional AMM model of monocentric city is somewhat outdated, it is always a good start to understand urban land use and urban population distribution. The key insight in the monocentric model is that the price of housing varies with accessibility to the central business district. Individuals residing far from the CBD are compensated for their long commutes with cheap housing, while individuals living at central locations pay a premium for space, canceling the advantage of low commuting cost. That is, as the curve AB in Figure 3.1 shows, the land rent at each location decreases with its distance to CBD.[2] The city border lies in the point where the rent of land for residential uses equals the value for agricultural uses. In Figure 3.1, the city border lies in $\bar{d}$, where the residential land rent equals the agricultural rent r_g. In an open city where utility level is fixed, as the agricultural rent increases to r_g', the city will shrink to $\bar{d}'$.

Figure 3.1: Determination of Urban Population: Open Cities



Because the land is expensive near CBD, dwellings near CBD will be smaller

[2]More specifically, the land rent at location d is a function of transportation cost τ, individuals' income w, and the utility level u. That is, $r = r(\tau, w, u; d)$. And there is $\partial r/\partial d < 0$.

because of substitution effect. This means the population density at each location will also decrease with its distance to CBD. Let us still use the curve AB to represent the downward sloping population density gradient. There are two ways to close the model: the open-city assumption where utility is fixed because individuals are perfectly mobile, and the closed-city assumption where the population is fixed. The open-city assumption is more appropriate because transportation costs have become so low and individuals have become more footloose. When the agricultural rent equals r_A, the population of the city is the integral of the density over 0 to $\bar{d}$, i.e., the area of Ar_AB. As the agricultural rent increases to $r_A^{'}$, the population reduces to the area $Ar_A^{'}B'$. Therefore, the population decreases with the agricultural rent.[3]

3.2 A System of Metropolitan Areas

The traditional AMM model is successful in explaining the determination of land values and population distributions within a city. But when we turn to the population distribution in a system of metropolitan areas, this model is incapable of handling the heterogeneity of income. Moreover, local amenities are found to be also important for locational choice of individuals. The Rosen-Roback model provides a intercity spatial equilibrium framework dealing with the heterogeneity in incomes and amenities. This section presents a model based on the intercity spatial equilibrium to analyze the impact of the opportunity cost land on population. This model consists of two parts. The first part describes the locational choice of individuals, with the result that higher land price must be compensated by higher local wages. The second part deems the metropolitan area as a unit of production, where the employment, or population, is determined by local wages.

[3]Under the open-city assumption (constant utility), the density gradient AB does not shift with the agricultural rent. When cities are closed, however, the density gradient will shift upwards with the agricultural rent because the city has become smaller and population should be more densely distributed everywhere.

3.2.1 Locational Choice of Individuals

Suppose individuals are homogeneous in preference, having a Cobb-Douglas utility function

$$\begin{aligned} U &= U(M_{it}, L_{it}; C_{it}) \\ &= M_{it}^{\alpha} L_{it}^{\beta} C_{it} \end{aligned}$$

where, in city i at time period t, M_{it} is a bundle of private consumption goods with a price normalized to unity, L_{it} is the consumption of land, and C_{it} is local amenities. Individuals, with labor income W_{it}, buy land from farmers at the price of P_{it}, which is solely determined by the agricultural sector. The spatial equilibrium condition requires that all cities at all times deliver the same utility $\underline{\mathrm{U}}_t$ to the marginal residents. Therefore, the locational choice of individuals can be expressed as

$$\max_{M_{it}, L_{it}} \; M_{it}^{\alpha} L_{it}^{\beta} C_{it}$$

$$s.t. \quad M_{it} + P_{it} L_{it} = W_{it}$$

with the equilibrium condition

$$U_{it} = \underline{\mathrm{U}}_t \quad \forall i$$

Setting $\alpha + \beta = 1$, the solution is

$$\ln W_{it} = \beta \ln P_{it} - \ln C_{it} + \ln \underline{\mathrm{U}}_t - (\alpha \ln \alpha + \beta \ln \beta) \tag{3.1}$$

and

$$\ln L_{it} = -\alpha \ln P_{it} - \ln C_{it} + \ln \underline{\mathrm{U}}_t + [\ln \beta - (\alpha \ln \alpha + \beta \ln \beta)]$$

It is can be seen from equation (3.1) that $\frac{\partial \ln W_{it}}{\partial \ln P_{it}} = \beta > 0$. The result means that, at equilibrium, wages must be higher to compensate individuals in places where lands are more expensive,

Labor Demand and Population

Local output for city i at time period t is

$$Y_{it} = A_{it} N_{it}^{\theta}$$

where N_{it} is the city employment or population[4], A_{it} is the city specific production factor, and $\theta \in (0, 1)$ is a nationwide constant.

Labor demand of city i in period t then is given by

$$\frac{\partial Y_{it}}{\partial N_{it}} = W_{it}$$

Substituting equation (3.1) for $\ln W_{it}$ yields

$$\ln N_{it} = \frac{1}{1-\theta} \left[\ln A_{it} - \beta \ln P_{it} + \ln C_{it} - \ln \underline{\mathrm{U}}_t + (\alpha \ln \alpha + \beta \ln \beta + \ln \theta) \right] \tag{3.2}$$

Note that $\frac{\partial \ln N_{it}}{\partial \ln P_{it}} = -\frac{\beta}{(1-\theta)} < 0$, which says population level will be lower in areas with higher opportunity costs of lands. This result is similar to the AMM model with open cities, but it highlights the impacts of local productivity and amenities.

Model Dynamics

Because the spatial equilibrium holds at any point of time by assumption, differencing equation (3.1), we can derive the dynamics of wages

$$\Delta \ln W_{it} = \beta \Delta \ln P_{it} - \Delta \ln C_{it} + \Delta \ln \underline{\mathrm{U}}_t \tag{3.3}$$

The positive sign of $\ln \Delta P_{it}$ means that local wages will grow faster in areas where agricultural land values appreciate faster.

Similarly, differencing equation (3.2) we have the dynamics for populations

$$\Delta \ln N_{it} = \frac{1}{1-\theta} \left[\Delta \ln A_{it} - \beta \Delta \ln P_{it} + \Delta \ln C_{it} - \Delta \ln \underline{\mathrm{U}}_t \right] \tag{3.4}$$

The sign of $\Delta \ln P_{it}$ is negative, which suggests population will grow slower in areas where agricultural land values appreciate faster.

To summarize, equation 3.2 and 3.4 provides the hypotheses that this study will test: both population level and growth will decline with agricultural prices.

[4]The assumption that employment equals population is to say people live in the cities where they work Glaeser et al. [2006].

3.3 Multiple-County Metropolitan Areas

Previous analysis assumes a single land price for each metropolitan area, but most MSAs contains more than a single county. So the question is how the agricultural price change of one county would affect the MSA with multiple counties. To answer this question, a model for multiple-county metropolitan areas is discussed in this section. In this model, wages are determined at the MSA level because each MSA is a labor market by definition. The population of each county is determined by the metropolitan level wage and its local amenities. As will be seen shortly, unlike the traditional AMM model, the land rent gradient and the population density gradients will shift with the agricultural rent even though the open city assumption still holds in this model. There are mainly two results of this model. First, the population of the metropolitan area is determined by the agricultural rent of all composing counties. Moreover, holding the agricultural rent of other counties constant, the impact of the agricultural rent on population is reduced by a factor of the number of counties relative to single-county MSA cases. Second, the county population is determined not only by the MSA level wage, its own amenity, and its own agricultural rent, it is determined by the agricultural rents of other counties as well. This result shows the technical difficulties of choosing counties as the observation unit, i.e., we may have to consider too many factors.

Suppose a metropolitan area j is composed of a system of linear counties denoted by i, locating around a common downtown core. All individuals are employed in the downtown core, but choose to live in different counties according to local amenities and housing prices. So the locational choice of individuals are described by the optimization problem

$$\max_{M_{ij},L_{ij}} \quad M_{ij}^{\alpha} L_{ij}^{\beta} C_{ij} \quad (\alpha+\beta=1)$$
$$s.t. \quad M_{ij} + p_{ij} L_{ij} + \tau d = W_j$$

where M_{ij} is the consumption goods with the price being normalized to unity, L_{ij} is the consumption of land, p_{ij} is the price of land, C_{ij} is local amenities, d is the distance of residence location to downtown, τ is the transportation cost, and W_j is the MSA level wages which do not depend on the residential choice of individuals. Individuals are assumed perfectly mobile so that the following equilibrium condition applies: utilities are constant over all counties and all metropolitan areas.

First order conditions give the standard solution to a Cobb-Douglas utility function that

$$p_{ij}L_{ij} = \beta(W_j - \tau d)$$

Totally differentiating the equilibrium condition $U(M_{ij}, Lij; C_{ij}) \equiv \bar{U}$ with respect to d in each county, combining FOCs above, generates the standard land price gradient and population density gradient

$$p_{ij}(d) = \frac{\beta}{k_{ij}}(W_j - \tau d)^{\frac{1}{\beta}}$$

$$n_{ij}(d) = \frac{1}{L_{ij}} = \frac{1}{k_{ij}}(W_j - \tau d)^{\frac{\alpha}{\beta}}$$

As usual, both land price and population density (the inverse of land consumption L_{ij}) at local d is decreasing with d. Note these gradients are county specific, picked up by differentiation constants k_{ij}. k_{ij} can be derived by plugging p_{ij} and L_{ij} back into the utility function such that

$$k_{ij} = \left(\frac{\bar{U}}{\alpha^{\alpha}C_{ij}}\right)^{\frac{1}{\beta}}$$

So the prices of land with the same distance to downtown core will be different if local amenities are different. Another point deserved to mention here is, as opposed to the traditional AMM model for open cities, the price and population density gradients do shift with agricultural rents.

Let $\underline{p}_{ij}$ be the agricultural rents in county i. The physical size of the "urban" ring in county i, $\bar{d}_{ij}$ is determined by the condition

$$p_{ij}(\bar{d}_{ij}) = \underline{p}_{ij}$$

which gives

$$\bar{d}_{ij} = \frac{W_j - (\underline{p}_{ij}\frac{k_{ij}}{\beta})^{\beta}}{\tau}$$

Integrating the population density over $[0, \bar{d}_{ij}]$ we can get the population in i

$$N_{ij} = \int_0^{\bar{d}_{ij}} \frac{1}{L_{ij}}\,\mathrm{d}d = \frac{1}{\tau}\left(\frac{\beta}{k_{ij}}W_j^{\frac{1}{\beta}} - \underline{p}_{ij}\right) \tag{3.6a}$$

Note $\frac{\beta}{k_{ij}}W_j^{\frac{1}{\beta}}$ is also the land price at the location $d_{ij} = 0$, denoted by $\bar{p}_{ij}$, so the population can also be written as

$$N_{ij} = \frac{1}{\tau}(\bar{p}_{ij} - \underline{p}_{ij})$$

This is because when at locations where transportation costs are the same ($d = 0$), with the same income, higher land price must be compensated by less land consumption, so the population density will be higher in counties where land prices are high (recall land prices also reflects local amenities).

We close the model by introducing the labor market equilibrium in metropolitan area j. Let the production function of j be

$$Y_j = A_j\left(\sum_i Nij\right)^{\theta}, \qquad 0 < \theta < 1$$

so the wage will be

$$\frac{\mathrm{d}Y_j}{\mathrm{d}N_j} = \theta A_j\left(\sum_i Nij\right)^{\theta-1} = W_j \tag{3.6b}$$

The equation system (3.6) describes the urban equilibrium. Unlike the system in section 2, which is recursive, this system is simultaneous. By totally differentiating

(3.6b) with respect to $\underline{p}_{ij}$ [5] we can solve for the impact of agricultural rents of one county on the entire metropolitan area

$$\frac{\partial \ln W_j}{\partial \ln \underline{p}_{ij}} = \frac{\beta(1-\theta)\underline{p}_{ij}}{\beta\tau \sum_i N_{ij} + (1-\theta)\sum_i \bar{p}_{ij}} > 0 \tag{3.7a}$$

$$\frac{\partial \ln \sum_i N_{ij}}{\partial \ln \underline{p}_{ij}} = -\frac{\beta \underline{p}_{ij}}{\beta\tau \sum_i N_{ij} + (1-\theta)\sum_i \bar{p}_{ij}} < 0 \tag{3.7b}$$

The direction of the the impact of p on W and N are the same as those of (3.1) and (3.2). The size of such impact is different. This can be seen if we compare (3.7a) and (3.7b) for single-county metropolitan areas with multi-county ones with identical counties. The impact of agricultural rent change in one county for single-county metropolitan areas are greater than multi-county metros by a factor of the number of counties, holding agricultural rents in other counties constant.

According to (3.7b), the total differential of the MSA population is given by

$$\mathbf{d} \ln \sum_i N_{ij} = -\sum_i \frac{\beta \underline{p}_{ij}}{\beta\tau \sum_i N_{ij} + (1-\theta)\sum_i \bar{p}_{ij}} \mathbf{d}\underline{p}_{ij}$$

Clearly the change in population depends on the changes in agricultural rents in all counties. If all $\underline{p}_{ij}$'s increase at the same time, the population of the metropolitan area will decrease. This is not necessarily the case for all time of course. However, As the supply and demand conditions of the agricultural section are likely to be similar in a single metropolitan area, it is very likely that $\underline{p}_{ij}$'s will move in the same direction for most of the times.

As for county level populations

$$\frac{\partial N_{ij}}{\partial \underline{p}_{ij}} = \frac{1}{\tau}\left[\frac{(1-\theta)\bar{p}_{ij}}{\beta\tau \sum_i N_{ij} + (1-\theta)\sum_i \bar{p}_{ij}} - 1\right] < 0 \tag{3.7c}$$

$$\frac{\partial N_{ij}}{\partial \underline{p}_{kj}} = \frac{1}{\tau}\frac{(1-\theta)\bar{p}_{kj}}{\beta\tau \sum_i N_{ij} + (1-\theta)\sum_i \bar{p}_{ij}} > 0, \quad k \neq i \tag{3.7d}$$

[5] Note N_i's are functions of W_j, and so is $\sum N_i$.

(3.7c) is how county i reacts to agriculturals of itself. The negative sign means as lands get more expensive, less individuals will flow in. (3.7d) is how county i reacts to agriculturals in k. The positive sign says as lands in other counties are getting relatively more expensive, people will move into i. This is because when $\underline{p}_k$ changes, wages of all counties will also increase, so land prices for all counties at all d must increase to eliminate the increase in utility, which suggests population in i should increase. So (3.7c) and (3.7d) together capture the distributional effect on metropolitan area population [6]. (3.7b)-(3.7d) together also says that, the response of population to agricultural rent at counties levels will be greater than if measured on MSA level. To see this, suppose $\underline{p}_{ij}$ increases first. The total population of urban area j will decrease, while populations in county k's ($k \neq i$) will increase, which means the population decrease in i must be greater than the that in urban area j.

3.4 Summary

The theoretical analysis of this chapter provides two empirical implications. First, as is shown in Section 3.2, three categories of factors determine urban growth: the productivity of urban areas, local amenities, and housing supply. For the purpose of this study, local productivity and amenities should be controlled to identify the impact of opportunity cost of land. Second, because of technical difficulties shown in Section 3.3, the observation unit for the empirical study should not be counties. The population of a county does not only depend on agricultural rents factors within itself, but also depends on the rent in other counties in the same urban area. Technically, to capture such relationship at county levels in the empirical study may require too many control variables. Moreover, because each MSA is a labor market by definition, focusing on composing counties may have less economic content.

[6] The tradition AMM model for open cities does not predict such redistributions because income is exogeneous in that model.

Chapter 4 Data and Summary Statistics

Section 4.1 discusses the design of empirical study, which, in turn, serves as a guideline of information needed to be collected to measure the value of farm land. A potential endogeneity problem with this measure is also discussed in this section. Section 4.2 discusses the agricultural data, including their sources, coverage, quality, and imputation issues. Section 4.3 evaluates the validity of the imputed agricultural variables through a set of regressions. To aggregate county-level data to MSA levels, I created a buffer for each MSA to account for possible spill over effect. The process of buffering is presented in Section 4.4. Finally, Section 4.5 presents data on the dependent variable and other determinants of growth.

4.1 Design of the Empirical Study

Four fundamental questions are raised in designing the empirical study. First, how should the value of farm land be measured? Second, what are appropriate observation units, counties or MSAs? Third, how is the dependent variable measured? Fourth, what factors should be controlled?

The first question, measuring the opportunity cost, is crucial to the empirical study, so it will be discussed in details in this section. Answers to other questions will be brief because they are relatively more straightforward and standard in the literature.

As discussed previously, directly using the market value of farm land in metropolitan areas is problematic because the market value is not only affected by agricultural practices but by urban demand as well. As an alternative, this study uses the agricultural net revenue as a measure, which is a combination of agricultural commodity price, cost, yield, and land used. The construction will be discussed in details shortly.

Agricultural prices can be reasonably deemed as exogenous because they are determined at national or international levels. Meanwhile, the volatility of agricultural prices provides possibilities of observing short term changes in land values and the impact of such changes. Such an advantage is not available in the traditional measure of the agricultural rent as used in previous studies.

To obtain a measure of the value of farm land, we first define the rental rate of agricultural land of one county as

$$r_t = \sum_j w_{jt}(p_{jt}y_{jt} - c_{jt} + g_{jt}) \tag{4.1}$$

where, at period t, r_t is the rental rate, p_{jt} is the market price of product j, y_{jt} is the yield of j per unit of land[1], c_{jt} is the labor and capital cost of producing j per unit of land, g_{jt} is the government payment or subsidies, and w_{jt} is the share of land used in producing j with respect to total farm land of the county.[2] Assuming a national financial market where interest rate is equal across all locations, the variation in land rents will completely capture the variation in farm land value.

Equation 4.1 provides a guideline for collecting the agricultural data needed to determine agricultural land value, and therefore, the opportunity cost. Constructing the measure for agricultural land value requires information on prices, yields, and land used for each agricultural products growing in each county as well as the total agricultural land to construct the appropriate weight, i.e., w_j.

Equation 4.1 also points out a potential endogeneity problem in this measure. While agricultural prices are exogeneous, other variables may be not. In a von Thünen world, as urban area grows, the distance of each parcel of land to cities will be changed, which may induce farmers to change their choices of products on that land, therefore the composition of products in each county will be changed, and so will

[1]The presence of yield in equation 4.1 captures the idea of Ricardian Rent.

[2]The summation of w_j's does not necessarily equal 1 because of double cropping.

be the weighting scheme.[3] The issue of potential endogeneity will be discussed and treated in more details in Chapter 5 and Chapter 6.

Equation 4.1 also include government payments because they have long been an important source of income for farmers. Data on government payment are not available during the studied period, therefore I imputed the payment according to 1977, 1981, 1985, 1990, and 1996 Farm Acts. The imputation of government payments will be discussed in the next section.

As seen in the next section, while the agricultural data are at the county level, counties may not be the appropriate units of observation. The population of one county in a metropolitan area is not only determined by factors within the county, but is affected by the whole labor market and housing market in the entire MSA, as well as amenities and public expenditures of other counties. Therefore, as is standard in this literature, MSAs will be the units of observation in the empirical study.

As for the dependent variable, as mentioned in Chapter 2 that in a intercity spatial equilibrium framework, the relevant measure of growth at the regional or urban level is provided by employment or population growth rather than income/output per capita or productivity growth. Therefore, this study will measure urban growth by population growth, which is characteristic of the "North American" growth literature. (Roberts and Setterfield [2006]) To obtain annual population growth, I will use the census annual estimates of population at county levels.

Finally, there is the issue of what additional factors affecting urban growrth can and should be controlled. In the literature of urban growth, three categories of factors determining growth have been recognized: human capital, local amenities, and land

[3]The impact of urban growth on farming is actually more complicated than what the von Thünen model describes. As Heimlich and Anderson [2001] summarize, farmers may be positively affected because of access to larger pool of labor force, greater off–farm employment opportunities for farmers to support farming operations, opportunities to grow new crops and market them in new ways, and they can also be negatively affected because of deteriorating yield from urban pollution, conflicts between growers and new suburban neighbors, curtailed milk–collection routes and less acess to grain elevators, and so on.

supply. This study will follow the growth literature to collect data on these controls. The panel data constructed in this study will reduce some of these controls, which will be discussed in Section 4.5.

4.2 Agricultural Data

4.2.1 Data on Crops

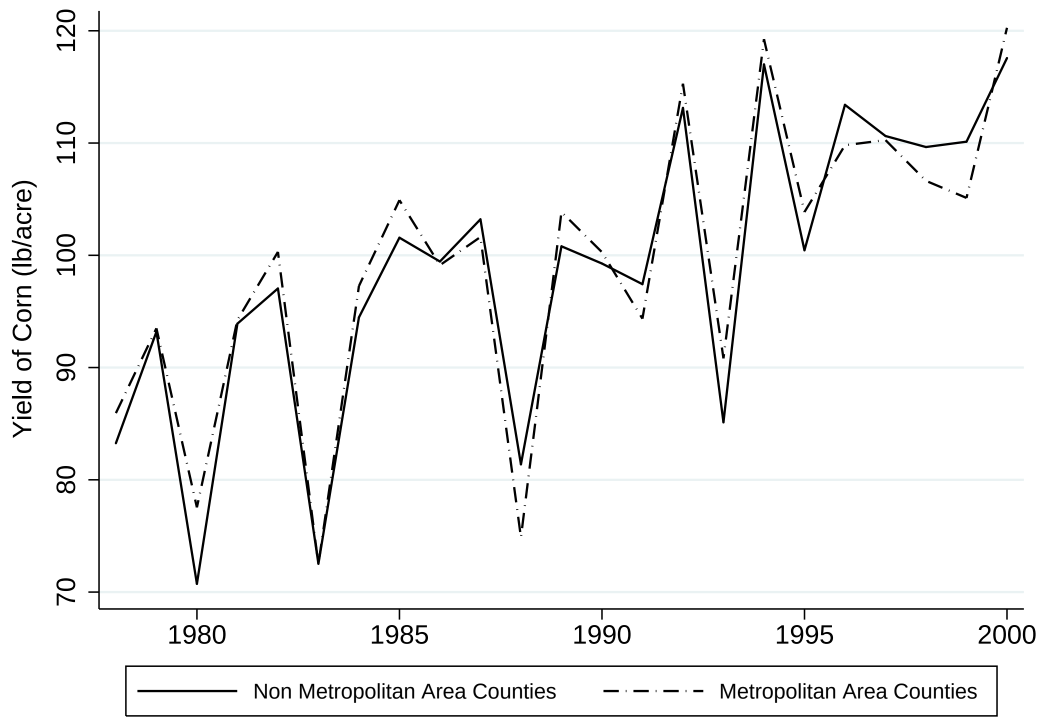
Prices, Yields, and Land Used

Eight crops were selected due to the restriction of data: corn, soybean, wheat, cotton, rice, barley, sorghum, and oats. Data on prices, yield per acre of land planted, and acreage planted for these crops of each county can be obtained from the Annual County Crop Survey by National Agricultural Statistics Service of USDA. Acreage for these eight crops accounts for over 90% of all crop lands nationwide. The longest possible time span for the data, which are also restricted by the availability of land variables, other controls, and population data, is from 1978 to 2000. New England states were dropped because the survey does not cover them.

The rest of this subsection will use corn as an example to present summary statistics for yields and acreage both over time and over regions. Table 4.8 and 4.9 reports summary statistics for yields. Table 4.8 reports the yield of corn per acre of land planted over time. From 1978 to 2000, the average yield of corn has increased by about 20%. Table 4.9 reports the summary statistics for counties within and beyond metropolitan areas for each Farm Resource Regions.[4]. Observations of different years are pooled. In Heartland, Northern Crescent, Northern Great Plains, and Fruitful Rim, the yields in metropolitan areas are statistically higher than in non metropolitan area. In Prairie Gateway and Basin and Range, yields in non metropolitan areas are higher. In other Eastern Uplands, Southern Seaboard, and Mississippi Portal,

[4]See the map of these regions in the Appendix of this chapter.

Figure 4.1: County Average Yield of Corn Overtime: National Level

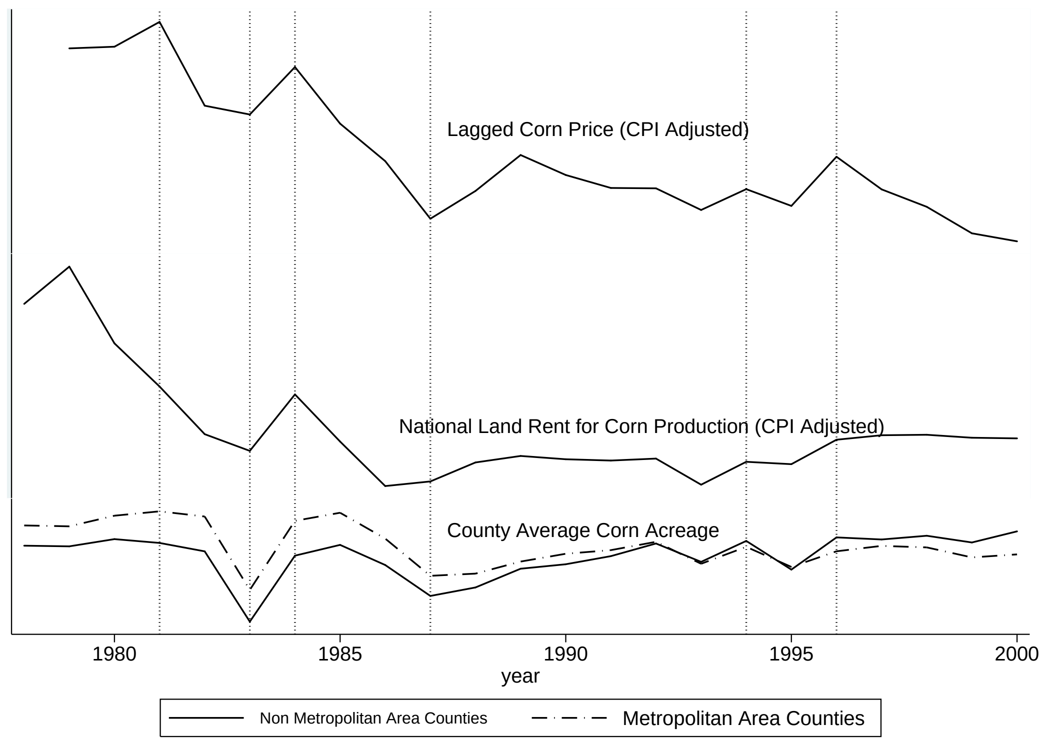


there are no significant differences. The corn yield difference between metropolitan and non-metropolitan counties, if there is any, is basically constant over time, i.e., it is the difference in the intercept. At national levels, as Figure 4.1 shows, such differences are not significant.

Table 4.10 and 4.11 report the summary statistics of planted acreage for corn. Table 4.10 reports the summary statistics over time. While the mean acreage for corn is increasing over time, the total acreage for corn at national levels are decreasing. This is partly because farmers in the North switched to more valuable soybean production starting from 1990s, and partly because small corn operations kept quitting production. Table 4.11 reports the summary statistics of corn acreage for metropolitan and non metropolitan areas for each region.

Figure 4.2 plots overtime movement of corn price, national average of land costs of corn production (both in 1988 dollars), and average corn acreage for counties in

Figure 4.2: Corn Prices, Average Acreage Planted, and Land Cost of Corn Production Overtime: National Level



Data Source:
(1) Corn prices and acreage: Annual County Crop Survey of NASS;
(2) Land costs of corn production: Annual Cost and Return Estimates of ERS.

and out of metropolitan areas. The data on prices and planted acreage are from the Annual County Crop Survey by NASS, and the land cost data are from the Annual Cost and Return Estimates by ERS as will be seen shortly. Several points are worth noting according to the graph. First, as mentioned earlier, starting from the mid 1970s, the price fell drastically until 1986. While in 1990s, a price spike during 1994 and 1996 stood out. Prices for other crops fluctuate in a similar pattern. These two periods provide excellent opportunities for this study to observe the impact of commodity price on urban growth. Second, the land costs, or land rents, fluctuate with the lagged price synchronously in most years. This pattern of synchronized movement of prices and land rents shows that the rent is determined by previous commodity prices, which justifies our use of commodity prices as a measure of the agricultural rent. Third, the corn acreage also fluctuates in the same direction with the lagged corn price, indicating that farmers adjusted planted acreage with price changes.

One interesting exception to this synchronized movement of these variables is the period of 1989-1993, where the acreage did not decrease with declining prices. The land rent was also stable in this period. The most likely reason for this distinct movement is that the corn cost declined faster than the price during this period (see Figure 4.3). This period (1989-1993) was also the period that the agricultural sector recovered from the crisis[5]. In 1993, the average acreage in non metropolitan areas had regained its previous level prior to the crisis. The acreage in metropolitan areas, however, never resumed its pre-crisis level. Similar to the average corn acreage, at the national level, permanent decreases were also found for total corn acreage and total crop land in metropolitan areas, but not in non metropolitan areas. It could be because that farmers had converted land to urban use during the crisis, which was not reversible in the short run.[6]

Some of these crops are highly concentrated in specific regions. For example, corn and soybean are mainly in the Midwest, while rice are only planted in Mississippi Portal and California. Table 4.12 reports the mean acreage for each crop for each region. The variation in crops planted in different regions provide the variation in the imputed land values. In traditional agricultural regions, e.g. the corn belt and plain areas, the data coverage is acceptable. But for states such as California and Florida where a large proportion of land is used by vegetables and fruits, omitting these crops may understate the land value. A remedy will be discussed in Subsection

[5]The cost drop itself may be the result of this recovery, say, new technologies were adopted to reduce costs.

[6]Other than converting land to urban uses, there were other reasons for losses of crop land, say, farmers converted farms to recreational uses, or were enrolled into conservation programs by retiring their crop land. However, such conversions are generally reversible, and can not be accounted for long term crop land losses.

4.2.4.

Cost Data

The cost data are from the Commodity Costs and Returns Estimates by the Economics Research Service (ERS) of USDA. ERS provides annual cost estimates of the crops selected. Unlike the County Crop Survey, cost estimates are at regional levels. The survey provides estimates for a detailed range of cost items Table 4.13 provides a sample of ERS cost estimates of corn production in 2007. To obtain non land costs, land rents and land associated taxes were removed from the total cost listed. Cost items for other crops are similar.[7]

Table 4.14 reports summary statistics of non-land cost or corn per acre of land over time. The long trend of cost decline in the 1980s, which extended further to 1993, was mainly due to the decrease in fertilizer, interest rate, and chemicals, while the increase in cost from 1993 to 1996 was mainly driven by the demand of input of corn production.

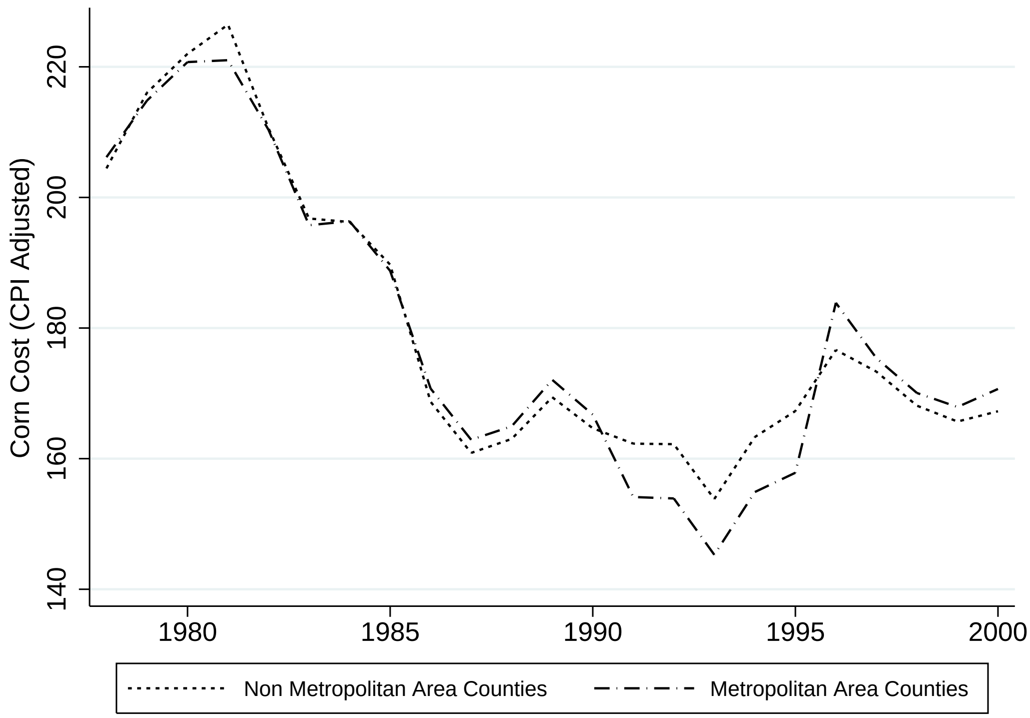
4.2.2 Data on Livestock

Because of data restrictions, only cattle was used to measure livestock use. Because two final products derived from cattle, beef and diary, account for over 60% of the total market value of all livestock associated products, we believe omitting other livestock should not cause serious measurement problem for certain areas.[8]

[7]ERS has made two changes in their estimates which causes data inconsistencies. The first is the account change in the structure of costs, which is less of concern because what the study needs is a total. The second, which is more problematic, is the change in the definition of agricultural regions. In 1996, ERS switched from an old system of Farm Production Regions, which is state-based, to a new system of county–based Farm Resource Regions. This requires a special note in the regression, say, cut the panel at 1995/1996 to compare the results.

[8]The grazing lands, which account for nearly 35% of the total land land area in U.S. in 2002 (Lubowski et al. [May 2006]), are mainly consumed by cattle and sheep. The number of cattle is generally nine times greater than that of sheep. The importance of sheep become even less in terms of grazing land consumed. As calculated by Daugherty [1989], the total dry forage consumption of sheep account for 6.4% of that of cattle in the biggest sheep producing state, Texas, in 1982.

Figure 4.3: Non-Land Cost of Corn Overtime ($/Acre)



Data on livestock are different from that on crops in two ways that requires different treatment. First, while the data on cattle production are available for every year with a good coverage, geographical cattle prices are not. I solve this problem by converting cattle into beef and milk production using information from the Livestock Yearbook. In other words, the value of cattle is captured by the value of their final products. Second, there is no data on land used for cattle. I solve this problem by assuming cattle production only use grazing land and turn to census data to get data on grazing land. The problem brought by this assumption is that cattle on feed will be included which may overstate the value of grazing land.

From Cattle to Beef and Milk Produced

The Annual County Survey data contain the number of all cattle, as well as milk cows, for each county.[9] Deducting the total cattle heads by milk cows heads, I obtained a count of "beef" cattle. Table 4.15 reports the summary statistics for cattle over time. The significant decrease in the county mean heads between 1988 and 1992, e.g. from 33780 to 30064 in 1988, is mainly because of the absence of Texas during this period. Table 4.16 reports the beef cattle and milk cows composition over time. From 1988 to 1992, the share of beef cattle is about 1% higher than other years. Again, this is caused by the absence of Texas, the beef cattle share of which is higher than the national average.

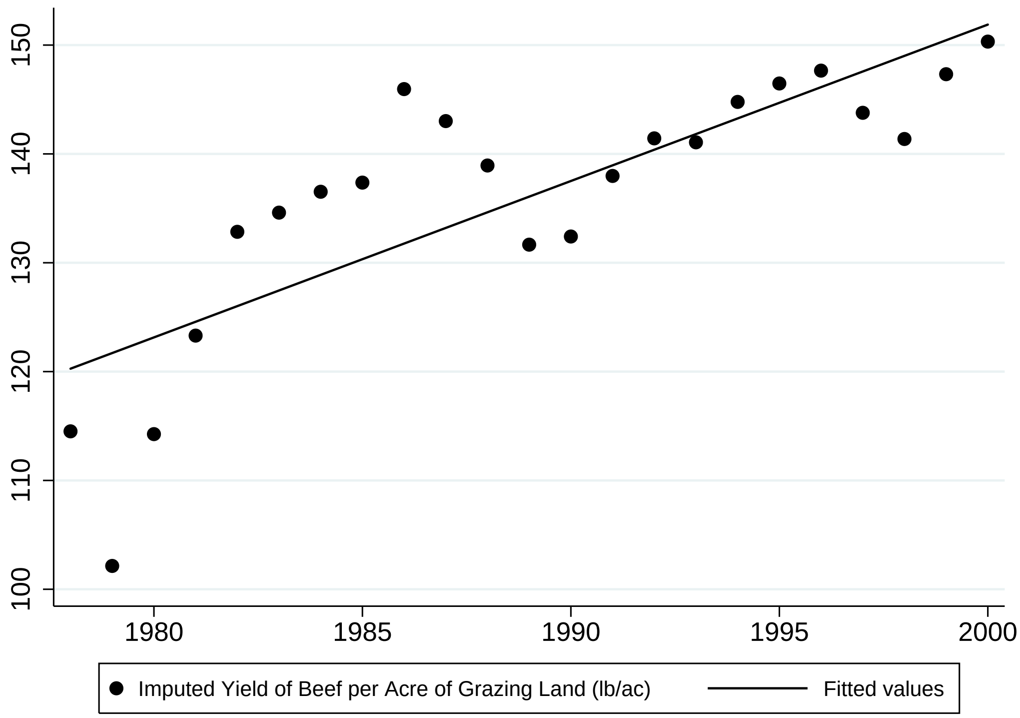
To convert beef cattle into beef production, I first imputed the ratio of beef to cattle stock by dividing the total beef production by total beef cattle from the Livestock Yearbook.[10] This ratio was then applied to cattle stock of each county to get the beef production. Dividing the beef production by grazing acreage, as will be explained in next subsection, a measure of beef per acre of land was obtained. Similarly, for milk production, I used the annual data on milk per cow from ERS for each agricultural region to impute the milk production for each county first, then imputed the milk production per acreage of grazing land.

Throughout this subsection, the beef will be used as the example to present summary statistics. Table 4.17 and Table 4.18 reports summary statistics of beef production per acre of grazing land over time and across regions. Due to the data missing for some major cattle states in various years, the overtime comparisons fails to capture the trend in beef yield changes. As an alternative, I created a balanced panel of

[9] Several states quitted the survey in various years, e.g., California during 1993 to 2000, Florida from 1978 to 1989, Idaho in almost the entire 1980s, Iowa between 1991 to 2000, Texas between 1988 and 1992, and Washington from 1978 50 1985.

[10] The ratio equals beef production divided by cattle stock of the previous year. Regression results showed that the correlation of beef with the previous year cattle stock is stronger than with the stock of the current year.

Figure 4.4: Imputed Yield of Beef Over Time (Lb/Acre)

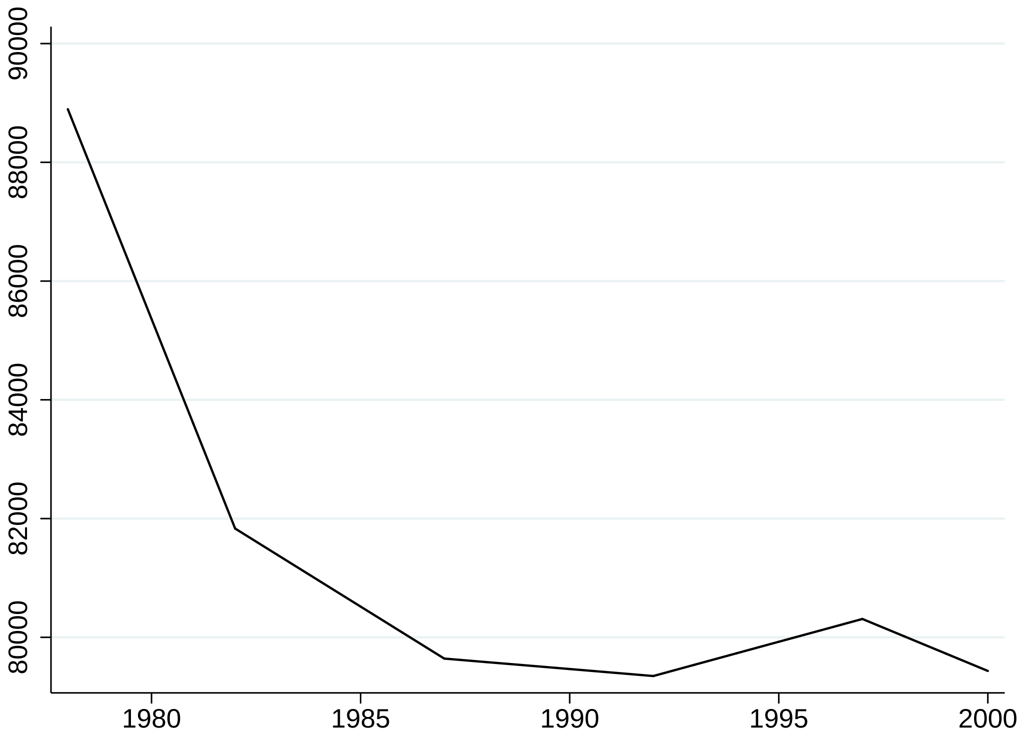


1,806 counties with full data coverage on cattle production across 1978 and 2000 to illustrate the overtime changes of relative variables from now on. Figure 4.4 shows the imputed yield of beef per acre of grazing land over time. On average, the yield of beef has grown from 120 lb/ac in 1978 to 150 lb/ac in 2000 contributed by increasing beef production per head of cattle, because of faster growing of cattle and the improvement in slaughter techniques, and decreasing acreage of grazing land.

Grazing Land

Because annual data of grazing land are not available, I turned to census data for three different categories of grazing land: cropland pasture, grassland pasture and range, and forest land grazed. Acreage for these three categories of land were summed up to obtain the total grazing land. Acreage for non census year was fitted with a linear

Figure 4.5: County Average Grazing Land Overtime (1000 Acres)



trend.[11] Table 4.19 reports the statistics for grazing land over years, and Table 4.20 compares grazing land across regions. Using the balanced panel of counties with full cattle data coverage mentioned earlier, the time path of average grazing land is plotted on Figure 4.5. As the graph shows, the grazing land experienced a sharp decline prior to 1987 and stayed at a relatively stable level of 80,000 acres since then.

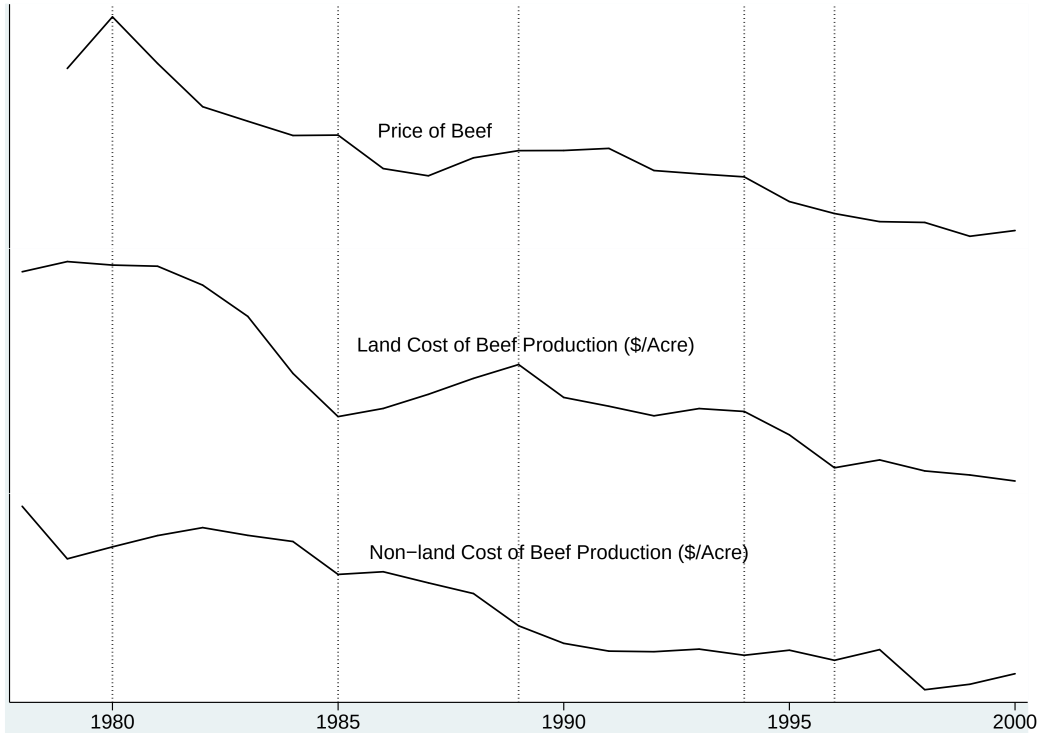
Livestock Cost

Similar to cost data on crops, ERS also provide cost estimation for milk by region by year, the unit of which is dollars per hundred weight. I converted the unit into dollars per acre of grazing land by using the production of milk of each county from the imputation above.

Unlike milk, ERS does not provide cost data on beef. As an indirect measure,

[11]Data for 1978 and 1982 are hand collected. Data for 1987 and 1992, which are in PDF forms, are transferred to XML files first, then read into STATA. Data for 1997 and on can be read directly.

Figure 4.6: Prices, Land Cost, and Non-Land Cost of Beef (1988 Dollars)



I used the ERS cow-calf cost (dollars/head) estimates, then converted the unit into dollars per acre of grazing land. The cow-calf cost may be a good measure for small operations in the North, but not for large feed-slaughter operations, especially in the South and West (Short [2001]). Table 4.21 provides a sample of cow-calf cost items. Table 4.22 summarizes the cost over time, while Table 4.23 compares the cost of beef over regions.[12] Costs of cattle are higher in the North because grazing is not feasible during the winter, and they must be fed with more expensive grains to survive.

Figure 4.6 plots lagged real prices of beef, imputed land and non-land cost of beef production ($/acre). All these three variables have experienced a long-term decline. Because the grazing land used to impute the unit cost was smoothed by year, the land cost (the rent of grazing land) does not show a synchronized movement with prices as seen for corn production.

[12]Land cost, including grazing fee and land rent, have been removed from the total cost of calf-cow cost.

4.2.3 Government Subsidies and Price Supports

Government payment have long been an important source of income for U.S. farms, so they need to be included when measuring land values.[13] The price support program, or Deficiency payment or Production Flexibility Contract payment according to the nomenclature change in different Farm Bills, has been chosen because it is associated with market price directly. To get the dollar amount of payment each county received, I imputed the payment for each crop according to Farm Bills from 1977 to 2002 by using the data in hand, then calculated the weighted average for each county.[14] Generally, the deficiency payment one county received in year t for a program commodity was imputed by the following formula

$$S_t = max[0, (\text{target price}_t - \text{market price}_t)] \times$$
$$\text{program yield}_t \times \text{program acreage}_t \times \text{factor}_t$$

and the difference between legislation in different years lies in the definition of target price, program yield, program acreage, and factors.[15] Set aside payments between 1978 and 1981 and direct payments between 1996 and 2000 were also imputed for each crop.[16]

To calculate the government payment for milk and diary products, because historical target prices were not available to this study, I divided the federal net expenditure on dairy product price support and related program by total milk production, and applied the ratio to milk production in each county. Table 4.24 and 4.27 report

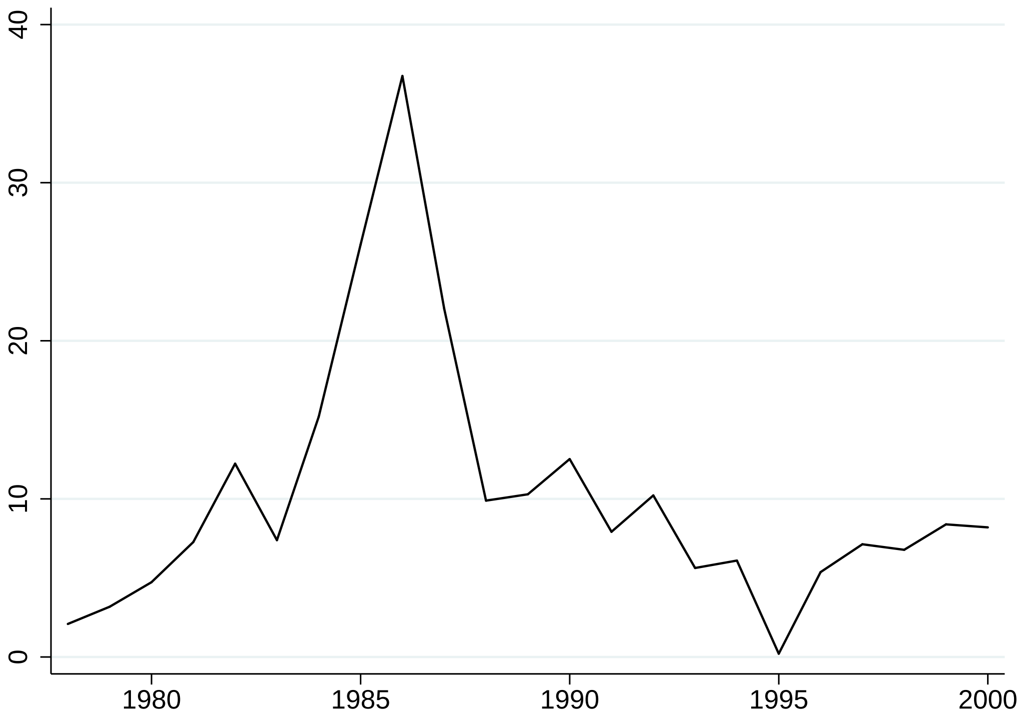
[13]Various studies have confirmed the capitalization of government payment into farm land values, e.g., Barnard et al. [1997], Roberts et al. [2003], Kirwan [2009], and Goodwin et al. [2011], a consensus of the degree of capitalization has not been reached though (Kirwan [2009]). In this study, I assumed that government payments were completed capitalized.

[14]Before 1996 Farm Bill act, I used the acreage in the NASS data assuming all farmers in the program. For 1996 to 2000, I used the ERS data on PFC acreage. The

[15]For example, the program yield used to be the simple average of previous 5 years from 1977 to 1981, the yield of previous year from 1982 to 1986, the Olympic average of last 5 years, the simple average of previous 5 years from 1991 to 1995, and a predetermined acreage after 1996. The factors include *set aside ratio* for each crop from 1978 to 1981, *acreage reduction ratio* for each crop from 1982 to 1990, and a universal .85 for all crops from 1996 to 2002.

[16]The payments each farm can receive are capped. But because farmers can split their farms to avoid such restrictions, the severity of the imputation error may be reduced.

Figure 4.7: Mean County Government Payments Over Time (1988 Dollar)



summary statistics of government payments over time and over regions. Figure 4.7 plots the imputed government payments over time. It can be seen that government payments peaked in 1986, triggered by the low commodity price that year, and hit a historical low in 1995 because of the price spike.

4.2.4 Aggregating Revenues, Costs, and Government Payments

Three variables were finally created at county levels: weighted revenue, weighted cost, and weighted government payment. These three variables together measure the farm land value, or the opportunity cost of urban lands. Using these three variables rather than integrating them together into a single rent measure, as suggested by equation 4.1, enables us to observe whether and how costs and government payments would affect urban growth other than commodity prices. Table 4.25, 4.26, and 4.27 summarize sample statistics of the weighted revenue, cost, and government payments for each Farm Resource Region.

According to equation 4.1, if we were able to obtain information on every agricultural product in each county, the land base would be the county's total farm land. Unfortunately, data on a large portion of agricultural products, wood products, are unavailable. Therefore I removed woodland (not pastured) from the base, and defined the land base as the sum of crop land and grazing land. Data for these categories of land are from census of 1978 to 2002, with non census year records being fitted by a linear trend. The reason for using census data on crop land, rather than using the sum of planted acreage of observed crops, is to account for double cropping. Directly using the summation of all observed planted land will overstate crop land and understate the weighted revenue, cost, and government payment. Table 4.28 reports the mean share of land base with respect to total farm land and total land area for each Farm Resource Region for census years.

Unobserved Crops

Other than wood products, there still are unobserved crops which may cause the same problem, i.e., understating the value of land. Unlike wood products, we do not observe directly the land associated with these unobserved crops. As discussed in the last subsection, using the observed planted acreage will lose the information on double cropping.

To reconcile, I multiplied the three variables created, revenue, cost, and government payment, by a factor equal to $\max\left[1, \frac{\text{total cropland}}{\Sigma(\text{observed planted acreage})}\right]$. This is to assume that land with unobserved crops has at least the same value as the land with observed crops. This assumption is justified by the fact that many of the unobserved crops are more valuable, such as vegetables, fruits, and tobaccos. Therefore, the adjusted measurement of land value can be deemed as the lower bound of the real value of the farm land in each county.

4.3 Validity Test of the Imputation

4.3.1 The Relationship between Agricultural Variables and Observed Land Value

As can be seen from previous subsections, the derivation of the three variables involved intense imputation. Certain assumptions were also made in some cases. A natural question, therefore, is whether and how well these variables measure the value of farm land. To answer this question, I regressed the market value of farm land from census of 1982, 1987, 1992, and 1997,[17] region by region, on the three variables created. I used counties not in MSAs first to exclude the impact of urban areas. To find a better measure for the land value, three alternative specifications of independent variables were tried: single year measures, 3-year moving averages, and 5-year moving averages. 3-year moving averages turned out to be superior to single year measures, which is understandable because single year yields are more vulnerable to short term climate shocks.[18]. Moreover, they were not inferior to 5-year averages: the R^2 did not improve in most cases using 5-year moving averages, and no significant difference were found for estimations with these two measures.

Regression results using 3-year averages are presented in Table 4.3.1. The first panel shows results of dollar–dollar regressions,[19] and the second panel shows the log–log results. Theoretically, coefficients of weighted revenue should be equal to those of weighted cost with opposite signs in dollar–dollar regressions. However, because the cost estimates by ERS is region based, coefficients of cost will be biased down due to the measurement error, and coefficients of revenue will be biased up because costs and revenues are positively correlated. This can be seen in the first panel of Table

[17] The market value is the average of all farm land, including woodland not pastured. This certainly is a problem for areas major in commercial logging.

[18] It may also be because that farmers refer to historical prices of multiple years rather than a single year in determining land values.

[19] All variables were adjusted by CPI with 1988 dollars being the base.

4.3.1.

The R^2's for Southern Seaboard and Basin and Range are relatively lower. These two regions have the lowest share of the "base land" relative to the total land area, and the lowest share of farm land relative to total land area. This may suggest some impact of non–farmland on the farmland which was not observed.[20] When pooling data of all regions together, the overall R^2 was 50% for the dollar–dollar regression and 60% for the log–log regression.

The coefficient of the imputed government payments is a puzzle. Theoretically, it should be positive, but the regression results show that, except for Heartland, Northern Plains, and Basin and Range, it is negative. It might be the correlation between the government payment and the unobserved products. Unobserved products are generally more valuable so that the land value is high even without any government payments. It might also be the correlation between the government payment and the measurement error of cost. For example, the cost of calf-cow production may over state the cost of feed-slaughter cattle production, which is more popular in the South and West. Our agricultural variable predict a low land value for counties majored in beef production in these area, but the true land value may be high. Meanwhile, these counties also receive less government payments because beef is not subsidized. Such a correlation may also lead to a negative coefficient for government payments.

A similar set of regressions were also run for counties within metropolitan areas. Results are presented in Table 4.2. In these regressions, our independent variables (weighted revenues, costs, and government payments) generally did not fit the land value well, which is expected due to the unobserved urban impacts.

[20]In Northern areas where grazing is not feasible year around, the imputed variables may have overstated the value of grazing land. Another set of regressions were also run with milk products being removed from the imputation because diary cattle may not ever be turned out to graze (Daugherty [1989]), results for Heartland and Northern Crescent were improved, but this was not the case for Eastern Upland, Fruitful Rim, and Basin and Range. These results suggest extra information on cattle on feed, which is not available for this study, will improve the measure of land values.

Table 4.1: Validity of Imputations: Rural Areas

Variable	Heartland	Northern Crescent	Northern Plains	Prairie Gateway	Eastern Uplands	Southern Seaboard	Fruitful Rim	Basin Range	Mississippi Portal
(1) Dollar Vs. Dollar (3-year Averages)									
Revenue	5.602***	4.521***	1.953***	3.646***	5.561***	5.067***	6.436***	5.414**	0.867
Cost	-3.877***	-4.127***	0.393	-2.340**	-3.617***	-4.652***	-4.936***	-0.776	0.665
Gov't Payment	1.776**	4.855***	1.562**	-4.340***	-0.336	4.794***	-11.119**	0.640	-1.565*
R^2	0.722	0.305	0.780	0.472	0.410	0.161	0.351	0.271	0.516
N	1040	438	437	514	903	777	294	262	393
Log Vs. Log (3-year Averages)									
Revenue	1.159***	0.549**	0.509***	0.713***	0.793***	0.697***	1.059***	0.882***	-0.049
Cost	-0.419***	-0.480***	-0.070	-0.119	-0.255***	-0.404***	-0.550***	-0.276	0.154
Gov't Payment	0.032*	0.193***	0.057**	-0.113***	0.021**	0.002	-0.031*	0.040*	-0.048***
R^2	0.714	0.375	0.839	0.599	0.443	0.168	0.486	0.463	0.448
N	1038	438	436	476	815	739	232	186	393

Significance levels $*$: 5% $**$: 1% $***$: 0.1%

Table 4.2: Validity of the Imputation: Metropolitan Areas

Variable	Heartland	Northern Crescent	Northern Plains	Prairie Gateway	Eastern Uplands	Southern Seaboard	Fruitful Rim	Basin Range	Mississippi Portal
				(1) Dollar Vs. Dollar (3-year Averages)					
Revenue	5.794***	0.803	12.711**	3.706**	8.977***	5.011***	1.897	17.568***	4.724***
Cost	-5.866***	-5.161**	-11.555	-1.526	-6.311***	-4.271***	0.636	-12.632*	-5.254***
Gov't Payment	7.222***	-1.832	-2.879	-13.310***	-3.148	3.016	-13.865**	2.270	0.105
R^2	0.338	0.135	0.497	0.211	0.296	0.065	0.137	0.415	0.257
N	932	770	71	269	625	979	434	91	230
				(2) Log Vs. Log (3-year Averages)					
Revenue	0.615***	-0.222	1.754***	0.990***	1.262***	0.549***	0.898***	0.267	0.406*
Cost	-0.465***	-0.327	-1.016*	-0.396	-0.577***	-0.254**	-0.474**	0.585	-0.279
Gov't Payment	0.196***	0.250***	-0.077	-0.102**	-0.008	0.006	-0.087***	-0.024	-0.046
R^2	0.409	0.213	0.714	0.332	0.348	0.071	0.262	0.707	0.312
N	932	763	71	262	605	950	323	62	220

Significance levels $*: 5\%$ $**: 1\%$ $***: 0.1\%$

4.3.2 The Impact of Unobserved Products

Although the signs of the coefficients of the agricultural variables are correct in previous regressions, it is unclear how the unobserved products would affect the effectiveness in measuring the land value. Among all unobserved products, wood products are the most prominent because woodland accounts for over 30% of the total agricultural land nationwide. Other agricultural land not covered by the base land includes land for buildings, stables, ponds, roads, in conservation programs, and being idled. If the value of these categories of land is correlated with the agricultural variables created[21], using these variables to measure the land value may have introduced biasness.

Although the information on unobserved products is limited, the agricultural census provides complete information on different land categories, which gives us an opportunity to decompose the land value. Because the agricultural land value is a weighted sum of the value of land with observed products and unobserved products, i.e.,

$$V = s^o V^o + s^u V^u \quad (s^o + s^u = 1) \tag{4.2}$$

where s^o is the share of land with observed products and $s^u (= 1 - s^o)$ is the share of land with unobserved products. In this equation, s^o is know (and so is s^u) because base land is known, V is known from the census data, V^o can be estimated by $V^o = \beta_0 + \beta_1 R + \beta_2 C + \beta_3 G + \varepsilon$, therefore V^u can be solved. More specifically, we can regress V on $s^o V^o$ and s^u on the regional basis to estimate the average value of V^u in each region.[22].

Table 4.3 compares the results for rural areas with and without decomposition for dollar–dollar regressions. As can be seen, the signs of agricultural variables reserve, while the coefficients of revenue and cost increase in magnitude, suggesting

[21]For example, woodland may have negative impact on cattle production because owners of the land may require cattle operators to fence their grazing land.

[22]In the following regressions, I actually estimate the equation $\frac{V}{s^0} = \beta_0 + \beta_1 R + \beta_2 C + \beta_3 G + \frac{s^u}{s^o} V^u + \nu$ so that I can directly compare these β's with those in Table 4.3.1 and 4.2

the existence of woodland or other categories of land may reduce the profitability of the traditional agricultural production. Moreover, R^2 has been improved in most regions, especially for mountain areas (Eastern Upland and Basin and Range). The estimated average value of land with unobserved products for each region (the coefficient of s^U/s^o) is generally less than the average value of all land, suggesting the land of unobserved products is lower than that used for traditional agriculture. While the decomposition changes the coefficients of agricultural variables significantly in dollar–dollar regressions, log–log results, as shown in Table 4.4, of the two specifications are very similar, suggesting the log form reduces the correlation between the unobserved product and the traditional sector.

When the similar decomposition process was applied to counties in metropolitan areas, nearly no improvement was gained (Table 4.5 and 4.6) . The main reason may be there were more alternative uses for agricultural land within urban areas than in rural areas, e.g., recreational farms and adaptive farms, and metropolitan areas are very different from each other in land use patterns. Therefore, the average value for land with unobserved products at regional levels does not measure the real value correctly.

Land Conversion between Crops

Another problem caused by the unobserved products is that not all land conversion land can be observed. In other words, changes in relative prices may induce farmers convert land from one crop to another rather than to urban uses. However, even the statement is true, there are two reasons that our agricultural variable are still valid in measuring the land value. First, the most prominent such conversion was from wheat to soybean started in the early 1990s. As acreages for both crops were observable on an annual basis, our agricultural variables can capture a large part of such conversions. Second, most crops in the data were covered by the commodity program. The only exception was soybean, which was not included until 1996. Before 1996, the subsidy policy required farmers stick to the registered program acreage in previous years for each crop to be eligible to claim payment for another year. Such requirement had restricted the flexibility of converting crops.[23] Therefore, even land conversion between crops can be an issue that should be noticed, this impact may be limited.

4.4 Sample Construction

Because the units of observation of this study are metropolitan areas, county data are aggregated to MSA levels. I started with the OMB definition of MSA/PMSA first and included all MSA counties as defined by the 1990 definition. To account for the spillover effect, counties not defined by the 1999 definition but adjacent or close to each MSA should also be included. To find such counties, I followed Saiz [2010] and created a buffer of 20 miles in radius about the centroid of the principal city of each MSA or PMSA. Any non MSA county touched the buffer, not necessarily completely fell in, this buffer were included as components of the corresponding MSA.[24] Metropolitan areas in the six New England states[25] were dropped because they do not have agricultural data. By buffering MSAs, 1323 counties were included for 301 metropolitan areas in contiguous states. Figure 4.9 shows these MSAs and their buffers. Figure 4.10 shows two specific MSAs, Louisville and Lexington, and their composing counties as defined by their buffers. As Figure 4.10 shows, the choice of 20 miles is appropriate for inland MSAs such as Louisville and Lexington.

[23] The 1996 Farm Bill cancelled such requirement to allow for more flexibility. In empirical studies, we can compare results before and after 1996 to examine whether the conversion between crops should be an issue.

[24] In Saiz [2010], the buffer size is 30 miles. But his observation units are land parcels instead of counties. Considering each county has its own geographical size, I reduced the radius to 20 miles. The 30-mile buffer covered 1900 counties as a total in my sample, which was unnecessary.

[25] Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut

Overlapping Buffers

One problem created by those buffers is that they may overlap. As can be seen in Figure 4.9, this issue is especially serious in coastal areas. To solve this problem, when a MSA county was covered by multiple buffers, I stuck to the original definition; when a non MSA county was covered by multiple buffers, I divided its population by the number of buffers covering it, and added the quotient into each MSA's population. For example, in Figure 4.10, Shelby County was covered by both Lexington and Louisville. I divided its population by two and added the quotient into Lexington and Louisville's population respectively. As for county agricultural variables, I simply added them into each buffer to calculate the averages.

4.5 Population and Other Determinants of Growth

The literature of urban growth and locational choice and has recognized three categories of factors that determine urban growth: human capital, local amenities, and housing and land supply. However, most studies in this literature used either cross-sectional data (Albouy [2008], Blomquist et al. [1988], and Saiz [2010] among others) or low frequency panel data (for example, Glaeser et al. [2001], Glaeser and Gyourko [2005], Glaeser and Shapire [2003], and Shapiro [2006]). Very few studies used high frequency panel data. In Glaeser and Gyourko [2006] where the housing prices at annual level were examined, only violent crime rate was included as a high frequency measure, while no impact on both housing price and housing stock was found.

The strategy is to control those variables that have been used frequently in studies with cross–sectional data or low frequency data, then examine the sensitivity of empirical results to the presence of these variables. Specifically, this study will measure the human capital with the share of labor force with at least a bachelor degree, together with measure s on income levels, including poverty rate, and share of families with income below national 20 percentile; use share of elder population and share of high income families as proxies for local amenities; use imputed population density to proxy whether the urban area is automobile friendly (Glaeser and Shapire [2003]); use the immigrants to capture the correlation between the pre-determined settlement patterns and immigration shocks (Altonji and Card [1991]).[26]

As for the housing and land supply, two measures have been used in the recently literature: the Wharton Regulation Index on local land use control and Saiz's (2010) measure of land availability. None of these two measures provides over-time changes. Although the land availability can be removed as a fixed effect, local land use control is definitely not fixed over time. This issue can be handled but splitting the panel into shorter ones with an assumption that land regulations do not change frequently.

The dependent variable, population growth, is from the annual estimation of county population by Census Bureau, which is a combination of tax return records and administrative records on birth and death. The problem of using annual estimation is that it undercounts population with significant jumps in decennial census years, 1990 and 2000 in this study, where adjustments were made according to census counts. This issue will be addressed in empirical analysis.

Table 4.7 provides sources of these data. Table 4.29 reports summary statistics for all MSAs observed. The list of these MSAs, together with their agricultural variables, is in Table 4.31. In Chapter 6, a group of agricultural MSAs are identified to better estimate the impact of agricultural prices. Summary statistics for these agricultural MSAs are in Table 4.30, and Table 4.32 lists these MSAs and their average agricultural variables.

[26] Annual variation of these variables are obtained by smoothing decennial census data, which clearly will introduce the problem of endogeniety. However, as just mentioned, we can examine whether the empirical results are sensitive to these controls.

Table 4.3: Decomposition of Land Value in Rural Areas (Dollar Measure)

Variable	Heartland	Northern Crescent	Northern Plains	Prairie Gateway	Eastern Uplands	Southern Seaboard	Fruitful Rim	Basin Range	Mississippi Portal
				(1) Without Decomposition					
Revenue	5.602***	4.521***	1.953***	3.646***	5.561***	5.067***	6.436***	5.414**	0.867
Cost	-3.877***	-4.127***	0.393	-2.340**	-3.617***	-4.652***	-4.936***	-0.776	0.665
Gov't Payment	1.776**	4.855***	1.562**	-4.340***	-0.336	4.794***	-11.119**	0.640	-1.565*
R^2	0.722	0.305	0.780	0.472	0.410	0.161	0.351	0.271	0.516
N	1040	438	437	514	903	777	294	262	393
				(2) With Decomposition					
Revenue	6.251***	5.871***	2.426***	4.499***	8.707***	8.097***	8.664***	8.531***	0.995
Cost	-4.258***	-5.238***	0.197	-3.057***	-5.731***	-7.566***	-6.756***	-5.051	0.91
Gov't Payment	3.315***	9.452***	2.187**	-3.672***	-2.223	8.039***	-18.164***	-1.297	-1.642
Value of all other land	771***	932***	289***	32	728***	647***	842***	2494***	700***
R^2	0.704	0.287	0.803	0.547	0.558	0.237	0.412	0.401	0.461
N	1040	438	436	511	902	777	291	255	393
				Average agricultural land value†					
	1062	878	298	540	942	1264	939	619	799
				Average share of agricultural land with unobserved products‡					
	0.175	0.337	0.156	0.107	0.295	0.357	0.246	0.112	0.275

Significance levels $*$: 5% $**$: 1% $***$: 0.1%

† Data are from Agricultural Census 1978-1997 and pooled together.

‡ This category of land include woodland, idle land or land enrolled in conservation program, and land for pond, roads and buildings.

Table 4.4: Decomposition of Land Value of Rural Areas: Logarithm Measures

Variable	Heartland	Northern Crescent	Northern Plains	Prairie Gateway	Eastern Uplands	Southern Seaboard	Fruitful Rim	Basin Range	Mississippi Portal
				(1) Without Decomposition					
Revenue	1.159***	0.549**	0.509***	0.713***	0.793***	0.697***	1.059***	0.882***	-0.049
Cost	-0.419***	-0.480***	-0.070	-0.119	-0.255***	-0.404***	-0.550***	-0.276	0.154
Gov't Payment	0.032*	0.193***	0.057**	-0.113***	0.021**	0.002	-0.031*	0.040*	-0.048***
R^2	0.714	0.375	0.839	0.599	0.443	0.168	0.486	0.463	0.448
N	1038	438	436	476	815	739	232	186	393
				(2) With Decomposition					
Revenue	1.156***	0.780***	0.498***	0.749***	0.726***	0.619***	0.950***	1.204***	-0.109
Cost	-0.396***	-0.686***	-0.060	-0.141	-0.237***	-0.375***	-0.552***	-0.735***	0.143
Gov't Payment	0.028	0.201***	0.067**	-0.105***	0.023***	0.007	-0.046**	-0.008	-0.059***
Value of all other land	0.227***	0.359***	0.082***	0.030	0.352***	0.244***	0.339***	0.438***	0.122***
R^2	0.689	0.324	0.857	0.648	0.633	0.229	0.731	0.617	0.443
N	1038	438	435	475	815	739	232	181	393

Significance level: * $p < 0.05$, ** $p<0.01$, *** $p<.001$

Table 4.5: Decomposition of Land Value of Metropolitan Areas: Dollar Measures

Variable	Heartland	Northern Crescent	Northern Plains	Prairie Gateway	Eastern Uplands	Southern Seaboard	Fruitful Rim	Basin Range	Mississippi Portal
					(1)Without Decomposition				
Revenue	5.794***	0.803	12.711**	3.706**	8.977***	5.011***	1.897	17.568***	4.724***
Cost	-5.866***	-5.161**	-11.555	-1.526	-6.311***	-4.271***	0.636	-12.632*	-5.254***
Gov't Payment	7.222***	-1.832	-2.879	-13.310***	-3.148	3.016	-13.865**	2.270	0.105
R^2	0.338	0.135	0.497	0.211	0.296	0.065	0.137	0.415	0.257
N	932	770	71	269	625	979	434	91	230
					(2) With Decomposition				
Revenue	5.608***	0.338	15.162**	4.449**	14.486***	6.745***	2.576	18.781**	5.876***
Cost	-5.784***	-7.364**	-14.04*	-1.672	-10.279***	-6.109***	0.611	-12.632	-7.219***
Gov't Payment	10.147***	-7.104	1.564	-14.478***	-6.568	4.491	-18.733***	5.985	0.722
Value of all other land	944***	982*	-477	322	1091***	928***	407**	226	675***
R^2	0.253	0.180	0.525	0.231	0.358	0.113	0.142	413	0.291
N	932	769	71	269	647	979	431	87	230
					Average agricultural land value†				
	1556	1817	494	817	1285	1729	2186	877	1087
					Average share of agricultural land with unobserved products‡				
	0.154	0.273	0.140	0.084	0.274	0.349	0.232	0.115	0.252

Significance levels $*: 5\%$ $**: 1\%$ $***: 0.1\%$

† Data are from Agricultural Census 1978-1997 and pooled together.

‡ This category of land include woodland, idle land or land enrolled in conservation program, and land for pond, roads and buildings.

Table 4.6: Decomposition of Land Value Metropolitan Areas: Log Measures

Variable	Heartland	Northern Crescent	Northern Plains	Prairie Gateway	Eastern Uplands	Southern Seaboard	Fruitful Rim	Basin Range	Mississippi Portal
(1) Dollar Vs. Dollar (3-year Averages)									
Revenue	0.615***	-0.222	1.754***	0.990***	1.262***	0.549***	0.898***	0.267	0.406*
Cost	-0.465***	-0.327	-1.016*	-0.396	-0.577***	-0.254**	-0.474**	0.585	-0.279
Gov't Payment	0.196***	0.250***	-0.077	-0.102**	-0.008	0.006	-0.087***	-0.024	-0.046
R^2	0.409	0.213	0.714	0.332	0.348	0.071	0.262	0.707	0.312
N	932	763	71	262	605	950	323	62	220
(2) Log Vs. Log (3-year Averages)									
Revenue	0.262	-0.83***	1.805***	0.908***	1.457***	0.453***	0.937***	0.093	0.254
Cost	-0.244*	0.124	-1.067*	-0.280	-0.749***	-0.235**	-0.528**	0.760	-0.161
Gov't Payment	0.201***	0.188***	-0.066	-0.104**	-0.005	0.008	-0.084***	-0.045	-0.080**
Value of all other land	0.022	-0.071	0.069	0.026	0.333***	0.265***	0.250***	0.132	0.075
R^2	0.334	0.239	0.742	0.373	0.445	0.111	0.354	0.752	0.358
N	932	762	71	262	627	950	322	58	220

Significance level: * $p < 0.05$, ** $p<0.01$, *** $p<.001$

Table 4.7: Data Sources

Data Item	Sources
Crops price, yield, acreage planted	Annual County Crop Survey by NASS, USDA
Crops, milk, calf-cow cost	Commodity Costs and Returns by ERS, USDA
Farm land cateories	Agricultural census 1978 - 2002. See notes.
Milk per cow	ERS survey
National beef production	Livestock Yearbook
1996 PFC acreage	ERS data
Population Estimates	Census annual estimates.
Share of elder population	Census annual estimates.
MSA Population Density	Imputed from census data
Share of Bachelor degree	Huduser, 2000
Share of workers in manufacture sector	Huduser, 2000
Poverty Rate	Huduser, 2000
Share of families below 20 pctile income	Huduser, 2000
Share of families above 80 pctile income	Huduser, 2000

Notes:
Data for 1978 and 1982 were hand collected.
Data for 1987 and 1992 were transferred from PDF files
Data from 1997 and on can be read directly into STATA.

Table 4.8: Summary Statistics: Yield of Corn Over Time (lb/ac)

Year	Mean	s.d.	Min	Max	N
1978	76.27	26.43	14.70	150.00	2836
1979	84.85	26.29	10.00	149.00	2861
1980	68.11	30.77	12.20	160.00	2860
1981	87.63	28.26	12.80	159.20	2822
1982	92.43	25.42	10.50	180.00	2830
1983	73.49	28.07	15.00	195.00	2829
1984	91.52	27.65	16.90	183.00	2826
1985	97.64	26.87	7.90	180.00	2821
1986	94.81	32.72	13.20	197.30	2795
1987	97.45	30.09	21.50	208.00	2778
1988	77.81	31.66	11.50	217.80	2792
1989	97.34	29.35	10.60	209.00	2774
1990	94.00	33.30	10.00	199.00	2778
1991	93.11	28.66	16.00	204.50	2792
1992	108.53	32.35	20.00	224.70	2799
1993	87.36	32.31	7.00	237.00	2799
1994	112.70	29.07	25.00	210.00	2806
1995	100.58	24.63	28.00	224.00	2753
1996	108.36	30.49	12.20	226.20	2776
1997	110.16	29.45	35.00	244.90	2810
1998	101.26	37.72	10.00	246.00	2789
1999	106.10	34.08	17.10	214.00	2695
2000	115.11	33.10	17.00	215.00	2668

Table 4.9: Summary Statistics: Yield of Corn by Region (lb/ac)

Region	Metro/Non Metro	Mean	s.d.	Min	Max	N
Heartland	Metro	116.99	25.07	16.00	184.00	251
	Non Metro	107.96	28.37	19.10	175.00	292
Northen	Metro	101.45	19.59	17.10	170.00	232
Crescent	Non Metro	92.01	21.60	19.00	172.00	120
Northern	Metro	88.71	31.91	11.00	164.50	21
Great Plains	Non Metro	80.86	31.67	7.00	166.00	148
Prairie	Metro	86.80	35.04	12.20	215.10	109
Gateway	Non Metro	107.90	37.62	10.00	224.70	263
Eastern	Metro	84.19	22.56	14.70	165.00	166
Uplands	Non Metro	85.01	21.31	13.70	159.40	231
Southern	Metro	73.46	26.86	14.10	190.00	265
Seaboard	Non Metro	74.37	26.87	11.50	195.00	203
Fruitful	Metro	100.13	40.09	11.50	246.00	129
Rim	Non Metro	94.92	42.04	10.00	216.00	96
Basin	Metro	117.21	36.19	15.00	217.40	27
and Range	Non Metro	121.03	34.52	7.90	233.00	80
Mississippi	Metro	86.10	27.40	24.00	168.80	56
Portal	Non Metro	85.68	26.45	20.00	174.40	98

Table 4.10: Summary Statistics: Acreage of Corn Over Time (100 ac)

Year	Mean	s.d.	Min	Max	N
1978	323.15	484.02	0.20	3923.00	2510
1979	322.48	485.55	0.10	3753.00	2507
1980	332.69	498.25	0.20	3869.00	2507
1981	337.40	504.76	0.10	3840.00	2473
1982	331.91	496.56	0.50	3891.00	2448
1983	249.00	348.89	0.30	2849.00	2395
1984	330.61	485.93	0.50	3738.00	2418
1985	343.54	499.01	0.50	3539.00	2410
1986	319.86	451.42	0.50	3168.00	2376
1987	279.49	395.35	0.50	2813.00	2350
1988	290.30	421.38	0.50	2977.00	2315
1989	312.19	466.04	0.50	3332.00	2301
1990	328.63	480.88	0.50	3384.00	2240
1991	334.11	486.27	1.00	3480.00	2258
1992	344.14	500.44	0.50	3490.00	2289
1993	324.53	464.58	0.50	3300.00	2240
1994	355.73	506.89	1.00	3600.00	2203
1995	332.34	474.63	2.00	3100.00	2133
1996	363.71	503.25	1.00	3320.00	2162
1997	368.81	502.08	0.50	3370.00	2139
1998	371.52	499.28	1.00	3380.00	2140
1999	371.33	496.70	1.00	3200.00	2064
2000	385.60	506.69	1.00	3310.00	2043

Table 4.11: Summary Statistics: Acreage of Corn by Region (100 ac)

Region	Metro/Non Metro	Mean	SD	Min	Max	N
Heartland	Metro	871.03	583.13	3.00	3923.00	249
	Non Metro	814.13	613.46	3.00	3274.00	290
Northen Crescent	Metro	417.57	377.51	1.00	2530.00	212
	Non Metro	286.02	379.63	0.10	2455.00	103
Northern Great Plains	Metro	337.33	513.18	1.00	2400.00	20
	Non Metro	218.68	300.01	1.00	2320.00	143
Prairie Gateway	Metro	127.69	183.15	0.30	1350.00	77
	Non Metro	335.91	471.70	0.10	2450.00	190
Eastern Uplands	Metro	60.83	74.78	0.70	544.00	135
	Non Metro	56.39	69.67	0.50	550.00	162
Southern Seaboard	Metro	102.76	134.17	0.50	938.50	212
	Non Metro	79.75	96.59	0.50	757.00	160
Fruitful Rim	Metro	108.97	164.41	1.00	1275.00	91
	Non Metro	89.74	103.27	1.00	962.00	62
Basin and Range	Metro	48.50	53.66	0.50	224.00	16
	Non Metro	34.00	44.52	0.40	270.00	45
Mississippi Portal	Metro	76.53	102.26	0.50	760.00	44
	Non Metro	72.82	114.86	1.00	950.00	83

Table 4.12: Acreages for All Observed Crops (100 ac)

Crop		Heartland	Northen Crescent	Northern Great Plains	Praire Gateway	Eastern Uplands	Southern Seaboard	Fruitful Rim	Basin and Range	Missi Portal
Corn	Acreage	840	374	233	276	58	93	101	38	74
	N	539	315	163	267	298	373	153	62	127
Soybean	Acreage	733	192	252	167	79	147	127	0	620
	N	534	210	67	184	201	348	50	0	146
Wheat	Acreage	134	65	1260	832	51	60	332	211	160
	N	472	252	167	344	213	361	122	82	119
Cotton	Acreage	402	0	0	488	72	77	403	42	296
	N	6	0	0	101	28	185	56	4	98
Rice	Acreage	244	0	0	159	32	39	296	113	333
	N	3	0	0	3	10	6	25	1	60
Barley	Acreage	41	13	291	15	7	16	133	102	6
	N	59	182	151	102	27	125	89	75	0
Oats	Acreage	95	69	131	48	19	17	46	26	21
	N	374	290	168	222	76	201	108	72	12
Sorghum	Acreage	61	3	58	254	30	14	252	9	72
	N	224	3	57	327	66	193	52	8	85

Table 4.13: Cost data of corn, 2007. (U.S., dol/acre)

Item	Value
Gross value of production:	
Primary product: Corn grain	467.61
Secondary product: Corn silage	1.33
Total, gross value of production	468.94
Operating costs:	
Seed	49.04
Fertilizer	93.13
Chemicals	24.38
Custom operations	10.93
Fuel, lube, and electricity	31.58
Repairs	14.86
Purchased irrigation water	0.13
Interest on operating capital	4.94
Total, operating costs	228.99
Allocated overhead:	
Hired labor	2.26
Opportunity cost of unpaid labor	24.34
Capital recovery of machinery and equipment	69.77
Opportunity cost of land (rental rate)	97.21
Taxes and insurance	7.52
General farm overhead	13.88
Total, allocated overhead	214.98
Total costs listed	**443.97**
Land cost (Rent + Taxes and insurances)	**104.73**
Cost as used in this study(cost - rent - tax)	**339.24**

Table 4.14: Summary Statistics: Cost of Corn Over Time (1988 dol)

Year	Mean	s.d.	Min	Max
1978	204.49	5.62	200.63	214.03
1979	214.53	7.50	209.06	227.09
1980	220.81	5.66	214.70	234.27
1981	226.87	14.16	211.44	250.84
1982	209.55	3.90	203.20	213.26
1983	197.20	4.22	188.83	202.59
1984	197.07	1.69	194.79	199.07
1985	189.03	5.77	176.27	198.61
1986	166.88	5.27	162.40	174.68
1987	162.89	2.97	158.11	166.31
1988	162.63	3.83	156.29	167.13
1989	170.93	4.34	160.84	177.80
1990	164.99	4.70	157.87	170.05
1991	159.26	12.04	145.55	189.61
1992	159.62	17.82	137.13	188.56
1993	149.21	13.90	133.60	182.93
1994	161.73	16.99	147.44	190.40
1995	166.97	18.30	149.63	198.01
1996	177.28	19.21	139.75	201.10
1997	172.82	16.20	140.31	193.98
1998	167.78	14.34	137.13	184.38
1999	165.42	14.09	135.77	180.98
2000	167.12	17.08	130.96	188.47

Table 4.15: Summary Statistics: Cattle by Year (1000 heads)

Year	Mean	s.d.	Min	Max	N
1978	39.13	39.22	0.10	635.00	2600
1979	36.86	39.08	0.10	644.00	2706
1980	36.87	38.59	0.10	584.00	2699
1981	37.83	39.47	0.10	638.00	2720
1982	38.41	39.55	0.10	599.00	2691
1983	38.11	39.84	0.10	595.00	2717
1984	37.46	39.99	0.10	597.00	2719
1985	36.24	39.68	0.10	580.00	2718
1986	35.10	37.99	0.10	532.00	2800
1987	33.78	35.94	0.05	460.00	2738
1988	30.64	33.76	0.05	354.00	2433
1989	29.92	33.40	0.10	374.00	2482
1990	29.77	33.86	0.10	400.00	2542
1991	29.36	34.41	0.10	450.00	2443
1992	29.63	34.82	0.10	495.00	2439
1993	31.26	33.95	0.10	480.00	2635
1994	31.95	35.97	0.10	595.00	2637
1995	32.58	36.56	0.10	628.00	2627
1996	32.97	37.32	0.10	684.00	2619
1997	32.44	37.83	0.10	772.00	2606
1998	32.09	37.56	0.10	691.00	2578
1999	31.50	36.88	0.10	669.00	2602
2000	31.68	37.28	0.10	723.00	2674

Table 4.16: Beef Cattle and Milk Cows

Year	All Cattle (1000 heads)	Share as of all cattle, %	
		Beef Cattle	Milk Cows
1978	39.13	89.39	10.61
1979	36.86	89.00	11.00
1980	36.87	89.11	10.89
1981	37.83	89.34	10.66
1982	38.41	89.42	10.58
1983	38.11	89.25	10.75
1984	37.46	89.22	10.78
1985	36.24	88.88	11.12
1986	35.10	88.51	11.49
1987	33.78	88.59	11.41
1988	30.64	87.60	12.40
1989	29.92	87.32	12.68
1990	29.77	87.46	12.54
1991	29.36	87.30	12.70
1992	29.63	87.50	12.50
1993	31.26	88.27	11.73
1994	31.95	88.50	11.50
1995	32.58	88.55	11.45
1996	32.97	88.65	11.35
1997	32.44	88.48	11.52
1998	32.09	88.23	11.77
1999	31.50	88.06	11.94
2000	31.68	87.86	12.14

Table 4.17: Summary Statistics: Yield of Beef Over Time (lb/ac)

Year	Mean	s.d.	Min	Max	N
1978	115.86	107.91	2.43	1544.52	2263
1979	103.62	99.65	2.60	1475.80	2344
1980	114.44	112.96	3.57	1711.86	2341
1981	121.88	122.16	3.03	1888.84	2360
1982	127.32	126.51	1.56	1812.93	2429
1983	127.84	126.32	1.75	1739.42	2434
1984	128.53	126.52	1.84	1665.25	2434
1985	129.27	126.54	2.21	1688.39	2434
1986	134.51	131.22	2.69	1762.18	2500
1987	130.26	130.50	1.49	1858.09	2567
1988	134.15	126.90	1.34	1877.67	2309
1989	127.00	119.56	1.38	1663.38	2352
1990	126.71	120.89	1.31	1698.65	2411
1991	124.25	119.64	1.37	1884.91	2313
1992	125.92	125.46	1.38	2059.42	2333
1993	121.53	125.64	1.27	2026.63	2457
1994	125.39	124.58	1.15	2011.50	2454
1995	127.10	125.94	1.17	2158.99	2444
1996	128.03	131.54	0.85	2368.39	2439
1997	124.59	129.25	0.94	2522.76	2443
1998	124.05	130.23	2.68	2690.88	2384
1999	128.50	134.99	2.79	2693.57	2410
2000	130.72	142.98	2.85	3005.41	2476

Table 4.18: Summary Statistics: Yield of Beef by Region (lb/ac)

Region	Mean	s.d.	Min	Max	N
Heartland	221.05	193.86	25.98	3005.41	480
Northen Crescent	193.89	145.02	18.31	1333.36	307
Northern Great Plains	51.86	39.14	4.88	207.27	96
Prairie Gateway	62.90	52.86	1.98	788.70	275
Eastern Uplands	88.59	35.51	2.68	251.86	396
Southern Seaboard	108.84	40.44	5.44	431.53	438
Fruitful Rim	79.11	92.94	0.85	1858.09	162
Basin and Range	28.61	28.57	1.56	273.26	96
Mississippi Portal	98.53	35.95	19.04	310.42	153

Table 4.19: Summary Statistics: Grazing Land (1000 Acres)

Year	Mean	SD	Min	Max	N
1978	123.79	237.68	0.30	3306.07	2589
1979	115.39	216.06	0.36	3346.86	2526
1980	113.22	213.60	0.40	3387.65	2526
1981	111.04	211.82	0.43	3428.45	2526
1982	109.98	273.78	0.46	6148.87	2632
1983	108.91	207.89	0.63	3483.87	2493
1984	108.56	207.75	0.53	3498.50	2493
1985	108.20	207.71	0.42	3513.13	2493
1986	107.85	207.78	0.32	3527.76	2493
1987	113.26	294.55	0.21	7329.41	2643
1988	118.66	245.58	0.32	3526.60	2541
1989	118.49	245.62	0.35	3510.80	2541
1990	118.32	245.80	0.37	3495.01	2541
1991	118.15	246.11	0.40	3479.21	2541
1992	117.25	294.76	0.42	5718.17	2663
1993	116.35	237.01	0.69	3456.84	2528
1994	116.15	236.13	0.62	3450.27	2528
1995	115.95	235.59	0.56	3443.70	2528
1996	115.75	235.39	0.49	3437.12	2528
1997	115.26	259.32	0.43	3430.55	2627
1998	114.78	230.69	0.84	3420.53	2539
1999	114.47	230.44	0.78	3410.51	2539
2000	114.16	230.35	0.69	3400.49	2539

Table 4.20: Summary Statistics: Grazing Land by Region (1000 Acres)

Region	Metro/Non Metro	Mean	SD	Min	Max	N
Heartland	Metro	32.30	32.67	0.54	340.11	249
	Non Metro	51.62	48.21	1.33	335.59	288
Northen	Metro	25.93	27.37	0.21	236.69	212
Crescent	Non Metro	27.85	29.24	0.63	147.96	110
Northern	Metro	438.14	563.00	6.88	2478.14	18
Great Plains	Non Metro	441.10	547.68	16.20	3542.40	90
Prairie	Metro	288.81	258.70	5.16	2541.73	95
Gateway	Non Metro	316.72	295.82	22.00	2993.41	177
Eastern	Metro	66.76	88.33	1.12	1107.65	167
Uplands	Non Metro	71.61	65.18	0.77	453.30	230
Southern	Metro	41.04	51.69	0.65	362.94	258
Seaboard	Non Metro	38.98	56.06	0.22	439.35	200
Fruitful	Metro	185.75	275.60	2.38	2064.04	125
Rim	Non Metro	245.32	373.42	3.14	7329.41	76
Basin and	Metro	361.78	449.42	28.42	2768.58	23
Range	Non Metro	447.04	496.24	2.38	6148.87	71
Mississippi	Metro	45.78	36.16	2.07	210.98	56
Portal	Non Metro	38.17	27.31	1.49	159.12	93

Table 4.21: Cow-calf production cost, 2007. (U.S., dol/bred cow)

Item	Value
Gross value of production:	
Steer calves	186.82
Heifer calves	116.49
Yearling steers	127.08
Yearling heifers	55.34
Other cattle	96.69
Total gross value of production	589.54
Operating costs:	
Purchased cattle for backgrounding	82.55
Feed:	
Concentrates and other feed	34.53
Supplemental feed	28.11
Harvested forages	192.17
Cropland pasture	16.18
Private pasture	110.16
Public land	2.83
Total feed costs	383.98
Other:	
Veterinary and medicine	26.29
Bedding and litter	0.50
Marketing	7.12
Custom operations	36.62
Fuel, lube, and electricity	57.68
Repairs	30.58
Interest on operating inputs	10.47
Total operating costs	635.79
Allocated overhead:	
Hired labor	4.31
Opportunity cost of unpaid labor	273.83
Capital recovery cost of machinery and equipment 3/	172.36
Opportunity cost of land	2.95
Taxes and insurance	37.70
General farm overhead	70.68
Total allocated overhead	561.83
Total costs listed	**1197.62**
Land cost (Rent + Taxes and insurances)	**169.82**
Cost as used in this study(cost - rent - tax)	**1027.80**

Table 4.22: Summary Statistics: Non-land Cost of Beef Production ($/ac, 1988 dol.)

Year	Mean	SD	Min	Max	N
1978	68.39	66.09	0.27	998.60	2522
1979	61.07	59.46	0.65	942.07	2463
1980	66.16	66.39	0.35	1076.34	2464
1981	70.32	72.05	0.21	1182.33	2469
1982	70.40	72.01	0.20	1100.54	2572
1983	70.80	70.90	1.20	1045.40	2450
1984	69.48	68.31	0.30	977.70	2452
1985	63.13	60.91	0.79	810.03	2452
1986	63.16	60.18	1.21	812.64	2452
1987	59.95	60.95	0.68	819.58	2601
1988	59.49	59.21	1.27	856.64	2503
1989	54.07	52.92	1.38	723.23	2502
1990	66.12	64.44	1.89	918.61	2504
1991	64.10	63.49	1.94	954.43	2504
1992	61.98	63.58	0.91	1017.58	2620
1993	64.08	65.44	1.07	1012.52	2491
1994	63.03	61.99	1.11	959.49	2490
1995	64.20	63.14	1.18	1034.68	2490
1996	98.13	110.64	1.77	2001.04	2491
1997	98.10	112.22	2.05	2202.83	2584
1998	92.02	103.88	1.71	2141.10	2498
1999	92.22	104.18	1.75	2052.23	2499
2000	93.40	110.47	1.70	2269.58	2498

Table 4.23: Summary Statistics: Non-land Cost of Beef by Region ($/ac, 1988 dol.)

Region	Metro/Non Metro	Mean	SD	Min	Max	N
Heartland	Metro	139.00	128.90	1.91	2269.58	248
	Non Metro	126.08	118.07	1.27	1325.51	284
Northen	Metro	117.80	79.40	6.77	764.29	193
Crescent	Non Metro	83.97	78.73	11.69	867.40	110
Northern	Metro	33.35	26.38	0.27	106.17	18
Great Plains	Non Metro	26.19	20.29	0.20	124.14	88
Prairie	Metro	30.85	17.42	1.86	151.80	95
Gateway	Non Metro	32.86	29.04	0.86	416.80	177
Eastern	Metro	52.30	20.13	0.00	146.84	165
Uplands	Non Metro	45.21	20.30	0.00	159.33	229
Southern	Metro	58.93	22.95	2.98	235.14	250
Seaboard	Non Metro	57.42	22.61	8.95	289.26	194
Fruitful	Metro	41.89	42.69	0.33	817.25	124
Rim	Non Metro	38.87	31.56	0.68	250.64	75
Basin and	Metro	18.62	18.12	1.37	135.84	23
Range	Non Metro	15.48	12.86	0.00	120.78	71
Mississippi	Metro	63.60	28.22	16.39	211.12	56
Portal	Non Metro	56.35	24.44	9.64	203.29	93

Table 4.24: Summary Statistics: Government Payments ($/ac, 1988 dol.)

Year	Mean	SD	Min	Max	N
1978	2.09	2.79	0.00	26.03	2503
1979	3.18	6.06	0.00	118.05	2461
1980	4.73	9.14	0.00	169.96	2463
1981	7.27	11.09	0.00	181.05	2466
1982	12.23	12.76	0.00	195.84	2564
1983	7.39	8.35	0.00	118.71	2537
1984	15.20	13.86	0.00	159.41	2539
1985	26.08	21.68	0.00	173.56	2541
1986	36.75	33.62	0.00	169.42	2545
1987	22.02	20.50	0.00	112.65	2705
1988	9.89	11.80	0.00	119.18	2684
1989	10.29	10.21	0.00	68.80	2682
1990	12.52	11.29	0.00	74.34	2712
1991	7.92	7.61	0.00	62.15	2711
1992	10.22	10.45	0.00	76.73	2755
1993	5.63	6.14	0.00	52.32	2722
1994	6.10	6.86	0.00	50.02	2719
1995	0.21	1.47	0.00	20.39	2711
1996	5.37	15.86	0.00	499.91	2705
1997	7.13	13.10	0.00	388.60	2731
1998	6.78	13.97	0.00	426.05	2665
1999	8.39	15.14	0.00	454.38	2677
2000	8.20	12.15	0.00	326.07	2682

Table 4.25: Weighted Revenue Statistics (County levels, 1988 dollar)

Region	mean	min	max	N
Heartland	221.69	42.52	1635.59	10,955
Northern Crescent	263.56	8.54	1742.86	6,928
Northern Great Plains	77.23	6.48	263.23	1,751
Prairie Gateway	105.00	6.29	475.79	5,646
Eastern Uplands	137.74	27.92	567.27	9,045
Southern Seaboard	157.65	9.62	691.56	9,892
Fruitful Rim	162.66	2.67	1627.67	3,134
Basin and Range	52.58	4.32	689.94	1,646
Mississippi Portal	172.56	5.34	540.48	3,367

Table 4.26: Weighted Cost Statistics (County level, 1988 dollar)

Region	mean	min	max	N
Heartland	144.19	23.37	855.14	10,955
Northern Crescent	232.51	5.44	1048.23	6,928
Northern Great Plains	55.78	2.53	153.69	1,751
Prairie Gateway	63.19	2.43	287.63	5,646
Eastern Uplands	91.05	13.43	553.04	9,045
Southern Seaboard	114.00	2.73	811.73	9,892
Fruitful Rim	132.22	1.66	1877.87	3,134
Basin and Range	34.26	2.11	457.62	1,646
Mississippi Portal	134.96	2.28	433.79	3,367

Table 4.27: Summary Statistics: Government Payments by Region ($/ac, 1988 dol.)

Region	Metro/Non Metro	Mean	SD	Min	Max	N
Heartland	Metro	16.84	19.71	0.00	136.95	248
	Non Metro	13.92	17.54	0.00	169.42	290
Northern	Metro	19.43	17.70	0.00	128.75	200
Crescen	Non Metro	13.23	13.44	0.00	111.40	112
Northern	Metro	7.75	10.41	0.00	58.60	21
Great Plains	Non Metro	6.74	8.69	0.00	93.65	111
Prairie	Metro	5.80	8.26	0.00	111.28	100
Gateway	Non Metro	6.72	10.22	0.00	151.16	202
Eastern	Metro	5.09	6.78	0.00	72.05	168
Uplands	Non Metro	4.16	5.97	0.00	89.11	233
Southern	Metro	7.91	10.19	0.00	101.21	257
Seaboard	Non Metro	7.46	9.81	0.00	79.83	202
Fruitful	Metro	11.56	19.46	0.00	195.84	123
Rim	Non Metro	7.78	13.79	0.00	175.11	81
Basin and	Metro	3.29	7.81	0.00	79.82	28
Range	Non Metro	5.79	33.02	0.00	499.91	92
Mississippi	Metro	15.39	21.33	0.00	157.44	57
Portal	Non Metro	14.65	18.83	0.00	134.72	97

Table 4.28: Share of farmland (County levels)

Region		1982	1987	1992	1997
Heartland	Base/Farmland	0.861	0.772	0.837	0.837
	Farmland/Total land	0.782	0.769	0.716	0.745
	Base/Total land	0.68	0.599	0.609	0.633
	N	522	521	419	420
Northern Crescent	Base/Farmland	0.754	0.688	0.707	0.704
	Farmland/Total land	0.41	0.387	0.37	0.392
	Base/Total land	0.329	0.28	0.277	0.291
	N	293	316	312	304
Northern Great Plains	Base/Farmland	0.818	0.764	0.815	0.835
	Farmland/Total land	0.855	0.848	0.847	0.873
	Base/Total land	0.699	0.65	0.694	0.732
	N	84	82	93	86
Prairie Gateway	Base/Farmland	0.861	0.825	0.858	0.888
	Farmland/Total land	0.829	0.831	0.845	0.856
	Base/Total land	0.711	0.681	0.723	0.76
	N	303	281	174	275
Eastern Uplands	Base/Farmland	0.702	0.703	0.715	0.71
	Farmland/Total land	0.432	0.42	0.406	0.429
	Base/Total land	0.321	0.311	0.306	0.322
	N	394	394	397	392
Southern Seaboard	Base/Farmland	0.672	0.634	0.635	0.633
	Farmland/Total land	0.349	0.318	0.282	0.327
	Base/Total land	0.24	0.206	0.181	0.215
	N	446	445	402	436
Fruitful Rim	Base/Farmland	0.782	0.75	0.755	0.738
	Farmland/Total land	0.475	0.417	0.325	0.367
	Base/Total land	0.408	0.334	0.262	0.293
	N	117	159	182	173
Basin and Range	Base/Farmland	0.863	0.845	0.867	0.866
	Farmland/Total land	0.296	0.377	0.379	0.411
	Base/Total land	0.252	0.316	0.326	0.357
	N	61	100	106	86
Mississippi Portal	Base/Farmland	0.782	0.714	0.749	0.708
	Farmland/Total land	0.501	0.463	0.444	0.471
	Base/Total land	0.403	0.336	0.346	0.352
	N	158	152	151	146

Table 4.29: Summary Statistics of MSAs

Variable	Mean	s.d.	Min	Max
Revenue	203.227	114.734	2.666	942.498
Cost	158.905	107.639	1.657	1111.708
Gov't Payments	13.337	16.278	0	128.752
Base Land Share	0.382	0.222	0.019	0.851
Population	580605	963675	56507	9242506
Popu Growth Rate	0.009	0.014	-0.075	0.122
College	0.192	0.066	0.073	0.474
Poverty Rate	0.127	0.038	0.042	0.266
Unemployment Rate	0.061	0.016	0.020	0.149
Manufacture	0.195	0.081	0.038	0.532
Popu Density	0.646	0.617	0.033	4.052
Low Inc Families	0.202	0.053	0.067	0.365
High Inc Families	0.171	0.06	0.069	0.431
Black	0.123	0.112	0	0.515
Elder	0.16	0.035	0.049	0.424

N=267, Avg. T=20.9

Table 4.30: Summary Statistics of Agricultural MSAs*

Variable	Mean	s.d.	Min	Max
Revenue	217.659	114.936	2.666	716.827
Cost	162.628	98.620	1.657	708.114
Gov't Payments	15.793	18.611	0	128.752
Base land share	0.549	0.16	0.303	0.851
Popu.	497596	823598	56507	8291553
Popu Growth Rate	0.009	0.013	-0.044	0.097
College	0.192	0.064	0.087	0.44
Poverty Rate	0.118	0.034	0.049	0.266
Manufacture	0.202	0.083	0.041	0.447
Popu Density	0.63	0.552	0.033	3.445
Low income families	0.19	0.049	0.094	0.365
High income families	0.175	0.054	0.075	0.429
Black	0.088	0.087	0.001	0.515
Elder	0.158	0.034	0.084	0.424

N=136, Avg. T = 19.58

* Base land share > 30%

Table 4.31: List of MSAs (All Obs)

MSA/PMSA	Revenue	Cost	Gov	T
Akron, OH	364.94	324.62	23.34	23
Albany, GA	158.17	121.98	12.29	23
Albany-Schenectady-Troy, NY	298.23	281.90	18.53	23
Alexandria, LA	186.94	128.56	13.33	23
Allentown-Bethlehem-Easton, PA	194.10	185.99	20.10	15
Altoona, PA	329.40	345.58	17.03	15
Ann Arbor, MI	246.75	190.38	20.02	23
Anniston, AL	145.44	89.38	2.89	23
Appleton-Oshkosh-Neenah, WI	462.73	420.32	30.46	23
Asheville, NC	172.79	122.75	6.51	23
Athens, GA	192.38	138.79	5.80	23
Atlanta, GA	148.43	88.27	3.20	23
Auburn-Opelika, AL	114.69	74.25	4.21	23
Augusta-Aiken, GA-SC	168.87	140.38	9.77	23
Baltimore, MD	228.40	204.87	20.35	23
Baton Rouge, LA	132.52	74.60	2.27	23
Bellingham, WA	838.75	889.12	23.49	13
Benton Harbor, MI	179.46	143.57	16.29	23
Biloxi-Gulfport-Pascagoula, MS	169.50	95.31	2.69	23
Binghamton, NY	346.99	331.99	19.33	23
Birmingham, AL	154.96	93.73	3.79	23
Bismarck, ND	59.75	47.00	4.55	23
Bloomington, IN	187.82	124.25	12.93	23
Bloomington-Normal, IL	257.65	148.15	20.22	23
Boise City, ID	277.79	205.89	9.42	10
Boulder-Longmont, CO	159.07	94.72	9.91	9
Bremerton, WA	62.88	27.50	0.00	13
Buffalo-Niagara Falls, NY	346.55	340.20	21.97	23
Canton-Massillon, OH	323.41	292.25	20.10	23
Cedar Rapids, IA	304.33	173.51	24.26	13
Champaign-Urbana, IL	252.80	147.34	20.07	23
Charleston-North Charleston, SC	151.19	128.42	8.48	23
Charleston, WV	61.96	34.74	0.96	23
Charlotte-Gastonia-Rock Hill, NC-SC	192.16	145.50	8.84	23
Charlottesville, VA	190.95	127.08	6.23	23
Chattanooga, TN-GA	164.73	108.31	4.33	23
Chicago, IL	266.11	170.74	22.55	23
Chico-Paradise, CA	166.33	115.35	44.24	15
Cincinnati, OH-KY-IN	137.20	89.12	6.91	23
Clarksville-Hopkinsville, TN-KY	185.31	126.06	11.61	23
Cleveland-Lorain-Elyria, OH	256.71	225.40	15.86	23
Colorado Springs, CO	25.65	13.94	0.88	9
Columbia, MO	142.74	87.40	5.88	23
Columbia, SC	178.73	140.71	9.94	23
Columbus, GA-AL	105.19	71.31	5.08	23
Columbus, OH	223.49	151.44	16.23	23
Corvallis, OR	116.03	85.48	17.00	18
Cumberland, MD-WV	186.07	164.19	9.92	23
Danville, VA	110.74	75.61	5.24	23
Davenport-Moline-Rock Island, IA-IL	312.51	178.53	27.36	13
Dayton-Springfield, OH	260.98	169.82	19.01	23
Daytona Beach, FL	38.65	19.41	0.00	9
Decatur, AL	177.38	119.83	8.30	23

Table 4.31: List of MSAs (continued)

MSA/PMSA	Revenue	Cost	Gov	T
Decatur, IL	254.77	146.16	19.91	23
Denver, CO	46.41	27.35	3.80	9
Des Moines, IA	269.39	148.69	19.95	13
Detroit, MI	210.66	162.45	16.55	23
Dothan, AL	152.94	126.21	8.81	23
Dover, DE	236.13	198.45	21.86	23
Dubuque, IA	358.38	253.82	28.74	13
Duluth-Superior, MN-WI	99.36	77.56	3.89	23
Dutchess County, NY	235.07	205.70	15.47	23
Eau Claire, WI	349.22	312.18	21.83	23
Elkhart-Goshen, IN	268.86	204.34	22.05	23
Elmira, NY	298.23	305.76	12.71	15
Enid, OK	118.48	73.09	13.14	23
Erie, PA	248.64	255.95	13.39	15
Eugene-Springfield, OR	103.36	74.36	12.42	18
Evansville-Henderson, IN-KY	225.34	154.15	18.81	23
Fargo-Moorhead, ND-MN	128.55	95.54	14.51	23
Fayetteville, NC	158.64	148.25	12.18	23
Fayetteville-Springdale-Rogers, AR	148.07	78.14	1.89	23
Flint, MI	211.15	164.76	17.66	23
Florence, AL	156.72	114.53	8.66	23
Florence, SC	167.45	164.80	16.32	23
Fort Collins-Loveland, CO	112.26	61.94	6.51	9
Fort Myers-Cape Coral, FL	34.16	17.19	0.00	9
Fort Pierce-Port St. Lucie, FL	58.84	40.29	0.31	9
Fort Smith, AR-OK	97.59	52.90	1.48	23
Fort Walton Beach, FL	96.26	87.32	3.65	9
Fort Wayne, IN	238.18	160.40	17.92	23
Fresno, CA	286.84	220.36	32.15	15
Gadsden, AL	156.75	109.32	5.90	23
Gainesville, FL	102.17	77.71	1.48	9
Gary, IN	231.89	157.04	20.48	23
Goldsboro, NC	162.34	152.83	14.50	23
Grand Forks, ND-MN	112.59	80.58	17.64	23
Grand Junction, CO	83.52	37.86	3.01	9
Grand Rapids-Muskegon-Holland, MI	278.20	239.25	20.76	23
Greeley, CO	203.83	101.56	11.87	9
Green Bay, WI	447.68	417.09	28.06	23
Greensboro–Winston-Salem–High Point, NC	181.06	137.57	8.32	23
Greenville, NC	171.20	157.27	15.13	23
Greenville-Spartanburg-Anderson, SC	150.92	95.11	3.89	23
Hagerstown, MD	321.22	338.33	18.62	15
Hamilton-Middletown, OH	234.63	157.66	18.65	23
Harrisburg-Lebanon-Carlisle, PA	356.41	362.01	21.63	15
Hattiesburg, MS	159.47	94.01	3.32	23
Hickory-Morganton-Lenoir, NC	225.12	165.51	8.22	23
Houma, LA	83.84	42.84	0.59	23
Huntington-Ashland, WV-KY-OH	94.17	63.97	3.27	23
Huntsville, AL	177.59	138.06	11.90	23
Indianapolis, IN	242.28	147.22	19.23	23
Iowa City, IA	288.47	164.92	23.48	13
Jackson, MI	258.84	211.71	21.66	23
Jackson, MS	160.26	112.60	8.63	23

Table 4.31: List of MSAs (continued)

MSA/PMSA	Revenue	Cost	Gov	T
Jackson, TN	188.29	171.60	16.91	23
Jacksonville, FL	184.39	190.85	3.20	9
Jacksonville, NC	161.16	153.17	13.44	23
Jamestown, NY	311.78	299.73	17.22	23
Janesville-Beloit, WI	377.12	310.19	27.40	23
Johnson City-Kingsport-Bristol, TN-VA	171.52	108.89	4.73	23
Johnstown, PA	259.27	270.21	13.66	15
Jonesboro, AR	219.09	188.22	33.67	23
Joplin, MO	145.89	93.95	5.14	23
Kalamazoo-Battle Creek, MI	202.54	163.54	18.10	23
Kankakee, IL	241.21	153.00	19.64	23
Kansas City, MO-KS	150.11	94.44	6.40	23
Kenosha, WI	323.54	247.91	25.81	23
Knoxville, TN	167.35	98.51	3.60	23
Kokomo, IN	262.23	158.65	20.64	23
La Crosse, WI-MN	332.47	287.82	20.62	23
Lafayette, LA	182.68	154.97	23.18	23
Lafayette, IN	240.76	145.13	19.70	23
Lake Charles, LA	149.55	133.69	21.00	23
Lakeland-Winter Haven, FL	54.15	31.75	0.13	9
Lancaster, PA	631.77	625.45	32.93	15
Lansing-East Lansing, MI	266.70	214.25	20.45	23
Lawrence, KS	167.09	91.30	5.79	9
Lawton, OK	101.21	69.70	9.49	23
Lexington, KY	125.20	69.72	2.81	23
Lima, OH	253.16	174.55	18.04	23
Lincoln, NE	223.60	130.18	11.94	23
Little Rock-North Little Rock, AR	177.49	130.38	18.06	23
Los Angeles-Long Beach, CA	97.61	61.14	3.51	15
Louisville, KY-IN	185.06	128.57	9.98	23
Lynchburg, VA	136.42	80.78	3.21	23
Macon, GA	165.95	135.96	9.26	23
Madison, WI	400.72	337.34	28.91	23
Mansfield, OH	248.95	190.28	17.25	23
Medford-Ashland, OR	57.84	33.33	1.31	18
Memphis, TN-AR-MS	169.42	145.10	12.45	23
Merced, CA	341.47	251.21	27.13	15
Middlesex-Somerset-Hunterdon, NJ	174.34	139.52	12.06	23
Milwaukee-Waukesha, WI	419.05	366.34	29.67	23
Minneapolis-St. Paul, MN-WI	299.91	247.29	21.50	23
Mobile, AL	206.34	140.16	8.18	23
Modesto, CA	420.24	300.01	26.36	15
Monmouth-Ocean, NJ	135.23	99.19	8.84	23
Monroe, LA	252.58	227.05	38.87	23
Montgomery, AL	133.54	89.38	5.81	23
Muncie, IN	233.43	149.46	16.61	23
Myrtle Beach, SC	131.29	120.01	9.61	23
Nashville, TN	142.66	86.96	4.13	23
New Orleans, LA	142.32	79.53	1.95	23
Newark, NJ	271.17	237.44	18.91	23
Norfolk-Virginia Beach-Newport News, VA-NC	175.55	136.14	13.62	23
Oakland, CA	55.79	30.08	1.97	15
Ocala, FL	93.12	72.71	1.22	9

Table 4.31: List of MSAs (continued)

MSA/PMSA	Revenue	Cost	Gov	T
Oklahoma City, OK	106.52	64.86	6.19	23
Olympia, WA	386.92	369.69	8.41	13
Omaha, NE-IA	244.68	153.82	15.72	23
Orlando, FL	76.24	68.19	1.00	9
Owensboro, KY	191.09	131.90	12.94	23
Panama City, FL	141.45	135.40	5.70	9
Parkersburg-Marietta, WV-OH	100.05	65.71	3.46	23
Pensacola, FL	180.90	206.74	13.38	9
Peoria-Pekin, IL	236.48	144.07	18.54	23
Philadelphia, PA-NJ	296.93	256.92	18.91	23
Pine Bluff, AR	226.71	178.96	32.20	23
Pittsburgh, PA	172.47	163.53	9.25	15
Pocatello, ID	21.30	14.85	8.46	10
Portland-Vancouver, OR-WA	194.50	151.06	16.83	18
Provo-Orem, UT	90.54	73.75	4.75	16
Pueblo, CO	23.40	13.47	1.01	9
Punta Gorda, FL	143.53	138.78	2.25	9
Racine, WI	298.33	227.45	22.75	23
Raleigh-Durham-Chapel Hill, NC	157.18	125.42	7.80	23
Reading, PA	295.36	291.77	20.31	15
Redding, CA	49.45	21.73	0.98	15
Reno, NV	62.21	25.04	0.75	15
Richland-Kennewick-Pasco, WA	154.44	118.80	16.35	13
Richmond-Petersburg, VA	176.71	130.76	9.71	23
Riverside-San Bernardino, CA	314.29	248.49	20.85	15
Roanoke, VA	177.72	124.45	5.93	23
Rochester, MN	309.37	230.13	22.92	23
Rochester, NY	313.63	294.42	25.32	23
Rockford, IL	315.83	222.30	26.83	23
Rocky Mount, NC	160.77	150.62	14.17	23
Sacramento, CA	247.63	153.21	22.44	15
Saginaw-Bay City-Midland, MI	187.04	137.08	15.80	23
St. Cloud, MN	316.76	281.94	21.35	23
St. Joseph, MO	177.01	117.66	9.19	23
St. Louis, MO-IL	185.21	128.80	12.45	23
Salem, OR	159.39	128.16	20.96	18
Salinas, CA	49.51	21.38	0.91	15
Salt Lake City-Ogden, UT	136.48	122.37	6.04	16
San Diego, CA	126.13	89.13	6.18	15
San Francisco, CA	213.21	157.92	12.82	15
San Jose, CA	73.51	39.87	2.86	15
San Luis Obispo-Atascadero-Paso Robles, CA	46.34	25.59	1.55	15
Santa Barbara-Santa Maria-Lompoc, CA	53.77	25.41	1.27	15
Santa Cruz-Watsonville, CA	67.72	33.21	1.66	15
Santa Fe, NM	10.40	4.81	0.12	23
Santa Rosa, CA	175.19	123.71	9.35	15
Sarasota-Bradenton, FL	101.06	75.37	0.68	9
Savannah, GA	125.80	102.08	7.32	23
Scranton–Wilkes-Barre–Hazleton, PA	244.60	253.31	12.24	15
Seattle-Bellevue-Everett, WA	843.59	863.65	22.16	13
Sharon, PA	269.99	276.50	14.93	15
Sheboygan, WI	462.92	424.96	29.95	23
Sherman-Denison, TX	95.55	51.92	3.67	23

Table 4.31: List of MSAs (continued)

MSA/PMSA	Revenue	Cost	Gov	T
Shreveport-Bossier City, LA	148.69	93.96	6.85	23
Sioux City, IA-NE	239.71	158.12	14.28	23
South Bend, IN	242.39	178.76	21.70	23
Spokane, WA	48.52	33.21	3.43	23
Springfield, IL	249.79	144.64	18.94	23
Springfield, MO	155.03	107.37	3.82	23
State College, PA	330.66	345.05	18.78	15
Steubenville-Weirton, OH-WV	108.70	82.27	4.56	23
Stockton-Lodi, CA	302.57	200.95	23.52	15
Sumter, SC	176.91	170.41	18.73	23
Syracuse, NY	390.87	379.69	26.10	23
Tacoma, WA	425.16	408.67	9.78	13
Tallahassee, FL	134.39	113.94	9.26	9
Tampa-St. Petersburg-Clearwater, FL	113.88	88.07	0.95	9
Terre Haute, IN	223.36	140.59	18.14	23
Texarkana, TX-Texarkana, AR	133.30	81.03	5.30	23
Toledo, OH	242.32	151.53	18.50	23
Topeka, KS	134.95	67.22	4.88	9
Trenton, NJ	144.39	104.62	10.11	23
Tulsa, OK	66.23	33.49	1.29	23
Tuscaloosa, AL	148.88	99.92	5.97	23
Utica-Rome, NY	370.47	368.75	21.12	23
Vallejo-Fairfield-Napa, CA	37.74	21.03	1.29	15
Vineland-Millville-Bridgeton, NJ	147.65	110.92	10.14	23
Washington, DC-MD-VA-WV	192.86	154.90	11.44	23
Waterloo-Cedar Falls, IA	333.59	198.90	27.22	13
Wausau, WI	358.51	339.94	21.42	23
West Palm Beach-Boca Raton, FL	4.80	2.32	0.23	9
Wheeling, WV-OH	99.49	70.00	3.34	23
Wichita, KS	158.22	87.01	10.71	9
Wichita Falls, TX	89.69	66.28	9.25	23
Williamsport, PA	265.81	260.83	18.92	15
Wilmington-Newark, DE-MD	239.24	215.34	20.50	23
Wilmington, NC	152.55	139.80	11.03	23
Yakima, WA	74.20	47.80	1.48	13
York, PA	215.58	204.08	15.86	15
Youngstown-Warren, OH	281.94	254.32	18.60	23
Yuba City, CA	144.92	86.04	23.64	15

Table 4.32: Agricultural MSAs*

	Base Land Share, %	Growth Rate, %	Cost	Gov't Payment	Revenue
Akron, OH	32.02	0.25	324.62	23.34	364.94
Albany, GA	36.69	0.49	121.98	12.29	158.17
Ann Arbor, MI	41.61	1.27	190.38	20.02	246.75
Appleton-Oshkosh-Neenah, WI	52.16	1.05	420.32	30.46	462.73
Benton Harbor, MI	40.55	-0.29	143.57	16.29	179.46
Bismarck, ND	76.19	1.04	47.00	4.55	59.75
Bloomington, IN	35.78	1.00	124.25	12.93	187.82
Bloomington-Normal, IL	85.12	1.14	148.15	20.22	257.65
Boise City, ID	81.51	3.78	205.89	9.42	277.79
Canton-Massillon, OH	41.81	0.03	292.25	20.10	323.41
Cedar Rapids, IA	76.47	0.09	173.51	24.26	304.33
Champaign-Urbana, IL	83.52	0.22	147.34	20.07	252.80
Chicago, IL	61.33	0.60	170.74	22.55	266.11
Chico-Paradise, CA	38.70	2.61	115.35	44.24	166.33
Cincinnati, OH-KY-IN	38.98	0.55	89.12	6.91	137.20
Clarksville-Hopkinsville, TN-KY	44.20	1.55	126.06	11.61	185.31
Colorado Springs, CO	49.27	2.84	13.94	0.88	25.65
Columbia, MO	63.02	1.54	87.40	5.88	142.74
Columbus, OH	55.89	1.10	151.44	16.23	223.49
Davenport-Moline-Rock Island, IA-IL	73.73	-0.71	178.53	27.36	312.51
Dayton-Springfield, OH	63.41	0.05	169.82	19.01	260.98
Decatur, AL	32.77	0.92	119.83	8.30	177.38
Decatur, IL	80.59	-0.66	146.16	19.91	254.77
Denver, CO	34.19	2.01	27.35	3.80	46.41
Des Moines, IA	73.33	0.65	148.69	19.95	269.39
Dothan, AL	30.73	0.60	126.21	8.81	152.94
Dover, DE	53.92	1.17	198.45	21.86	236.13
Dubuque, IA	74.00	-0.67	253.82	28.74	358.38
Eau Claire, WI	48.85	0.65	312.18	21.83	349.22
Elkhart-Goshen, IN	58.49	1.38	204.34	22.05	268.86
Enid, OK	83.73	-0.32	73.09	13.14	118.48
Evansville-Henderson, IN-KY	57.16	0.42	154.15	18.81	225.34
Fargo-Moorhead, ND-MN	81.10	1.13	95.54	14.51	128.55
Fayetteville-Springdale-Rogers, AR	43.36	2.80	78.14	1.89	148.07
Flint, MI	45.80	-0.13	164.76	17.66	211.15
Fort Collins-Loveland, CO	30.29	2.94	61.94	6.51	112.26
Fort Pierce-Port St. Lucie, FL	52.24	2.27	40.29	0.31	58.84
Fort Smith, AR-OK	35.73	1.21	52.90	1.48	97.59
Fort Wayne, IN	67.75	0.59	160.40	17.92	238.18
Fresno, CA	44.05	2.80	220.36	32.15	286.84
Gary, IN	44.32	-0.09	157.04	20.48	231.89
Goldsboro, NC	35.71	0.72	152.83	14.50	162.34
Grand Forks, ND-MN	64.95	-0.18	80.58	17.64	112.59
Grand Rapids-Muskegon-Holland, MI	48.81	1.32	239.25	20.76	278.20
Greeley, CO	65.36	1.71	101.56	11.87	203.83
Green Bay, WI	42.08	1.25	417.09	28.06	447.68
Hagerstown, MD	37.68	0.89	338.33	18.62	321.22
Hamilton-Middletown, OH	53.97	1.29	157.66	18.65	234.63
Harrisburg-Lebanon-Carlisle, PA	30.36	0.71	362.01	21.63	356.41
Huntsville, AL	32.02	1.67	138.06	11.90	177.59
Indianapolis, IN	59.81	0.99	147.22	19.23	242.28
Iowa City, IA	72.58	1.62	164.92	23.48	288.47

Table 4.32: Agricultural MSAs (continued)

	Base Land Share, %	Growth Rate, %	Cost	Gov't Payment	Revenue
Jackson, MI	39.53	0.21	211.71	21.66	258.84
Jackson, TN	42.01	1.10	171.60	16.91	188.29
Janesville-Beloit, WI	62.79	0.45	310.19	27.40	377.12
Johnson City-Kingsport-Bristol, TN-VA	31.26	0.59	108.89	4.73	171.52
Jonesboro, AR	67.12	1.25	188.22	33.67	219.09
Joplin, MO	60.39	1.06	93.95	5.14	145.89
Kalamazoo-Battle Creek, MI	56.63	0.37	163.54	18.10	202.54
Kankakee, IL	82.18	0.04	153.00	19.64	241.21
Kansas City, MO-KS	57.91	0.98	94.44	6.40	150.11
Kenosha, WI	45.80	0.90	247.91	25.81	323.54
Kokomo, IN	73.07	-0.11	158.65	20.64	262.23
La Crosse, WI-MN	48.09	0.67	287.82	20.62	332.47
Lafayette, LA	33.94	0.89	154.97	23.18	182.68
Lafayette, IN	78.57	0.86	145.13	19.70	240.76
Lakeland-Winter Haven, FL	49.51	1.81	31.75	0.13	54.15
Lancaster, PA	60.15	1.32	625.45	32.93	631.77
Lansing-East Lansing, MI	50.27	0.41	214.25	20.45	266.70
Lawrence, KS	68.37	1.58	91.30	5.79	167.09
Lawton, OK	72.11	-0.11	69.70	9.49	101.21
Lexington, KY	74.53	1.28	69.72	2.81	125.20
Lima, OH	73.94	0.10	174.55	18.04	253.16
Lincoln, NE	75.06	1.34	130.18	11.94	223.60
Louisville, KY-IN	40.15	0.34	128.57	9.98	185.06
Madison, WI	60.23	1.39	337.34	28.91	400.72
Mansfield, OH	56.70	-0.17	190.28	17.25	248.95
Memphis, TN-AR-MS	38.71	0.99	145.10	12.45	169.42
Merced, CA	77.08	2.87	251.21	27.13	341.47
Milwaukee-Waukesha, WI	48.02	0.36	366.34	29.67	419.05
Minneapolis-St. Paul, MN-WI	44.25	1.50	247.29	21.50	299.91
Modesto, CA	75.15	3.40	300.01	26.36	420.24
Muncie, IN	66.29	-0.40	149.46	16.61	233.43
Nashville, TN	41.97	1.87	86.96	4.13	142.66
Oakland, CA	54.79	1.74	30.08	1.97	55.79
Oklahoma City, OK	62.69	1.23	64.86	6.19	106.52
Omaha, NE-IA	78.58	0.75	153.82	15.72	244.68
Orlando, FL	49.39	2.91	68.19	1.00	76.24
Owensboro, KY	50.69	0.39	131.90	12.94	191.09
Peoria-Pekin, IL	71.00	-0.20	144.07	18.54	236.48
Pine Bluff, AR	35.15	-0.20	178.96	32.20	226.71
Pocatello, ID	41.72	1.23	14.85	8.46	21.30
Provo-Orem, UT	30.27	2.79	73.75	4.75	90.54
Pueblo, CO	31.23	0.01	13.47	1.01	23.40
Punta Gorda, FL	76.42	2.05	138.78	2.25	143.53
Racine, WI	52.70	0.43	227.45	22.75	298.33
Richland-Kennewick-Pasco, WA	53.66	2.27	118.80	16.35	154.44
Rochester, MN	68.69	1.45	230.13	22.92	309.37
Rochester, NY	34.46	0.29	294.42	25.32	313.63
Rockford, IL	70.36	0.66	222.30	26.83	315.83
Sacramento, CA	31.93	3.22	153.21	22.44	247.63
Saginaw-Bay City-Midland, MI	47.38	-0.20	137.08	15.80	187.04
St. Cloud, MN	56.42	1.12	281.94	21.35	316.76
St. Joseph, MO	68.98	0.01	117.66	9.19	177.01

Table 4.32: Agricultural MSAs (continued)

	Base Land Share, %	Growth Rate, %	Cost	Gov't Payment	Revenue
St. Louis, MO-IL	44.42	0.36	128.80	12.45	185.21
Salinas, CA	62.57	1.99	21.38	0.91	49.51
Salt Lake City-Ogden, UT	46.27	1.82	122.37	6.04	136.48
San Francisco, CA	46.04	0.74	157.92	12.82	213.21
San Jose, CA	38.38	1.47	39.87	2.86	73.51
San Luis Obi-Ata-Paso Robles, CA	58.40	3.04	25.59	1.55	46.34
St Barbara-St Maria-Lompoc, CA	43.40	1.86	25.41	1.27	53.77
Santa Fe, NM	64.93	2.29	4.81	0.12	10.40
Santa Rosa, CA	31.48	2.60	123.71	9.35	175.19
Sarasota-Bradenton, FL	57.06	2.00	75.37	0.68	101.06
Sheboygan, WI	56.04	0.53	424.96	29.95	462.92
Sherman-Denison, TX	65.88	1.22	51.92	3.67	95.55
Sioux City, IA-NE	74.98	0.16	158.12	14.28	239.71
South Bend, IN	54.36	0.43	178.76	21.70	242.39
Springfield, IL	76.93	0.32	144.64	18.94	249.79
Springfield, MO	63.04	1.76	107.37	3.82	155.03
Stockton-Lodi, CA	84.57	3.11	200.95	23.52	302.57
Syracuse, NY	38.22	0.02	379.69	26.10	390.87
Tampa-St. Petersburg-Clearwater, FL	34.37	1.56	88.07	0.95	113.88
Terre Haute, IN	62.17	-0.14	140.59	18.14	223.36
Texarkana, TX-Texarkana, AR	31.63	0.74	81.03	5.30	133.30
Toledo, OH	70.89	0.05	151.53	18.50	242.32
Topeka, KS	70.03	0.37	67.22	4.88	134.95
Tulsa, OK	66.52	1.25	33.49	1.29	66.23
Vallejo-Fairfield-Napa, CA	38.44	3.17	21.03	1.29	37.74
Waterloo-Cedar Falls, IA	79.20	-0.78	198.90	27.22	333.59
West Palm Beach-Boca Raton, FL	42.80	2.65	2.32	0.23	4.80
Wheeling, WV-OH	30.30	-0.88	70.00	3.34	99.49
Wichita, KS	76.86	0.96	87.01	10.71	158.22
Wichita Falls, TX	77.73	0.41	66.28	9.25	89.69
Wilmington-Newark, DE-MD	30.57	1.10	215.34	20.50	239.24
York, PA	41.29	1.23	204.08	15.86	215.58

* Base land share > 30%

Figure 4.8: Farm Resource Regions

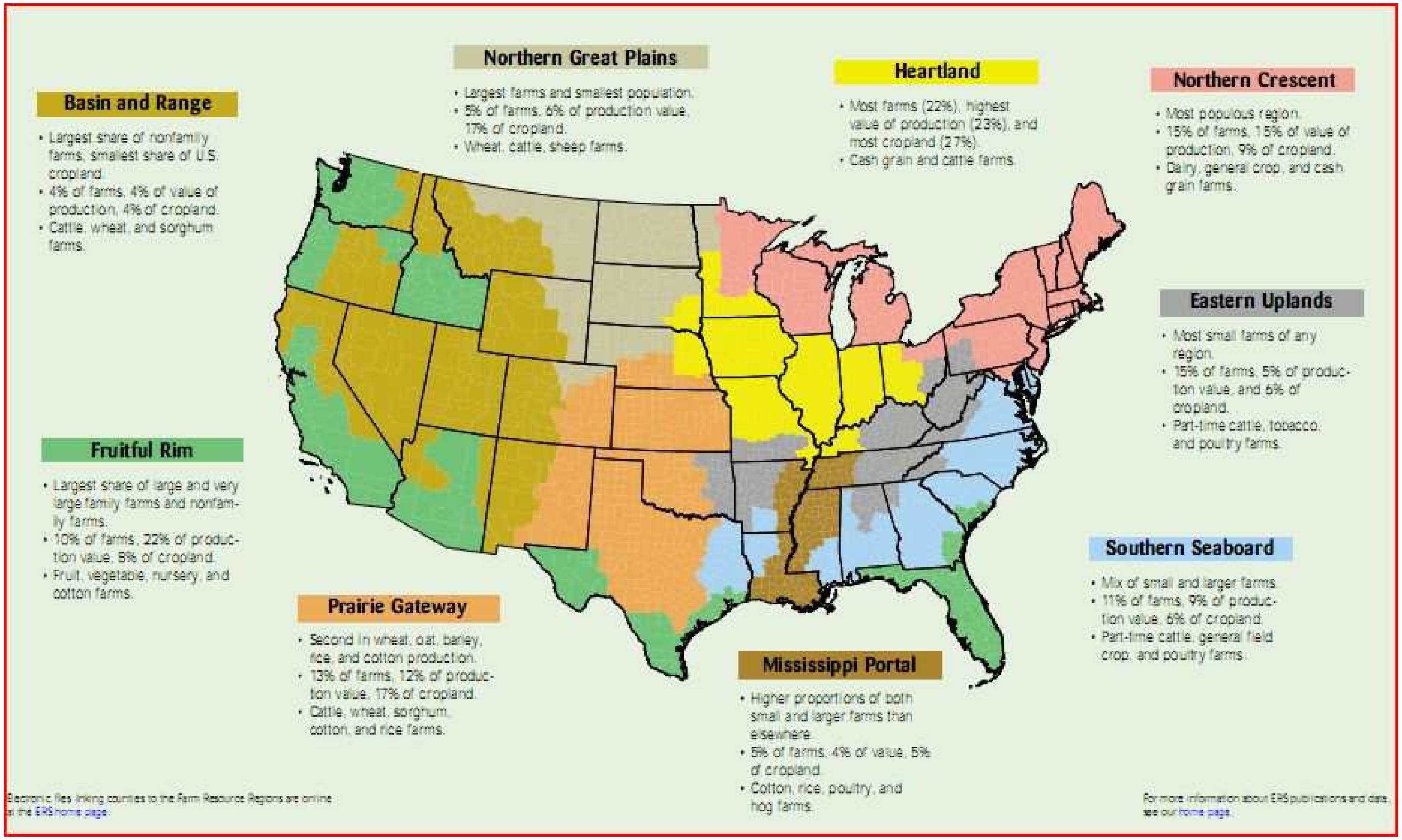


Figure 4.9: MSA Buffers: 2000 Definition

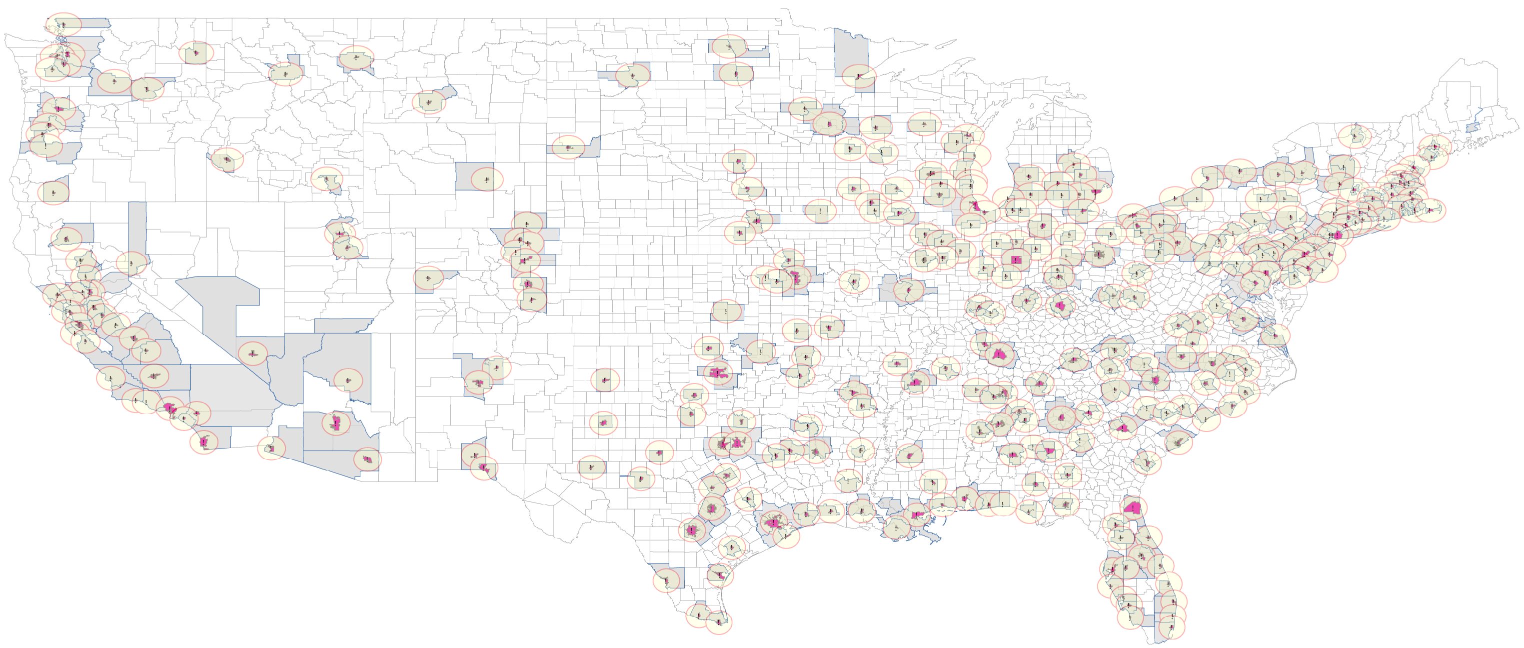


Figure 4.10: MSA Buffers: Lexington and Louisville, KY

Notes: The yellow area is Lexington defined by its buffer, and the shaded area is Lexington–Fayette MSA by OMB definition. Other counties belong to Liousville. Shelby County is covered by both buffers.

Chapter 5 Empirical Methodology

Section 5.1 discusses alternative measures of the agricultural variables that will be used in the regressions, including the reason of why a specific form of a measure is considered, and the expected results or the implications of using it. Section 5.2 discusses the subsamples that will be used in the regressions, together with the information each subsample is capable of conveying, together with the expected results of using it. Section 5.3 discusses the regression specifications. The need for a dynamic framework will be shown in this section. Section 5.4 discusses the estimation technique used to address the dynamic panel bias.

5.1 Measuring the Agricultural Rent at the MSA Level

Simple Averages and Weighted Averages

As shown in Chapter 4, the appropriate observation levels for this study are MSAs, so we need to aggregate the county-level agricultural variables into MSA levels. Two methods of aggregation are used: simple averages, and weighted averages, with the weight for each county being its share of agricultural land within the metropolitan area.

There are two reasons that the weighted average may be superior to simple averages. First, counties with less agricultural land are presumably closer to cities, so farming practices for observed crops in these counties will be more likely affected by urban development. Giving them a smaller weight helps reduce the endogeneity problem as mentioned in Section 4.1. However, as discussed in Section 4.1, the impact of urban areas on farming can be both positive and negative, therefore we can not determine the direction of bias caused by this issue of endogeneity.

Second, counties with less farm land and closer to cities may have more unobserved crops. This can be seen in Table 5.1, which compares the simple averages and weighted averages for revenues, costs and government payments. Nearly in all regions, except for Northern Great Plains and Prairie Gateway (Southern Plains) where simple averages are slightly (and insignificantly) higher, weighted averages for **both** revenue and cost are higher, which can not be completely attributed to differences in farming practices or productivities in metropolitan and non-metropolitan areas. The most likely reason for this phenomena is that counties with less agricultural land have more unobserved crops. As the revenue and cost are county averages, i.e., total revenue and cost divided by agricultural land, the observed average revenue and cost will be both lower in counties with more unobserved crops.For example, the difference between the simple averages and weighted averages are the most significant in the Northern Crescent and the Fruitful Rim. Relative to other regions, Northern Crescent has more unobserved tobaccos, beans, and potatoes; while the Fruitful Rim, as its name suggests, is highly concentrated in vegetables and fruits in certain areas. Moreover, if the unobserved crops are correlated with the distance to cities, say, the closer to cities the more unobserved crops, the observed revenue and cost will be negatively correlated with distance to cities. In dynamic cases, this means the changes in observed revenue and cost are negatively correlated with urban growth,[1] suggesting the unobserved crops are not fixed and panel data techniques will not help. Moreover, if shocks to urban labor markets have persistent impact so that population growth are serially correlated, using lagged revenue and cost in regressions will not eliminate the correlation either. This source of endogeneity will bias our estimation down.

Dollar Measures and Log Measures

While the agricultural variables are in dollar measures, logarithmic transformation of the agricultural variables are also considered. This not only allows us to interpret the results in elasticities, it is also more appropriate than the dollar measure in an intercity spatial framework. The impact of a one–dollar increase in land values, and in turn, a one-dollar increase in housing prices may be non-linear across locations considering the differences in

[1]Taking the revenue for an example, the real average revenue at time period t equals $\frac{TR_t^O+TR_t^{UO}}{L_t}$, while the observed average revenue is $\frac{TR_t^O}{L_t}$, where TR_t^O is the total observed revenue, TR_t^{UO} is the total unobserved revenue, and L_t is the agricultural land. When urban area grows so that L_t decreases in $t+1$, TR_O decreases faster than TR_{UO}, so the change in observed average revenue does not equal the change in the real revenue.

Table 5.1: Simple Averages Vs. Weighted Averages: Revenues, Costs, and Government Payments

	Average Revenue		Average Cost		Average Gov't Pymt	
Region	**Simple**	**Weighted**	**Simple**	**Weighted**	**Simple**	**Weighted**
Heartland	236.23	237.88	154.48	155.35	17.53	17.54
Northen Crescent	290.43	301.52	255.87	266.52	19.74	20.39
Nother Great Plains	100.94	100.87	68.07	67.92	8.43	8.41
Prairie Gateway	85.28	85.00	54.12	53.83	4.94	4.92
Eastern Uplands	150.60	154.58	105.61	109.53	5.95	6.49
Southern Seaboard	159.48	162.23	120.44	124.63	8.99	9.57
Fruitful Rim	170.07	182.95	128.68	141.80	10.53	9.89
Basin and Range	94.03	100.21	64.73	68.45	7.31	7.78
Mississippi Portal	161.39	166.53	120.61	127.10	12.86	14.57

incomes and amenities. Using the logarithmic form will reduce such heterogeneities.

One problem brought by using the log form is that the agricultural rent (Revenues - Costs + Gov Payments) may be negative or zero in some periods. In this case, the strategy is letting the log of revenues, costs, and government payments enter into the regressions separately instead of integrating them into a single rent measure. We then examine the coefficients of each agricultural variable. While we expect the coefficients for the dollar revenues and costs to be equal in size with opposite signs, we do not expect such equality would hold for agricultural variables in log forms. In fact, the coefficients of the agricultural variables should be proportional to the value of the sample mean of these variables. [2]

Time Structures

Several alternative time structures are also considered because they have different implications for farmers' decisions. To see this, suppose the value of a parcel of land for agricultural use, not adjusting for risks, is the present value of the stream of future agricultural rents, i.e., $V_t = \Sigma_{k=t+1}^{\infty} \frac{r_k}{(1+i)^k}$. Farmers may look forward or backwards when trying to determine the value of the land. Using the lagged term of the agricultural variables implies farmers look backwards, while using the current or forward terms suggests they look forward and some process of rational expectation may apply[3].

When different time structures are tried, one natural question is how long farmers would look forward or backword. Two measures are considered: 3–year moving averages and single year measures. As is discussed in Chapter 4, while 3–year moving averages is no worse than 5–year moving averages in terms of R^2, it is better than single year measures in determining land values.[4] But single year measures are more capable of capturing short term changes in agricultural prices. Therefore in cases where short term changes in agricultural variables

[2] To see this, suppose the population is a function of the agricultural rent (log) , thus a function of ln (Revenue - Cost + Gov Payment), i.e.,

$$\ln N = f[\ln(r)] = f[\ln(R - C + G)]$$

The partial derivative of $\ln N$ with respect to Revenue, for example, is

$$\frac{\partial \ln N}{\partial R} = f' \frac{\partial \ln r}{\partial R} = f' \frac{\partial r}{\partial R} \frac{1}{r}$$

which implies

$$\frac{\partial \ln N}{\partial \ln R} = f' \frac{R}{V}$$

Therefore, for regressions with log agricultural variables, the coefficient of each agricultural variable will be proportional to its sample averages, i.e.,

$$\frac{\partial \ln N / \partial \ln R}{\partial \ln N / \partial \ln C} = -\frac{R}{C}$$

[3] If the behavior price of products follows a unit root process, we may expect forward prices have no impact on urban growth

[4] The exponential moving average is not considered because it introduces inconsistency in the measure of agricultural variables in different years. For example, both starting in 1978, exponential moving averages for 1979 and 1989 are different in structure. Interpretation of the estimation results based on exponential moving averages is impossible.

need to be addressed, single year measures will be used with additional lagged measures being controlled.

5.2 Alternative Samples

Samples by Base Land Share

As shown in Chapter 4, the agricultural variables together measure the value of the base land in each county and, after aggregating, in each MSA. If the base land share is very low in one metropolitan area, it is hard to believe that our agricultural variables actually measure the opportunity cost of urban lands. The lowest MSA base land share in the data, for example, is below 7%.[5] In this case, there is a strong possibility that correlation between population and agricultural land value, if any, is spurious. It is possible that our measures and the population are affected by the same unobserved factors, e.g., industrial land uses, military land use, and so on. Therefore, to both examine the robustness of the empirical results and to estimate the impact of agricultural variables accurately, it is necessary to restrict observations to samples with a minimum of agricultural land. To determine a sensible threshold for the base land share, several subsamples by base land share will be used.[6]

Samples by Periods

Between 1978 and 2000, there were periods with drastic price changes such as 1978 to 1986 and 1994 to 1996. It is natural to argue that the correlation between price changes and urban growth would be stronger in these periods. In the regressions in the next chapter, the two periods mentioned will be examined with special notes.

---

[5] Charleston-North Charleston, SC and Savannah, GA.

[6] For an example, see Table 4.32 for a sub sample of MSAs with base land share greater than 30%, and Table 4.30 for its summary statistics.

Samples with and without Declining MSAs

As argued by Glaeser and Gyourko [2005], supply conditions of the housing market do not bind for declining MSAs, i.e., these MSAs are not in equilibrium. However, including declining MSAs could affect our results in predictable manners. For example, in periods when the commodity prices drop, the theory predicts metropolitan areas to grow faster. In declining MSAs, however, the correlation between agricultural prices and population could be positive, which blurs our results. On the contrary, when the commodity prices increase and the theory predicts slower growth, including declining may magnify our results artificially. To address this issue, samples with and without declining populations will also be examined.

5.3 Specifications of the Regression Models

5.3.1 Baseline Specification

Examining the impact of agricultural variables on population levels

As suggested by Equation 3.2, the preliminary regression model is specified as

$$\ln N_{i,t} = \beta_0 + \beta_1 V_{i,\cdot} + \gamma Z_{i,t-1} + \nu_i + \varepsilon_{i,t} \tag{5.1}$$

where $N_{i,t}$ is the population of metropolitan area i of period t, $V_{i,\cdot}$ is the vector of agricultural variables (alternative measures and time structures may apply), $Z_{i,t-1}$ represents all other determinants discussed in Section 4.5, such as measures of human capital and amenities, ν_i is the fixed effect, and $\varepsilon_{i,t}$ is the error. The lag of $Z_{i,t}$ suggests that the contemporaneous population level is determined by the past local productivity and amenities.

With the high frequency annual data, several reasons imply a dynamic model should be considered. First, unlike the analysis in in Chapter 3 where no adjustment cost is assumeed, the adjustment of capital or labor may be costly exist in high frequency observations. Therefore the contemporaneous level of population depends on the level of the previous period. Second, shocks for local markets may be persistent so that the population level is serial correlated. Third, as noted by Glaeser and Gyourko [2006], because housing prices and housing units are both serially correlated in the short run, population may also be serially correlated. These factors suggest a dynamic model

$$\ln N_{i,t} = \alpha_0 + \alpha_1 \ln N_{i,t-1} + \beta_1 R_{i,.} + \beta_2 C_{i,.} + \beta_3 G_{i,.} + \gamma Z_{i,t-1} + \nu_i + \varepsilon_{i,t} \tag{5.2}$$

where N is the population, R is the revenue, C is the cost, G is the government payment, and Z represents all other controls. We expect a negative sign for the revenue R and government payment, and a positive sign for the cost C. As mentioned earlier, various forms and time structures of R, C, and G will be examined in regressions.

Population Growth Rate

If the agricultural variables created do affect population levels, it is reasonable to argue that they should also affect population growth rate. However, the sizes of the impacts may differ. Taking the lagged revenue for an example

$$\frac{\partial \Delta \ln N_t}{\partial R_{t-1}} = \frac{\partial \ln N_t}{\partial R_{t-1}} - \frac{\partial \ln N_{t-1}}{\partial R_{t-1}}$$

Therefore the impact of R_{t-1} on the population growth rate depends on how R_{t-1} affects both N_t and N_{t-1}. If $\frac{\partial \ln N_{t-1}}{\partial R_{t-1}} = 0$, then the impact of R on population growth rate should be equal to that on levels.

The empirical model for population growth rate is then specified as

$$\begin{aligned} \Delta \ln N_{i,t} =& \theta_0 + \theta_1 \Delta \ln N_{i,t-1} + \theta_2 \ln N_{i,t-1} + \phi_1 R_{i,.} + \phi_2 C_{i,.} + \phi_3 G_{i,.} \\ & + \pi Z_{i,t-1} + \nu_i + \varepsilon_{i,t} \end{aligned} \tag{5.3}$$

The lagged growth rate, $\Delta \ln N_{i,t-1}$, is included because shocks to labor market may be persistent. $\ln N_{i,t-1}$ is also included as a natural control. $Z_{i,t-1}$ is the same as in (5.2).[7] As have mentioned, agricultural variables will be included with various forms and time structures.

[7] According to equation 3.4, we should include changes in amenities and productivities when examining the population growth rate. Following Glaeser and Shapire [2003] and Glaeser and Tobio [2008], we can assume that $Z_{i,t-1}$ also determines the increase in amenities and productivities and estimate a reduced-form equation. So π does not equal γ.

5.4 Estimation Technique

In this dynamic panel setup, the fixed-effect estimator is biased and inconsistent because of the dynamic panel bias arises (Nickell [1981]). To see this, consider first differencing Equation 5.2 (other regressors are omitted here to focus on the dynamic bias)

$$\ln N_{i,t} - \ln N_{i,t-1} = \alpha_1(\ln N_{i,t-1} - \ln N_{i,t-2}) + (\epsilon_{i,t} - \varepsilon_{i,t-1})$$

Although the fixed effect ν_t has been differenced out, $(\ln N_{i,t-1} - \ln N_{i,t-1})$ is now correlated with $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$ because $\ln N_{i,t-1}$ is correlated with $\ln varepsilon_{i,t-1}$. When α_1 is positive, $(N_{i,t-1} - N_{i,t-2})$ and $(\nu_t - \nu_{t-1})$ will be negatively correlated, so the impact of $N_{i,t-1}$ will be underestimated in a degree of $1/T$. Moreover, when the estimation α is biased, so will be the estimation of β's if our agricultural variables are correlated with population, which is what we want to show.

The Arellano–Bond estimator is chosen to deal with the dynamic panel bias, i.e., using $N_{i,t-2}$ to instrument for ΔN_{t-1}. There are two methods dealing with dynamic panel bias: the Arellano–Bond estimator and Arellano–Bover/Blundell-Bond estimator. Although the latter is more efficient, it requires the fixed effect to be uncorrelated with regressors (Roodman [2006]). In this study, two factors may lead to violations of this condition: first, as found by Burchfield et al. [2006], access to water supply affects urban sprawl; second, as Saiz [2010] points out, flat land is an important in determining housing supply. Both factors also favor farming by either increasing the yield or lowering the cost. Therefore, the Arellano–Bover/Blundell-Bond estimator is out of consideration.

Chapter 6 Empirical Results

Section 6.1 reports preliminary results using the entire sample. As our agricultural variables fail to measure the opportunity cost of land in areas with little agricultural land, these results should be analyzed and tested further. Section 6.2 reports and analyses empirical results for the period of 1978 to 1990. This period was featured by a long and drastic price drop starting from the late 1970s, and the correlation between agricultural variables and growth was strong enough to provide important lessons to examine the impact of agricultural prices on urban growth. Section 6.3 presents the results for 1990s, which was featured by a price spike in 1994-1996. Results for this period are not as significant as the first period. As I restricted observations to MSAs with more agricultural land, however, some significant results were obtained. Results show that the growth was indeed affected by agricultural prices even in a short term change of two years. Guided by the findings in previous two sections, in Section 6.4, data from 1978-1990 and 1990-2000 were pooled together to estimate the impacts of agricultural variables. By using the estimation results, Section 6.5 simulates the impact of a series of hypothesized corn price shock.

6.1 Preliminary Results: Entire Sample

Table 6.1 reports the estimation results using the entire sample for both Equation (5.2) and (5.3). Year dummies are also included to capture possible correlation across idiosyncratic errors.[1] Several states did not join NASS's survey on cattle in every year, including California (missing from 1993 to 2000), Colorada (from 1987 to 2000), Florida (from 1978 to 1989), Idaho (from 1978 to 1988), Iowa (from 1991 to 2000), Oregon (from 1978 to 1980), Texas (from 1988 to 1992), Utah (from 1978 to 1982), and Washington (from 1978 to 1985). Keeping observations of these states in these periods without cattle data will create unreasonable jumps at both ends of these periods, therefore observations for these periods were

[1] Year dummies were also added in all following regressions.

dropped.[2] The final panel is therefore unbalanced, with 267 MSAs of an average of 20.90 years of observations. Fortunately, the Arellano-Bond can handle unbalanced panel. As discussed in Chapter 4, 3-year moving averages of agricultural variables fit the farm land value better than single-year measures, this section starts with 3-year moving averages for regressions. Results with single-year measures are left for subsequent sections. As discussed in Chapter 5, we expect weighted averages of agricultural variables to be superior to simple averages in the sense of reducing endogeneity, therefore this section only reports results with weighted averages. Results with simple averages are left for subsequent sections.

Table 6.1: Emtire Sample Estimation: The Impact of Agricultural Variables on Population and Population Growth

Variables	Population Level	Population Growth
$\log(\text{Revenue})_{t-1}$	-0.0100***	-0.0060*
$\log(\text{Cost})_{t-1}$	0.0080***	0.0040*
$\log(\text{Gov't payment})_{t-1}$	-0.0008***	-0.0008***
$\log(\text{population})_{t-1}$	0.9470***	-0.0320***
$\Delta\log(\text{population})_{t-1}$		0.2950***
College_{t-1}	0.1899***	0.1631***
Black_{t-1}	0.1036***	0.0908*
Elder_{t-1}	0.2025***	0.1866***
Poverty rate_{t-1}	-0.1230***	-0.0583
Manufacture_{t-1}	-0.0038	-0.0062
Immigrants_{t-1}	0.3269***	0.2651***
$\text{Unemployment}_{t-1}$	-0.1212***	-0.0767***
Popu density_{t-1}	-0.0383***	-0.0437***
†Low inc families_{t-1}	-0.1949***	-0.1471***
††High inc families_{t-1}	-0.1652***	-0.1269***
N	267	267
Avg T	20.90	19.90

SignificanceLevel: *0.05; **0.01; ***0.001

† Share of family below national 20 percentile income.

†† Share of family above national 80 percentile income.

Agricultural variables are county weighted averages.

As Table 6.1 shows, as the 3-year moving average of agricultural revenue doubles, urban

[2] Because data on cotton for Texas are also missing before 1988, there is little hope to consistently measure the agricultural variables for counties in Texas, therefore MSAs in Texas were not included in the analysis in this chapter.

population will be 1% lower, and the population growth rate will be 0.6% percent point lower; as the 3-year moving average of agricultural cost doubles, the population will be 0.8% higher, and the growth rate will be 0.4% higher; as the 3-year moving average of agricultural subsidy doubles, the population will be 0.08% lower, and the growth rate will be 0.08% percent point lower. All impacts are significant with expected signs. However, several reasons suggest that these results may be inconsistent. First, a certain proportion of these MSAs do not have much agricultural land. As our agricultural variables only measure the value of agricultural land, it is likely that these variables are subject to unobserved impact of other factors. Second, these results do not pass the panel cointegration test, which suggests spurious correlation may exist. Third, the series of population growth rate do not pass panel unit root tests when observations of 2000 is included, suggesting decennial years should be treated. These issues will be treated in subsequent sections.

6.2 Results for 1978-1990

6.2.1 Population Levels: 1978 - 1990

Results

The model estimated is as specified by Equation 5.2 with the level of population as the dependent variable. Table 6.2 reports the baseline results. The first column of Table 6.2 reports the baseline result, where all observations were used.[3] The agricultural variables were 3–year moving averages weighted by the base land area share. Coefficients of these three agricultural variables are all significant at 0.1% level with correct signs. However, as declining MSAs were excluded (column (2)), coefficients for revenues and costs become insignificant. The decrease in significance is actually as expected. In a period of price drops, say 1980s, we would expect urban areas to grow. Adding declining areas into our sample then will dampen the results.[4] This result suggests including declining MSAs may cause problems. More results regarding declining MSAs will be discussed with other results.

[3] See Table 4.31 for the list of these MSAs, and Table 4.30 for summary statistics.

[4] Including declining MSAs does not necessarily always dampen the results. In periods where commodity prices increase, including them may increase significance artificially.

Table 6.2: The Impact of Agricultural Variables on Population: 1978-1990

Varible	All Obs	Declining MSAs Excluded	Southern Seaboard Excluded	Base Land Share> 20%		Base Land Share> 30%	
				1978-1990	1978-1989	1978-1990	1978-1989
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log(Revenue)$_{t-1}$	-0.0070**	-0.0038	-0.0081*	-0.0122***	-0.0130***	-0.0214***	-0.0236***
log(Cost)$_{t-1}$	0.0071**	0.0045	0.0079*	0.0093**	0.0089**	0.0180***	0.0196***
log(Gov't Payment)$_{t-1}$	-0.0009**	-0.0012**	-0.0005	-0.0007	-0.0006	-0.0011*	-0.0014**
log(population)$_{t-1}$	0.9720***	0.9664***	0.9721***	0.9893***	0.9521***	0.9980***	0.9642***
College$_{t-1}$	0.1454***	0.1623***	0.0960	0.1566**	0.2583***	0.1637**	0.3050***
Black$_{t-1}$	0.4008***	0.4751***	0.6398***	0.2667***	0.1771*	0.2107*	0.0797
Elder$_{t-1}$	0.3633***	0.3013***	0.2040**	0.2452*	0.2558*	0.1144	0.1516
Poverty rate$_{t-1}$	0.3812***	0.2648***	0.1711**	0.2783***	0.2514***	0.2267**	0.2078**
Manufacture$_{t-1}$	-0.0708***	-0.0776***	-0.0921***	-0.1237***	-0.1086***	-0.1377***	-0.1154***
Immigrants$_{t-1}$	0.4482***	0.5092***	0.5239***	0.4132***	0.3968***	0.3122***	0.2910***
Popu density$_{t-1}$	-0.0280***	-0.0371***	-0.0430***	-0.0308**	-0.0448***	-0.0293*	-0.0571***
†Low income families$_{t-1}$	-0.8581***	-0.7787***	-0.7281***	-0.7369***	-0.7543***	-0.6640***	-0.6626***
††High income families$_{t-1}$	-0.3215***	-0.3255***	-0.3211***	-0.3227***	-0.2973***	-0.2451***	-0.2046***
N	232	178	142	130	129	99	98
Avg T	9.841	9.826	9.528	10.223	9.357	10.232	9.398

Significance Level: * 0.05 ** 0.01 *** 0.001

Agricultural variables are weighted moving averages.

† Below national 20 percentile

†† Above national 80 percentile

A closer look at the sample shows that the insignificant results in (2) were caused by the presence of the Southern Seaboard. Column (3) reports the results using the same sample as (2) but without the Southern Seaboard. Significant results were regained when excluding this region. However, this result does not necessarily suggest that the opportunity costs of land do not affect urban growth in this region. Note the average base land area of this region is the lowest among all regions with the base land share of over 90 percent of MSAs in this region below 30 percent. It is more likely that because base lands are rather limited in this region so that our agricultural variables poorly measure the opportunity cost in that region.

Column (4) and (6) restricted observations to base land share greater than 20% and 30% respectively. As can be seen, the significance of these results increases monotonically with the base land share threshold. These results suggest that the insignificant results in column (5) is not caused by the inclusion of the Southern Seaboard, but rather the inclusion of MSAs with less agricultural lands surrounding them.

Column (5) and (7) report results without 1990. The results for agricultural variables are similar qualitatively but more significant, especially for the subsample with base land share greater than 30%. It seems that Census's adjustment of population estimation does cause some problems to our estimations.

Most of the coefficients of other independent variables are as expected except for that of the poverty rate. The positive sign for poverty is due to the inclusion of the percentage of low income families. When low income families were dropped, the coefficient of poverty rate is negative and significant. This is because when the share of low income families is held constant, increasing poverty rate means bigger family sizes of the poor which leads to larger populations.

Table 6.3: The Impact of Agricultural Variables on Population Level with Different Measures: 1978-1990

	Base Land Share > 20%			Base Land Share > 30%		
	Weighted average(log)	Simple average(log)	Dollar	Weighted average(log)	Simple average(log)	Dollar
	(1)	(2)	(3)	(4)	(5)	(6)
Revenue$_{t-1}$	-0.0122***	-0.0196***	-0.00004***	-0.0214***	-0.0284***	-0.00006***
Cost$_{t-1}$	0.0093**	0.0202***	0.00005***	0.018***	0.0283***	0.00008***
Gov't payments$_{t-1}$	-0.0007	-0.0009	-0.00002*	-0.0011*	-0.0012**	-0.00002***
log(population)$_{t-1}$	0.9893***	1.0051***	0.9970***	0.9980***	0.9646***	1.0040***
College$_t - 1$	0.1566**	0.0707	0.1051*	0.1637**	0.2389***	0.0924
Black$_{t-1}$	0.2667***	0.1823*	0.2281**	0.2107*	-.01843	0.2022*
Elder$_{t-1}$	0.2452*	-0.0341	0.2081*	0.1144	-0.1764	0.0314
Poverty rate$_{t-1}$	0.2783***	0.1422*	0.2792***	0.2267**	0.1321	0.1913**
Manufacture$_{t-1}$	-0.1237***	-0.1343***	-0.0994***	-0.1377***	-0.1600***	-0.1058***
Immigrants$_{t-1}$	0.4132***	0.2975***	0.3644***	0.3122***	0.1633***	0.2586***
Popu density$_{t-1}$	-0.0308**	-0.0451***	-0.0264*	-0.0293*	-0.07946***	-0.0212
†Low income families$_{t-1}$	-0.7369***	-0.5912***	-0.6739***	-0.6640***	-0.6123***	-0.5678***
††High income families$_{t-1}$	-0.3227***	-0.2340***	-0.2138***	-0.2451***	-0.1044*	-0.1042
N	130	130	130	99	98	99
Avg T	10.223	8.362	10.223	10.232	7.500	10.232

Significance Level: * 0.05 ** 0.01 *** 0.001

† Below national 20 percentile

†† Above national 80 percentile

The size of the impact of revenue is impressive: doubling the revenue lead to a 2.36% decrease in population. However, note that holding cost and government consistent, doubling revenue will lead to the rent more than doubled. Fore example, the mean revenue is 225 and the mean cost is 158, doubling the revenue leads to a 336% increase in the agricultural rent. When factoring by the discount rate, say 4%, the value of the land will be 80 times higher. Of course, this requires the increase of the revenue to be permanent. But the point is the change in land value led by changes in the agricultural variable may be enormous, which helps to explain the sizable impact of the revenue.

As the results show, the coefficient of the revenue is always greater than that of the cost. Recall the analysis in 5.1, the ratio of the two coefficients should equal the ratio of the sample means. Because the mean revenue is greater than the mean cost, we do expect the impact of log revenue is stronger. The impact of log government payments is one seventeenth that of the revenue, which is also as expected because the mean government payments is $16, or about one sixteenth of the mean revenue.

Table 6.3 reports the results with different measures, say, simple averages of revenues and costs, and dollar measures of revenues and costs. Two subsamples withbase land share greater than 20% and 30% respectively were used. Similar to previous results, the signifances of agricultural variables increase monotonically with the base land share. In these results, the coefficient for costs are higher in sizes, which is out of expectation. As for the dollar measures, we reject the null that the coefficient for costs is equal to that of revenues at 5% level, but not at 1%.

Robustness

Because the analysis is national based, it might be possible that these results are subject to the presence of influential regions. Moreover, as shown in Chapter 1, the difference between growth pattern in the first half of 1980s was mainly the difference between the North and other regions. Considering the growth pattern of the North has long been different from that of the West and the South, one could argue that the correlation between population is actually due the unobserved difference between the North and other regions, but not the difference in agricultural variables. To address such a possibility, regressions were run for the North (Heartland, Northern Crescent, and Northern Great Plains) and all other regions (basically the South and the West) separately. The results show that even within the North, the impacts of our agricultural variables are still significant and as expected. These results are presented in Table 6.4.

Table 6.4: The Impact of Agricultural Variables by Regions: 1978-90

		Other Regions (West and South)		
Variable	North	Other Regions	Southern Seaboard Excluded	Base Land >20%
$\log(\text{Revenue})_{t-1}$	-0.0109**	-0.0056	-0.0218***	-0.0233***
$\log(\text{Cost})_{t-1}$	0.0105**	0.0061	0.0152**	0.0152***
$\log(\text{Gov't payments})_{t-1}$	-0.0009	-0.0020***	-0.0018*	0.0000
N	67	101	65	63
Avg T	10	10	9	11

Significance Level: * 0.05 ** 0.01 *** 0.001

Note: Agricultural Variables are MSA weighted averages.

To deal with potential influential years, I cut the panel at 1986, where the price fall came to an end. The initial results with all observations are restricted, but as I restricted to observations with base land share greater 40% (30% for 1979 to 1986), significant results were obtained. The significance of the results do not change in different periods. Table 6.17 shows the results.

Different Time Structures

Table 6.5 examines the impact of agricultural variables with different time structures. The moving averages were not used in this set of regression because they are a combination of three single–year measures by definitions, and it is impossible to identify the impact of one particular structure. For this set of regression, as an alternative,, single year measures were used while lagged measures were controlled. For example, to examine the impact of contemporaneous agricultural variables, the following model is used

$$\ln N_t = \beta_0 + \beta_1 \ln V_t + \beta_2 \ln V_{t-1} + \beta_3 \ln V_{t-2} + \epsilon_{it}$$

where V_t represents the agricultural variables in single year measures.

As the results show, only the first order lags, both the lagged level and the lagged changes, has an impact with correct sign. This result may suggest farms and landowners look backward to determine the current land use. More importantly, the results show that populations do respond to short term shocks. The fact that future prices do not have any impact does not necessarily suggest farmers do not look forward. If agricultural prices follow a unit-root process, which is true, this fact is also consistent with rational expectation hypothesis.

Table 6.5: Time Structures of Agricultural Variables on Population: 1978-1990

Variable	Lagged	Contempo.	Future
log(Revenue)	-0.0118***	0.0051	0.0004
log(Cost)	0.0119**	0.0008	0.0017
log(Gov't payments)	-0.0001	0.0000	0.0000
Δlog(Revenue)	-0.0099***	0.0054	0.0004
Δlog(Cost)	0.0113**	-0.0031	0.0017
Δlog(Gov't payments)	-0.0003	-0.0004	0.0000

Significance Level: * 0.05 ** 0.01 *** 0.001

Note: Agricultural variables are single year measures.

Cointegration Test

As discussed in Section 5.2, in areas where base land share is low, spurious correlation may emerge. Therefore, to test cointegration, I used the sample with base land share greater than 30%. The panel unit root tests show that the population level, agricultural revenues, and costs are first-order integrated, while government payments are not. So a panel cointegration test is conducted for population, revenue, and cost. The results show that the series is cointegrated.

6.2.2 Population Growth Rate: 1978-1990

To examine the impact of agricultural variables on population growth rate, a similar set of regressions was run to estimate the model specified by Equation 5.3 for the period of 1978-1990. According to Equation 5.3, the lagged population growth rate is controlled to capture persistent labor shocks, and the lagged population level is controlled to address the different growth pattern of MSAs of different sizes. Most of the results are similar to those in the last sub section.

Results

Table 6.18 reports the base results. The regression of column (1) used all MSAs from 1978 to 1990. While no significant results were found, dropping the Southern Seaboard regained significance. Column (2) reports the result without the Southern Seaboard. When excluding observations in 1990, the sizes of the coefficients of our agricultural variables have increased, and the government payments have become significant, suggesting the population data adjusted by census is more problematic for estimation of population changes rather than levels. The regression in column (4) excluded declining MSAs, which dampens our estimation. Again, when I restricted observations to more agricultural area, both the size of. The regression in column (5) used the simple averages instead of weighted averages, which made the result insignificant. The regression in column (6) used dollar values for our agricultural variables, where the sign of the government payment switched, which may be caused by outliers.

Again, the influence of the Southern Seaboard is more likely a measurement problem because the base land share is the lowest in this region. In Table 6.6, I kept MSAs with their base land share greater than 20% and 30% respectively, and also keep MSAs in the Southern Seaboard. The results are significant again. As Table 6.6 shows, the coefficients of the coefficients increase in sizes monotonically with the threshold of base land share.

Table 6.6: The Impact of Agricultural Variables on Population Growth: 1978-1990

Variables	Base land share> 20%	Base land share> 30%
$\log(\text{Revenue})_{t-1}$	-0.0137***	-0.0235***
$\log(\text{Cost})_{t-1}$	0.0096**	0.0187***
$\log(\text{Gov't payments})_{t-1}$	-0.0006	-0.0014**

Significance Level:* 0.05; ** 0.01; *** 0.001

Robustness

Similar to last subsection, I also checked for influential regions. Results are reported in Table 6.7. These results confirm that the directions of the impacts of agricultural variables on population growth are not region sensitive. That is, we still have significance with correct signs for revenue, cost, and government payments in both the North (Heartland, Northern Crescent, and Great Northern Plains) and all other regions (the South and the West). In estimations with all other regions (column (3) and (4)), population growth rate is lower in MSAs with higher land value. Moreover, when excluding the Southern Seaboard, the effects are also significant, except for the government payment, for other regions. Although the sample sizes may seem too small for these region based regressions, but the purposes of these regressions is not to get an consistent estimation but to examine whether we can trust comparisons across regions.

Table 6.7: The Impact of Agricultural Variables on Growth by Regions:1978-1990

			All Other Regions	
				Southern Seaboard
	All Obs	North	All Other	Excluded
Variables	(1)	(2)	(3)	(4)
$\log(\text{Revenue})_{t-1}$	-0.0041	-0.0212***	0.0014	-0.0143*
$\log(\text{Cost})_{t-1}$	0.0030	0.0136***	0.0018	0.0143**
$\log(\text{Gov't Payment})_{t-1}$	-0.0012**	-0.0008	-0.0007	-0.0014
N	157	66	87	51

Significance Level: * 0.05; ** 0.01; *** 0.001

I also examine the impacts of agricultural variables for shorter periods. Table 6.8 reports these results. Originally no significant results were found. But when I restricted observations with based land share greater than 30%, significant results (at 0.1%) for 1979-86 were obtained. As for the period of 1986 to 1989, no significant results were found until the restriction of observations was raised up to 40%, but only the revenue shows the significant result at 5% level. However, when I included 1990, the significant result disappear. One explanation for these results may be the agricultural commodity market finally came to a rest after 1986, where there was no enough variations in prices for us to observe their impacts.

Finally, I examined the impact of the changes in agricultural variables on population growth rate, but no significant results were found.

Table 6.8: Influential Years between 1978 and 1990 for Population Growth

	1986-90		1986-89		1978-1986	
		Base land		Base land		Base land
Variables	All Obs	>30%	All Obs	>40%	All Obs	>30%
$\log(\text{Revenue})_{t-1}$	-0.016	-0.0048	-0.0185*	-0.0045	-0.0215***	-0.0052
$\log(\text{Cost})_{t-1}$	0.0048	-0.004	0.0116	-0.0038	0.0167***	0.0039
$\log(\text{Gov't Pymt})_{t-1}$	0.0001	0.0028*	0.0006	0.0005	-0.0019**	-0.0007

Significance Level: * 0.05; ** 0.01; *** 0.001

6.3 Results for 1990-2000

6.3.1 A Glance at the Population Growth during the Price Spike

Before proceeding to regression results, some phenomena may help understand the impact of price spike in this period. Starting from 1994, the prices for crops experienced a rapid escalation driven by economic growth in newly industrialized Asian countries and the depreciation of the U.S. dollar. The corn and wheat prices peaked in 1995, while the soybean price peaked in 1996. Figure 6.1 illustrates these price changes. The stock to use ratio of these crops also hit a historic low in this period (Peters et al. [2009]). Because the feed grains was an important input in milk production, the milk price also rised in 1995 (Figure 6.2). However, by resorting to grazing lands, the beef production had avoided such an increase in cost, and the beef price actually dropped during the same period (Figure 6.3).

To observe the impact of the price spike, I focused on the sample agricultural MSAs, i.e., MSAs with base land share greater than 30%. Then I divided these MSAs into the "Beef Area" and the "Crop Area" according to their historical beef production and crop production.[5] Figure 6.4 compares the growth patterns of these two groups. First note the population growth rate of the "Crop Area" was always lower than both the "Beef Area" and

[5]The "beef" group contains MSAs with beef production above the sample median. The similar criterion applies to crops area.

Figure 6.1: Price Indices of Corn, Wheat, and Soy (1993=100)

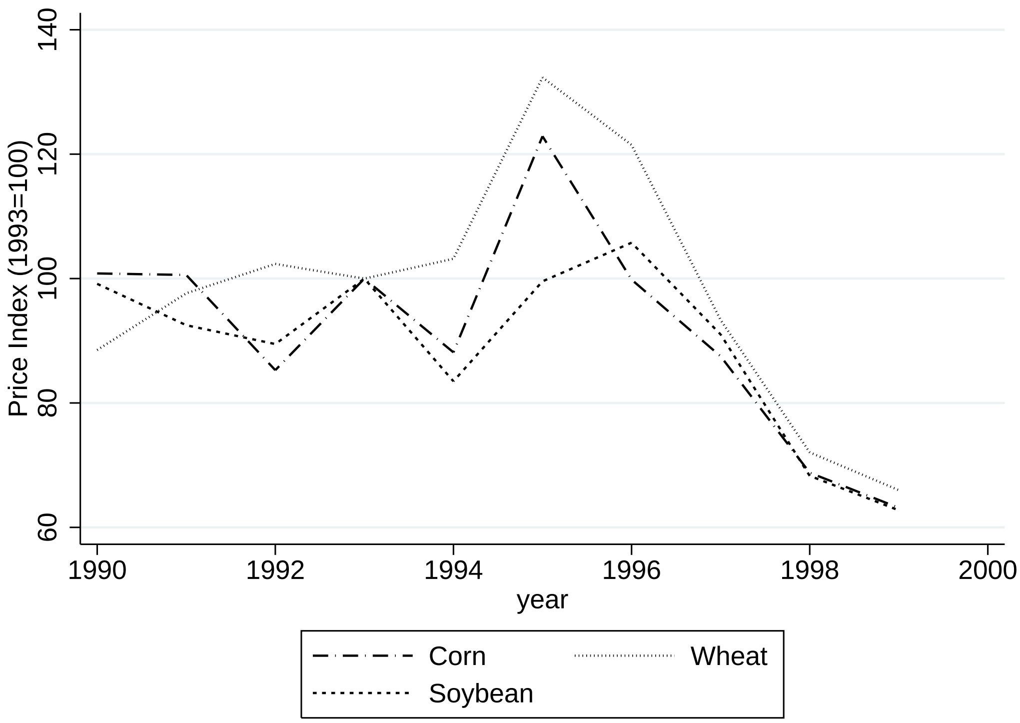


Figure 6.2: Price Indice of Corn and Milk (1993=100)

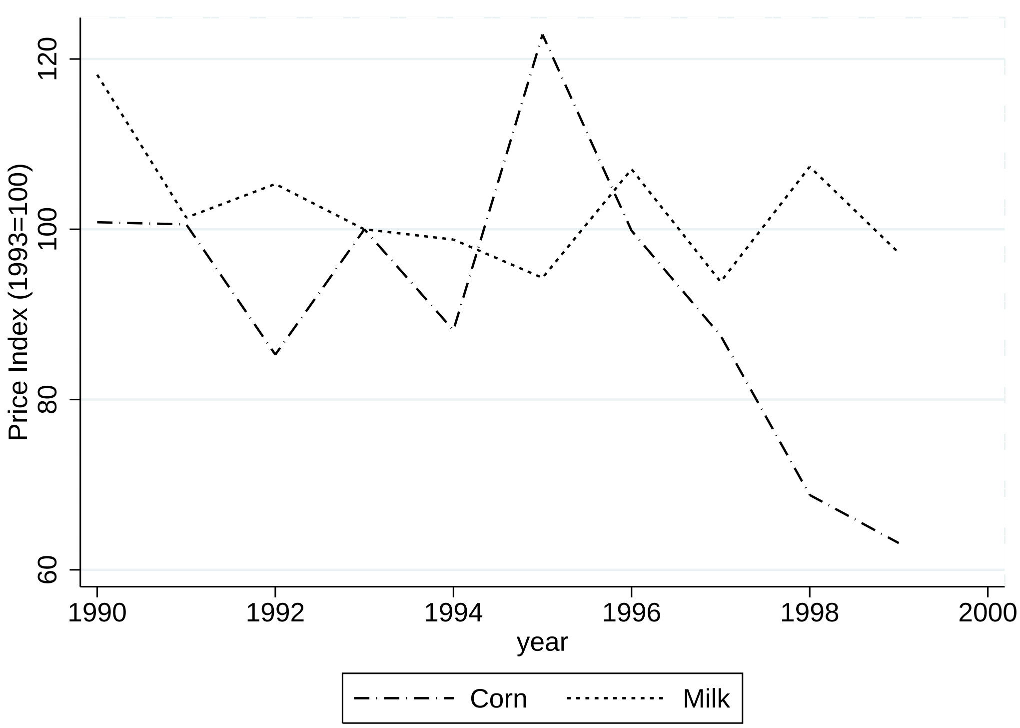


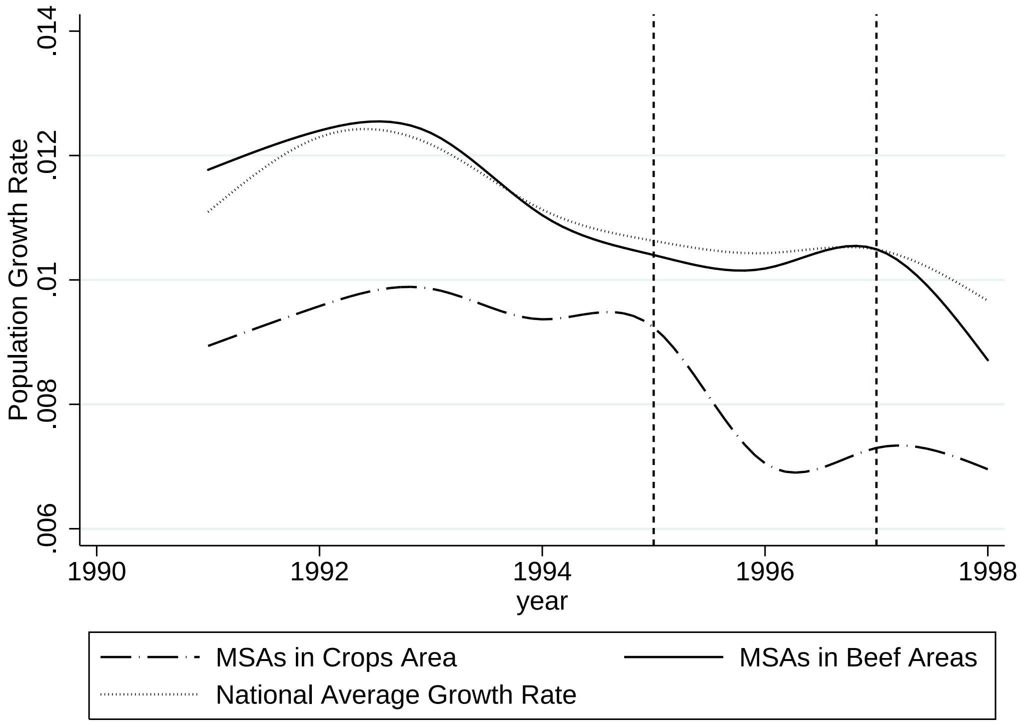
Figure 6.3: Price Indice of Corn and Beef (1993=100)

the national average. This is because the "Crop Area" is basically in the North, while a large portion of the "Beef Area" is either in the South or in the West. Starting from 1995, the average population growth rate of the crop area started to decrease, while similar changes did not happen in the beef area or nationwide. The decrease in population growth rate was relatively sizable, from 0.9% to 0.7%, a decrease of 20% relative to the average growth rate of the crop area. No explanation has been given to this growth rate change during this period previously, and the changes in the opportunity cost is definitely a appealing one.

6.3.2 Population Levels: 1990-2000

Unlike the period of 1978 to 1990, results for 1990 to 2000 are rather limited. One reason may be that variations in prices were limited in most years in this period. Moreover, although there was a price spike during the mid 1990s, there were also considerable amount of idle lands accumulated during the depressed decade prior it, which were brought back to use quickly in response to the price spike (Peters et al. [2009]). Put it another way,

Figure 6.4: Population Growth Rate - MSAs Major in Grains Vs. MSAs Major in Beef



land supply was not tight during this period. However, when focusing on this short period of spike, some significant results were still found by restricting observations to MSAs with large amount of agricultural land.

In the first set of regressions for this period with all observations, no significant results were found. Therefore I restricted my observations to MSAs with base land share greater than 30%. The subsample contains 95 MSAs. Table 6.19 reports the regional composition of these MSAs, Table 6.20 reports sample statistics of these MSAs. The mean population is 503,875, and the mean population growth rate is 0.9%. As mentioned earlier, restricting samples with base land share greater than 30% gives a bias toward the North: MSAs in Heartland and Northern Crescent together accounts for 63% of this subsample. Because of this restriction, it is not feasible to study specific regions (it is mainly the North after all). Therefore for the robustness check, I only cut this period in 1996, which is the turning point of the price spike.

Column (1) of Table 6.21 reports the results for the sample of 95 MSAs from 1990 to

2000. It can be seen that only the revenue is significant at 5%. However, when 2000 was excluded, both revenue and cost are significant with correct signs. The reason may be the miscounting of census's annual population estimation.

Column (3) reports the result without declining MSAs, which is improved compared with the result in column (1). However, when comparing column (4) where both 2000 and declining MSAs were dropped, no difference were found. This suggests that the miss counting problem is more serious in growing areas, but nothing can be say how declining MSAs affect our estimation at this point.[6]

Column (5) and (6) report results with simple averages of agricultural variables. The impact of revenue is smaller when measured by simple averages, while the impact of cost is greater. The most likely reason is that, as discussed in Section 5.1, the population growth is correlated with unobserved crops so that estimations with simple averages are not consistent. It may also be because of the introduction of Farm Resource Region in 1996 according to which ERS estimate the regional cost of each products.

Table (7) and (8) report results with dollar measures. When including 2000 (column (7)), both the impacts of revenue and government are not significant, while that of the cost is significantly negative. However, when 2000 was dropped, the impact of revenue is significantly negative.

In all these estimations, results with 2000 are generally worse than those without 2000. The most likely reason is the adjustment of census population data. When 2000 was included, even the first order difference of the population (population growth rate) did not pass the panel unit root tests. However, when 2000 was excluded, the growth rate series become stationary.

The AR(2) testing results show that when including declining MSAs, the estimation errors are serial correlated. But it is not the case when declining MSAs were dropped. This confirms the finding of Glaeser and Gyourko [2005] that population decreases in a persistent way in declining areas.

[6]Many of the coefficients of controls also changes significantly for regressions with and without declining MSAs, say, the share of high and low income families, the share of population with Bachelor degree or higher, and the share of elder.

Because the price of agricultural products spike peaked in 1996, I cut the panel at 1996 and 1997 to observe the impact of the spike.[7] Results are presented in Table 6.9. For the period after 1996, I also examining the impact of 2000 by running regressions with and without it. Because the government payment is not significant in any of this set of regressions, I also examine the results without government payment, hoping more significant results will be obtained because the collinearity between government payments and revenues and costs.[8] For the period of 1990-1996, the revenue is significant at 1% level.[9] It is worth to mention that the size of the coefficient is close to that of 1978-1990 results with a similar sample, i.e. restricting observations to MSAs with base land share greater than 30%. The significant results disappear when the ending year was pushed back to 1995. This result confirms the impact of the price spike from 1994 to 1996.

Table 6.9: Influential Years for Population: 1990-2000

	1990-1996		1996-2000	1996-1999	
	All Var.	No Gov.		All Var.	No Gov.
$\log(\text{Revenue})_{t-1}$	-0.0239***	-0.0261***	-0.0026	-0.0088**	-0.0085**
$\log(\text{Cost})_{t-1}$	0.0132	0.0144*	0.0003	0.0057	0.0056
$\log(\text{Gov't Pymt})_{t-1}$	-0.0013		0.0019*	0.0003	
N	89	89	89	89	89
T	5	5	5	4	4

Significance Level:*0.10;**0.05;***0.01

Table 6.10 summarizes results for single year measures, which answer the question whether the population respond to instantaneous differentials in revenues, costs, and government payments. In these regressions, lagged agricultural variables were also controlled for. As can be seen, the lagged and contemporaneous single year revenues are both significant with the same size, while the costs are not.

[7] I also cut the data at 1997 to examine whether the introduction of the new definition of agricultural regions, based on which the ERS cost estimates were conducted, will change the results. Only the 1996 cut is reported because there will be only 3 years of observation for 1997-1999 period. But similar results were obtained for periods of 1990 to 1996 and 1997.

[8] The degree of correlation was not high though. When I regressed the government payment with revenue and cost, the squared R is only 18%, almost half of that in 1978-2000.

[9] It is also significant at 0.1%, but because the sample size is small for this period, I raised the significance level to 10%, 5%, and 1%.

Table 6.10: Time Structures of Agricultural Variables on Population: 1990-2000

	Lagged	Contempo	Forward
log(Revenue)	-0.0053**	-0.0018	0.0014
log(Cost)	0.0048	-0.0057	-0.0010
log(Gov't payments)	0.0001	0.0001	-0.0001

Significance Level: * 0.10; ** 0.05; *** 0.01

Table 6.22 examines the impact of price changes on population levels. However, no significant results were found.

6.3.3 Population Growth

Results for population changes for all observations in all years are reported in Table 6.23. Again, 2000 turns out to be influential in estimation. As mentioned earlier, the panel unit root test shows that the panel contains unitroot in population **growth rate**, which is unreasonable because the growth rate is believed to be stationary at least for growing MSAs. Moreover, while 2000 was dropped, the testing results show that panels are stationary. When 2000 is excluded, the estimation results are as expected again. Estimation results with simple averages of agricultural variables are more significant this time. But as discussed earlier, they may be inconsistent due to the correlation between the measurement error with the population growth.

Results for population changes before and after 1996 are reported in Table 6.11. As can be seen, the estimated impact of agricultural variables are stronger for the period of 1990 to 1996 than 1996 to 1999. The contrast is mainly due to the price spike. For example, the stronger result does not change when the ending year of the first period was extended to 1997, but drops significantly when the ending year was pushed back to 1995.

Table 6.24 reports the impact of agricultural variables with different time structures. Two periods of deeper lags for each agricultural variables are also controlled in these regressions. Only the lagged revenue was found having significant impact with the correct sign. The forward revenues and costs have counter-intuitive signs, but they did not pass the Granger causality test.

Table 6.25 reports the results for agricultural variable changes on population growth

Table 6.11: Influential Years for Population Growth: 1990-2000

Variables	1990-1996		1996-2000	1996-1999	
$\log(\text{Revenue})_{t-1}$	-0.0143*	-0.0229***	-0.0030	-0.0083*	-0.0079*
$\log(\text{Cost})_{t-1}$	0.0073	0.0116	-0.0017	0.0036	0.0033
$\log(\text{Gov't payments})_{t-1}$	-0.0050*		0.0017	0.0003	
N	89	89	89	89	89
T	5	5	5	4	4

SignificanceLevel:*0.10;**0.05;***0.01

rate. No significant results were found. This may due to the price changes in 1990 were to limited. Again, the counter-intuitive signs for the forward costs and revenues do not pass the Granger causality test.

6.4 Final Estimation

6.4.1 Results

Analyses of previous sections have provided several implications for estimating the impact of the agricultural variables. First, only observations with fair amount of agricultural lands should be included. Previous results have shown that spurious correlation may arise in metropolitan areas with restricted agricultural land. This is understandable because the agricultural land value is a poor measure for the opportunity cost of land in those metropolitan areas. Therefore, I chose MSAs with base land share greater than 30% as my sample to estimate the impact of agricultural variables. While there is no rationale stating a reasonable criteria for the sampling, I found that 30% is a good choice. In a set of unreported estimations, the estimation results had become stable when base land share was raised to 30% and above. The sample size is also acceptable with 119 MSAs/PMSAs. As stated previously, the panel is unbalanced with the average time span of 18.25. Table 6.26 reports summary statistics of the sample. Table 4.32 in Appendix lists these MSAs together with their mean revenues, costs, and government payments.

Second, decennial years have influential impacts. The estimation results, especially those for growth rate, are sensitive to decennial years. This issue is especially serious for 2000 where even the series of the population growth rate with 2000 is not stationary.

Therefore, I both present the results with and without decennial years.

Third, results in previous section have shown that the contemporaneous change in agricultural variables do not have significant impact on growth, therefore I first chose to use the lagged 3-year moving averages in the regression. The lagged terms of agricultural variables also help to overcome the endogeneity issue as discussed in Chapter 4. While using the 3–year moving averages puts a structural constraint on the agricultural variables of different time structures, i.e., agricultural variables of each year having the same impact on growth, I relaxed the constraint by including agricultural variables of different years (up to 3 year lag) separately in the estimation.

Finally, as have been shown in Chapter 5 and previous sections, county weighted averages of agricultural variables behave better in estimations than simple averages, e.g., the results are more stable with weighted averages, and the relationship between the coefficient of revenue and cost is more consistent with the analysis in Section 5.1. Therefore, I chose to use the weighted averages in the final estimation.

Table 6.12 reports the results of agricultural variables on population levels. Column (1) reports the regression result with 1990 and 2000, while the column (3) reports the result without 1990 and 2000. The estimation results with decennial years show that as the 3-year moving average of the weighted revenue doubles, the population will decrease by 1.53%. When decennial years are excluded, the impact is reduced to 1.35%. As the 3-year moving average of the weighted cost doubles, the population will increase by 1.05% according to the estimation with decennial years, or by 0.83% according to the estimation without decennial years. The ratio of the coefficient of revenue to cost is between 1.6 to 1.7, which is greater than the ratio of mean revenues to mean costs (217/162=1.33). This is as expected however. Recall the cost estimates are on regional levels, which will introduce measurement error in the estimation. The coefficient of cost then will be biased toward zero. Because revenues and costs are positively correlated, the estimation for revenue will be biased up. Future works need to address such biasness. The estimated impact of government payment is not significant in regressions with decennial years, but is significant at 5% level (one-tail) in regressions without decennial years.

Table 6.12: The Impact of Agricultural Variables on Population: 1978-2000

	1978-2000		1978-1999‡	
Variables	(1)	(2) IV	(3)	(4) IV
$\log(\text{Revenue})_{t-1}$	-0.0153***	-0.0184***	-0.0135***	-0.0150***
$\log(\text{Cost})_{t-1}$	0.0105***	0.0130***	0.0083***	0.0086***
$\log(\text{Gov't payment})_{t-1}$	-0.0001	0.0000	-0.0004	-0.0003
$\log(\text{population})_{t-1}$	0.9549***	0.9566***	0.9191***	0.9204***
College_{t-1}	0.0699*	0.0371	0.2701***	0.2143***
Black_{t-1}	0.0079	-0.0112	0.1044*	0.0635
Elder_{t-1}	0.0304	-0.0082	0.0918	0.0643
$\text{Poverty rate}_{t-1}$	0.0493	0.0326	0.1219*	0.1176
Manufacture_{t-1}	-0.0380*	-0.0442*	-0.0463*	-0.0654*
Immigrants_{t-1}	0.2525***	0.1963***	0.3659***	0.3012***
$\text{Unemployment}_{t-1}$	-0.1347***	-0.1403***	-0.4283***	-0.4365***
$\text{Popu density}_{t-1}$	-0.0242***	-0.0192*	-0.0520***	-0.0486***
†$\text{Low inc families}_{t-1}$	-0.2917***	-0.2399***	-0.3543***	-0.3160***
††$\text{High inc families}_{t-1}$	-0.1279***	-0.0734*	-0.0733	-0.0196
N	119	119	119	119
Avg T	17.25	16.20	15.61	14.56

SignificanceLevel:*0.05 **0.01 ***0.001

‡ 1990 also excluded.

† Share of family below national 20 percentile income.

†† Share of family above national 80 percentile income.

Column (2) and (4) report IV estimations, with agricultural variables being instrumented by further lags, i.e., $\log(Revenue)_{t-1}$ is instrumented by $\log(Revenue)_{t-2}$ and so on. As discussed in Chapter 5, even agricultural variables are already in lagged forms, it is still possible that they are correlated with contemporaneous growth if the impacts of shocks to labor market or growth are persistent. In fact, empirical results show that both population and population growth rate are serially correlated. And if the endogeniety problem is mainly caused by unobserved crops, such correlation will bias our results down. Instrumenting with further lags helps to reduce this issue of endogeneity. As can be seen in column (2) and (4), the results do improve.[10]

Table 6.13 reports the results of agricultural variables on population growth. According to the estimation results, population growth rate will be 1.12 to 1.30 percent point lower,

[10]In a set of unreported regressions with simple averages of agricultural variables, the coefficients of all agricultural variables are smaller in magnitude than those with weighted averages.

depending on the sample and specification used, as the revenue doubles, and will be 0.6 to 0.84 point higher as the cost doubles. The impact of revenue is significant at 0.1% level. The impact of cost is also significant at 0.1% level, but when observations from decennial year are dropped,it is only significant at 5% level. Note the estimation results are generally lower than those for population levels, which suggesting $\frac{\ln N_t}{R_{t-1}} \neq 0$. This is because the measures we use here. Although previous sections show that the contemporaneous impact of single year measures of agricultural variables is zero, it is not the case for moving averages because the contemporaneous moving averages also contain information from $t-2$. Similar to estimations with population levels, column (2) and (4) report results of IV estimations. As can be seen, coefficients of IV estimations are greater in magnitude.

Table 6.13: The Impact of Agricultural Variables on Population Growth: 1978-2000

	1978-2000		1978-1999‡	
Variables	(1)	(2) IV	(3)	(4) IV
log(Revenue)$_{t-1}$	-0.0130***	-0.0152***	-0.0112***	-0.0125***
log(Cost)$_{t-1}$	0.0084***	0.0099***	0.0060*	0.0061*
log(Gov't payment)$_{t-1}$	0.0000	0.0000	-0.0003	-0.0003
log(population)$_{t-1}$	-0.0431***	-0.0442***	-0.0803***	-0.0831***
Δlog(population)$_{t-1}$	0.2734***	0.2817***	0.2072***	0.2078***
College$_{t-1}$	0.0265	0.0209	0.2128***	0.1886***
Black$_{t-1}$	-0.0443	-0.0413	0.0460	0.0457
Elder$_{t-1}$	0.0273	0.0149	0.0852	0.0775
Poverty rate$_{t-1}$	0.0513	0.0469	0.1495*	0.1474*
Manufacture$_{t-1}$	-0.0337*	-0.0340*	-0.0471*	-0.0520*
Immigrants$_{t-1}$	0.1737***	0.1579***	0.2968***	0.2777***
Unemployment$_{t-1}$	-0.0867*	-0.0812*	-0.3651***	-0.3547***
Popu density$_{t-1}$	-0.0230*	-0.0184*	-0.0517***	-0.0469***
†Low inc families$_{t-1}$	-0.2081***	-0.1880***	-0.2965***	-0.2850***
††High inc families$_{t-1}$	-0.0542	-0.0317	-0.0138	0.0036
N	119	119	119	119
Avg T	16.25	16.20	14.61	14.56

SignificanceLevel:*0.05 **0.01 ***0.001

‡ 1990 also excluded.

† Share of family below national 20 percentile income.

†† Share of family above national 80 percentile income.

Table 6.14 reports the estimates with single year measures.[11] According the estimation

[11] Decennial years were dropped in these regressions.

results, the population will be 0.5% lower when the revenue doubles in the previous, and will be 0.78% higher if the cost double in the previous year. Moreover, the estimation results also show that agricultural variables in the most recent year have the strongest impact. While revenues in all years are significantly negative, the second and third order lags of cost are not significant.[12] However, no significant results are found for government payments for all lags. Note that the coefficients of single year measures are less than those of moving averages. This is because the moving averages contains information for all past three years, so doubling the moving averages requires all three single years measures to doublee. A more sensible comparison should be comparing the summation of the coefficients for different years. The sum of the coefficients for revenues of different lags is -1.24%, close to the estimation of 3-year moving averages which is -1.35%. The similar is also true for costs.

6.4.2 Sensitivity Checks: Further Lags for Population

Table 6.15 reports the sensitivity of the results to further lags of population. Column (1) reports the base result for population level, and column (2) reports the results with a further lag of population level. Column (3) reports the base result for growth rate, which is mathematically equivalent to the result in column (2), and column (4) reports the result with a further lag for growth rate, i.e. $\Delta\,\text{logpopulation}_{t-2}$, which is equivalent to a lag up to time period of $t-3$. As can be seen, the impact of agricultural variables declines with more lag. However, the impact of lag population disappear at $t-3$, but the impacts of our agricultural variables are still highly significant with correct signs.

6.4.3 Sensitivity Check for Control Variables

As mentioned in Section 4.5, it is very likely that the controls used may be endogeneous. If these controls are uncorrelated with agricultural variables, including them into the regression may not bias the results, but may change the standard error. To check whether our results are sensitive to these controls, two strategies were applied. First, I ran a set

[12] As discussed above, this might be because of the measure error of the cost measure.

Table 6.14: Final Estimation 1978-2000: Single Year Measures‡

Variables	Popu. level	Popu. Growth
$\log(\text{Revenue})_{t-1}$	-0.0055***	-0.0045*
$\log(\text{Cost})_{t-1}$	0.0078***	0.0053*
$\log(\text{Gov't payment})_{t-1}$	0.0001	0.0000
$\log(\text{Revenue})_{t-2}$	-0.0038*	-0.0025
$\log(\text{Cost})_{t-2}$	0.0009	0.0006
$\log(\text{Gov't payment})_{t-2}$	0.0002*	0.0002
$\log(\text{Revenue})_{t-3}$	-0.0031*	-0.0020
$\log(\text{Cost})_{t-3}$	0.0030	0.0026
$\log(\text{Gov't payment})_{t-3}$	0.0000	-0.0001
$\log(\text{population})_{t-1}$	0.9556***	-0.0475***
$\Delta\log(\text{population})_{t-1}$		0.2718***
College_{t-1}	0.0871***	0.0875***
Black_{t-1}	0.0286	0.0144
Elder_{t-1}	0.0441	0.0705
$\text{Poverty rate}_{t-1}$	0.0075	0.0220
Manufacture_{t-1}	-0.0507***	-0.0357*
Immigrants_{t-1}	0.1876***	0.1676***
$\text{Unemployment}_{t-1}$	-0.2148***	-0.1436***
$\text{Population density}_{t-1}$	-0.0200***	-0.0194***
†$\text{Low income families}_{t-1}$	-0.2320***	-0.1863***
††$\text{High inc families}_{t-1}$	-0.1168***	-0.0844*
N	119	119
Avg T	14.56	14.56

Significance level: * 0.10, ** 0.05, *** 0.01

‡: Both 1990 and 2000 are excluded.

† Share of family below national 20 percentile income.

†† Share of family above national 80 percentile income.

Agricultural variables are single year measures.

Table 6.15: Sensitivity to Further Lags of Population

	Population Level		Growth Rate	
	(1)	(2)	(3)	(4)
$log(Revenue)_{t-1}$	-0.0153***	-0.0130***	-0.0130***	-0.0119***
$log(Cost)_{t-1}$	0.0105***	0.0084***	0.0084***	0.0107***
$log(Gov'tpayment)_{t-1}$	-0.0001	0.0000	0.0000	0.0001
$log(population)_{t-1}$	0.9549***	1.2305***	-0.0431***	0.2417***
$log(population)_{t-2}$		-0.2734***		-0.2877***
$\Delta(population)_{t-1}$			0.2734***	
$\Delta(population)_{t-2}$				-0.0293

Significance Level: *0.05 **0.01 ***0.001

of regressions with each control individually each time, and compare the results with the base result in Subsection 6.4.1. These results are reported in Table 6.27 and Table 6.28. These results show that, including a different control variable each time does not change the estimation result much: for population levels, the estimation results range from -0.0120% to -0.0189% for revenue, and between 0.0093% and 0.0142% for cost; for growth rate, the estimation results range from -0.0098% to -0.0160% for revenue, and between 0.0062% and 0.0107% for cost.

The second strategy is to include each control variable in a stepwise way. Table 6.29 and 6.30 report results for these regressions. For population levels, the coefficient of revenue ranges from -0.0164% to -0.0130% with correct signs, and the coefficient for cost ranges from 0.0062% to 0.0081% with correct signs. For growth rate, the coefficient for revenue ranges from -0.0108% to -0.0130%, and the coefficient for cost ranges from 0.0062% to 0.0086%.

The sensitivity check shows that although these controls may have some impact on the estimated impact of agricultural variables, such impacts are generally mild and keep the estimation results in a relatively narrow range.

6.5 Simulations

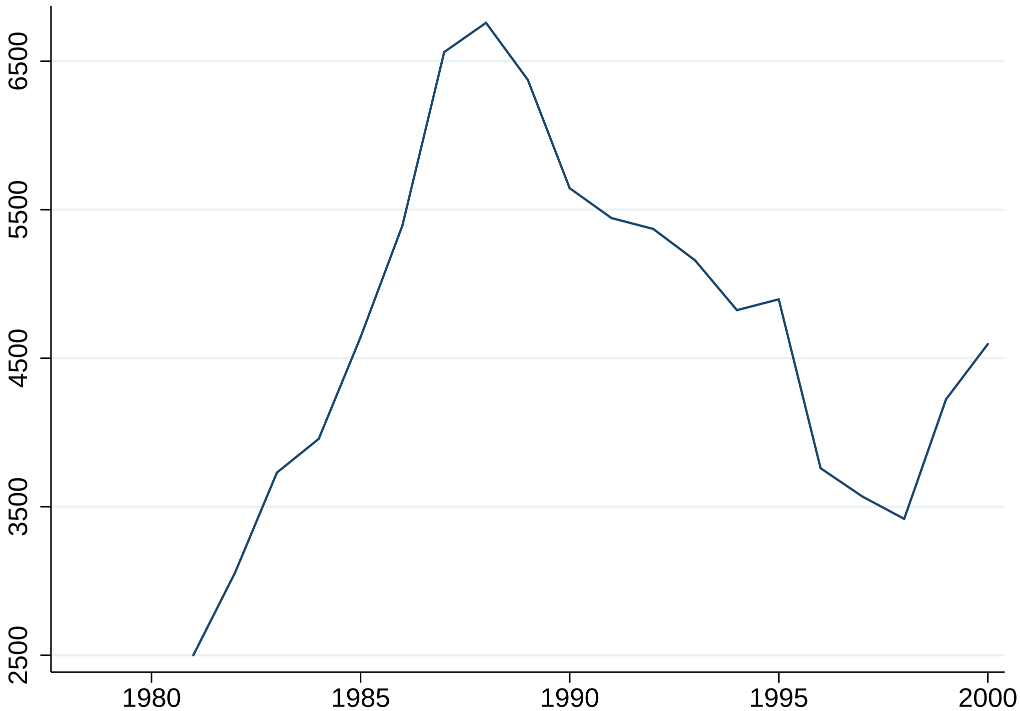
6.5.1 Simulation of Government Subsidies

To simulate the impact of government payments, I used estimation results with 3-year moving averages of agricultural variables. Decennial years were excluded.

Simulated Impacts of Government Subsidies on Population Level

According to the simulation results, on average, the population would have been 4,763 higher between 1980 to 2000 for our agricultural MSAs. Figure 6.5 illustrates the average impact of government payment over time. The impact ranges from as low as 2,500 in 1981 when commodity prices were still high, and to as high as 6,700 in 1988. In 1988, the simulated population change led by government payments is -1.38%, i.e., population would have been 1.38% higher without government payments. Simulated population change

Figure 6.5: Simulated Impact of Government Payments on Population Level



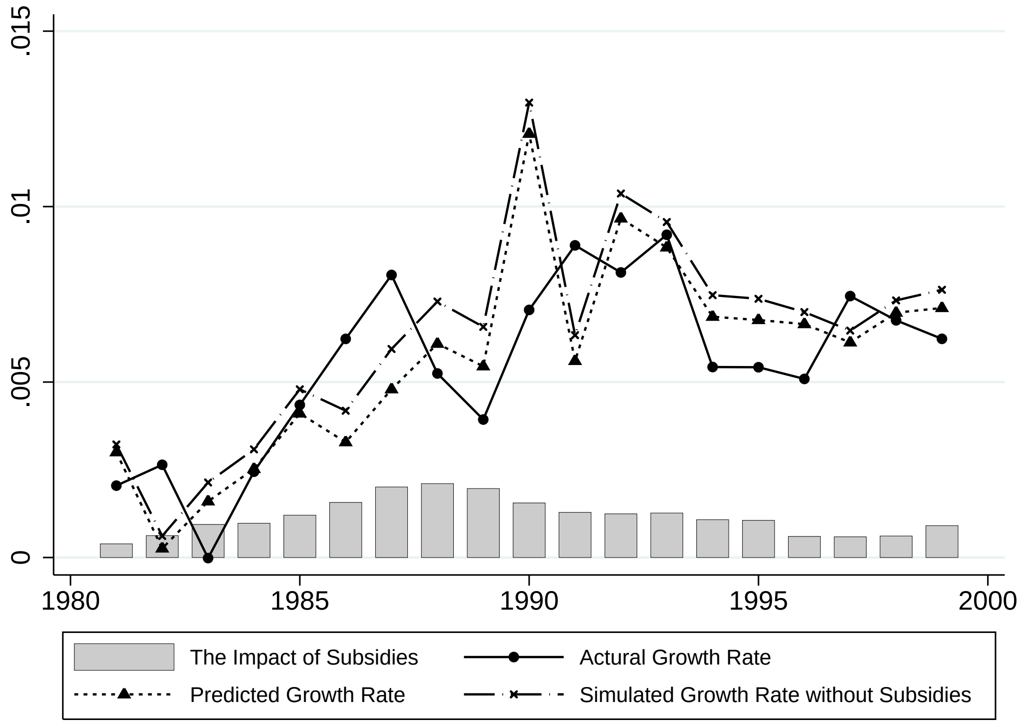
led by government payments in 1988 ranges from 104 of population loss, or -0.02% of the population, for Vallejo–Fairfield–Napa of California, up to 124,393 of population loss, or -1.69% of the population, for Chicago PMSA. Table 6.32 reports these simulated population changes of agricultural MSAs in 1988.

As for the population growth rate, government payments had decreased the population growth rate of those agricultural MSAs by 0.094%, or 11% of the average growth rate, from 1978 to 2000. In 1988, the average growth rate of our agricultural MSAs would have been 0.14% higher without government payments. In the same year, The impact of government payment ranges from 0.002% for Vallejo-Fairfield-Napa of California to 0.18% for Lancaster of Pennsylvania.

To illustrate the impact, I chose two MSAs with different base land share: Cincinnati with the base land share of 40%, and Indianapolis with the base land share of 60%. Both MSAs grew steadiy during 1980 to 2000,[13] and have complete and consistent records of

[13]The average growth rate is 0.5% for Cincinnati and 1% for Indianapolis during this period

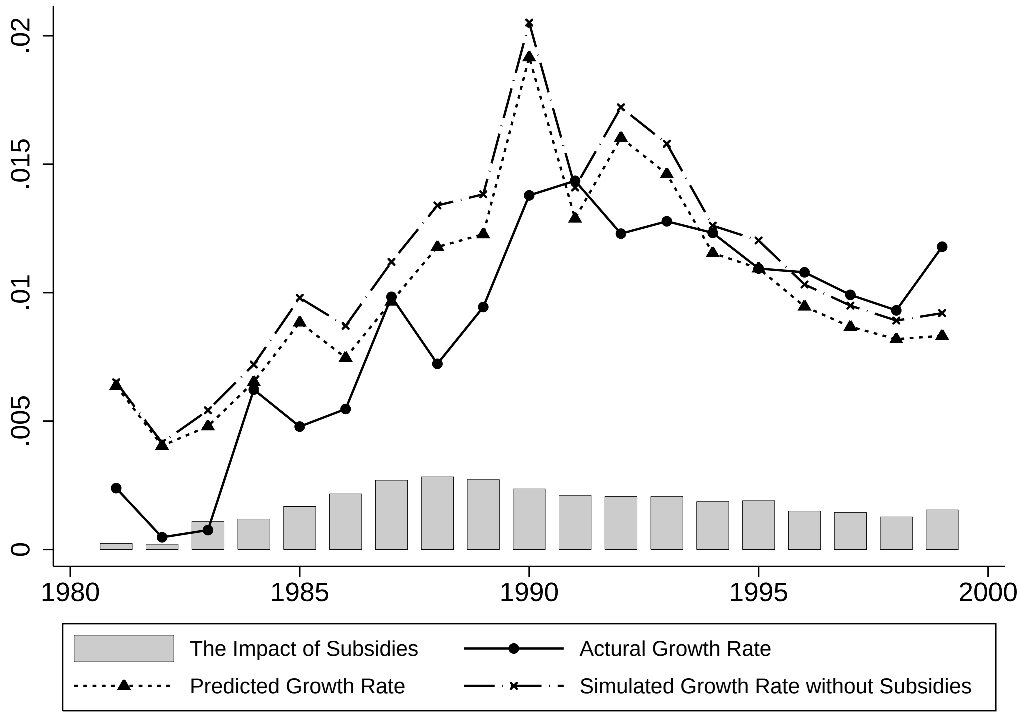
Figure 6.6: Simulation of the Impact of Government Payments on Population Growth Rate: Cincinnati



agricultural variables.

To simulate, I use the data from 1978 to 1999 for these two MSAs assuming government payments were absent. The agricultural variables used are 3-year moving averages. On average, the government payment have reduced the growth rate by 0.03%, or 5% of the average growth rate, for Cincinnati during 1978 to 2000; and the growth rate of Indianapolis has been reduced by 0.06% by government payments, or 6% of the average growth rate, during the same period. Of course, the impact of government payment is not constant over time. The strongest impact happened in 1988 where the government payments were the highest: a decease of 0.12% in growth rate, or 23% of the growth rate in 1988, for Cincinnati, and a decrease of 0.16% in growth rate, or 22% of the growth rate, for Indianapolis. Figure 6.6 and 6.7 illustrate the simulation results for these two MSAs.

Figure 6.7: Simulation of the Impact of Government Payments on Population Growth Rate: Indianapolis



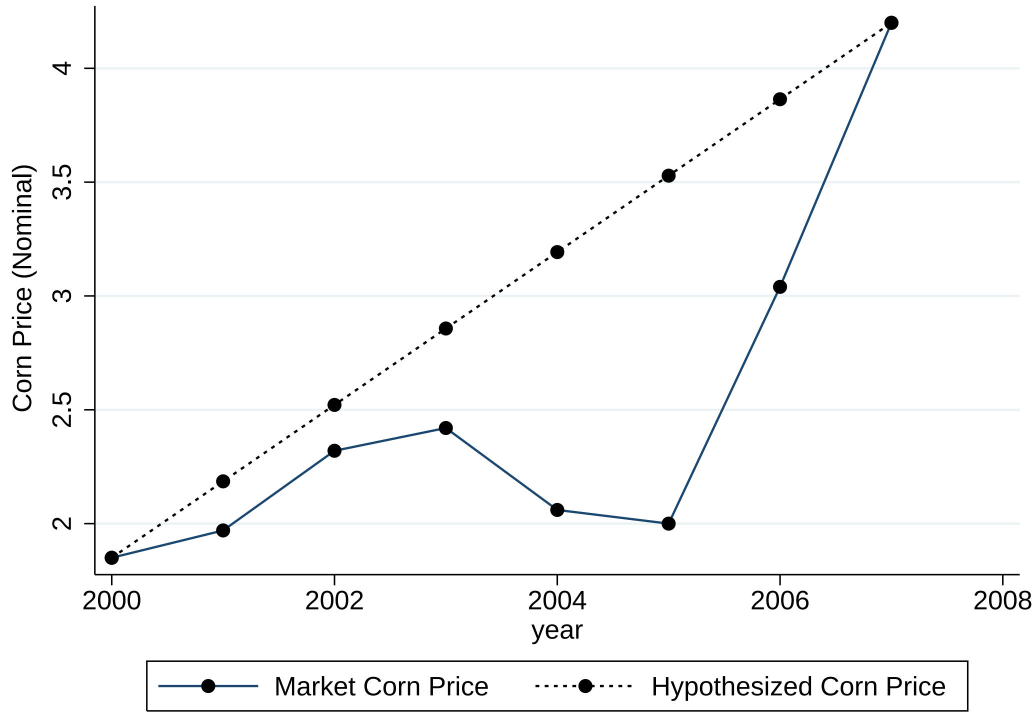
6.5.2 Simulation of of Biofuel Demand

To illustrate the simulated impact of price shocks, I used the changes in corn prices between 2000 (1.85 $/lb) and 2007 (4.0 $/lb).[14] According to the simulation of Rosegrant [2008], 39% of the price increase between 2000 and 2007 was attributable to biofuel demand. This is to say, the real corn price would have increased by 80% and 45% with and without the demand of biofuels. I then will use these information to examine the impact of biofuels on urban population growth. The hypothesized price serie together with the actual price are plotted in Figure 6.8.

To simulate, I first selected 36 MSAs with a minimum of 40% of agricultural land used for corn production. I then calculated the hypothesized revenues, with and without the impact of boifuel respectively, for each of them. The increase of the revenue attributable to boifuel demand ranges from 0.2% to 25.9%. The hypothesized revenue is then used

[14]Prices are nominal. CPI is 172.2 for 2000, and 207.3 for 2007.

Figure 6.8: Corn Prices

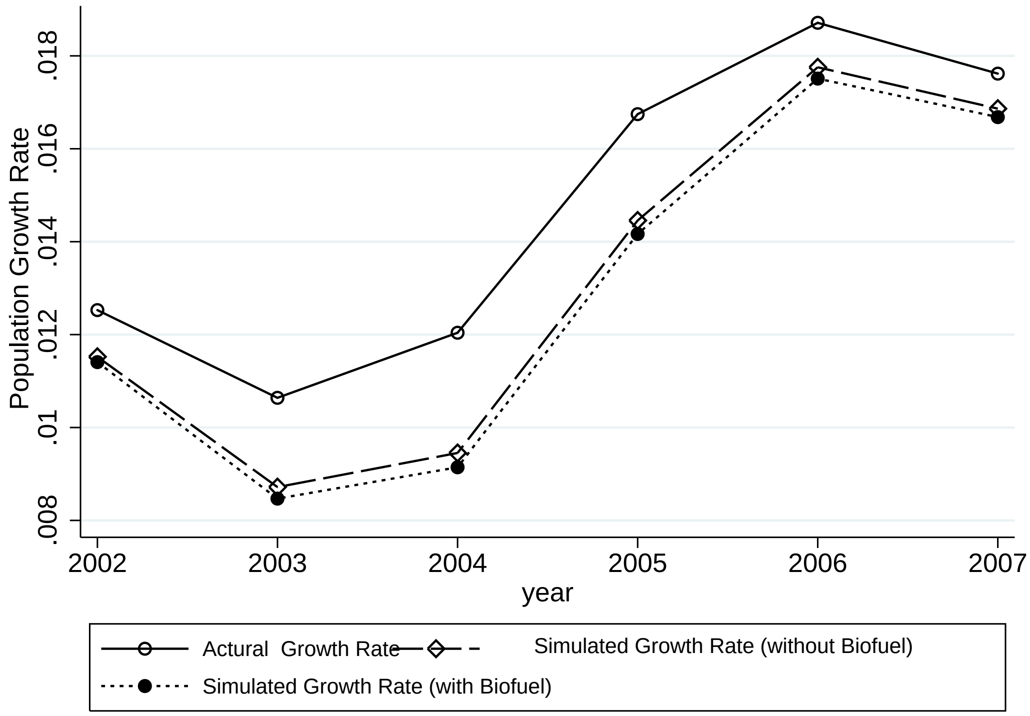


to predict the population. Simulation results for each selected MSA are reported in Table 6.33. Simulation results show that, on average, the annual population change would be 415, or 0.06%, higher without the demand of biofuel, and the total average population change between 2000 and 2007 is 2907, or 0.4% of the population. The relatively low change is because the shock has been smoothed over 2000 and 2007, ending up with an annual increase of 4% in prices led by biofuel.

For a specific MSA, the impact of biofuel can be more significant. Take Des Moines as an example. Des Moines is composed of 5 counties by 1999 OMB definition. Another three counties are included by its buffer. The average base land share of the buffer defined MSA is 73.3%, with a minimum of 50.87% and a maximum of 90.03% for different composing counties. The top product in this area, followed by soybean, is corn, with an average 52% of its crop land engaged in corn production over time.

To calculate the revenue and cost, I used the actual data on all products from 2000 to 2007 in this area except for corn, i.e., only the hypothesized revenue captures the marginal

Figure 6.9: Simulation: The Population Growth Rate of Des Moines



impact of the corn price shock. The simulated population growth rate was calculated by using the hypothesized revenue and the actual cost The simulation result is shown in Figure 6.9. As the Figure shows , the simulated population growth rate is always lower because the hypothesized prices are higher, which reflects the level effect. The average difference between the actual growth rate and the simulated growth rate is 0.2%. As the actual corn price begins to accelerate in 2005, the two growth rates begin to converge. As for the hypothesized price series netted of biofuel demand, because a fixed percentage is assumed (39%), the simulated growth rate is parallel to the previous simulation results, which accounts for .0078 percent point, or 7.6% change, decrease in population growth rate.

6.5.3 Technological Change: Yield Increase of Corn

The impact of technological change is rather complicated. It may increase the revenue of farmers because the productivity of land has increased, but it may also decrease the revenue because the increase in supply may reduce the price. Furthermore, the change in the equilibrium price depends on the elasticity of the supply and demand of agricultural products. Another complexity is that the technological change can be a consequence of price changes rather than the cause. The period that the U.S. agricultural recovered from the 1980 crisis, say 1988 to 1994, provides an opportunity of simplifying these complexities. First, the yield of corn increased about 15% during this period[15]. Second, the price of corn was relatively stable during this period so it is hard to believe the technological change was induced by increasing price. This change may just be because of the structural change in the agricultural sector.

To simulate the impact of the technological change during this period, I first calculated the land share of corn for all agricultural MSAs in the sample, then calculated the change in revenue led by the change in yield of corn. Finally, I applied the coefficient estimated in the last section to find the impact on population. Because the technological change was a rather slow process, I calculated the accumulated impact on population of such change instead of the annual impact. Table 6.16 reports the average impact for each agricultural region. The impact of such changes was most pronounced in the Heartland and Northern Crescent, which is reasonable because these two regions had the highest land share for corn. The population was decreased by 0.088% and 0.051% respectively. In 9 MSAs, the impact of the increase in corn yield had been greater than 0.1%, including Bloomington-Normal, Chicago-Gary-Kenosha, Davenport-Moline-Rock Island, Decatur, New York-Northern New Jersey-Long Islan, Peoria-Pekin, Philadelphia-Wilmington-Atlantic City, Rockford, and Springfield. The corn land in these area accounted for at least 60% of all agricultural land.

[15]There may have been other factors that was attributable such as favorable weather, but here we just assume this increase was completely due to technological change.

Table 6.16: Simulated Impacts of Technological Improvement in Corn Production: 1988–1994[1,2]

Region	Land share for corn	Populatioin	Population Change %	Population Change Number	Growth Rate
Hearland	0.396	611,858	-0.088	-538	-0.086
Northen Crescent	0.264	482,830	-0.051	-248	-0.051
Northern Great Plains	0.040	115,014	-0.016	-18	-0.015
Prairie Gateway	0.031	275,724	-0.010	-27	-0.011
Eastern Uplands	0.061	468,087	-0.014	-64	-0.014
Southern Seaboard	0.103	198,017	-0.022	-44	-0.018
Fruitful Rim	0.034	681,860	-0.008	-54	-0.008
Basin and Range	0.012	560,873	-0.007	-39	-0.005
Mississipp Portal	0.038	324,496	-0.009	-30	-0.009

1. The impact is the accumulated impact during 1988 and 1994.

2. The change in yield is assumed to be completely attributable to technological change.

Table 6.17: Influential Years for Population: 1978-1990

	1986-89 †		1986-90 †		1978-1986 0††	
	MA3	Single year	MA3	Single year	MA3	Single year
$\log(\text{Revenue})_{t-1}$	-0.0241**	-0.0072	-0.0272***	-0.0077	-0.0153***	0.0000
$\log(\text{Cost})_{t-1}$	0.0107	-0.0001	0.0190*	0.0026	0.0118**	0.0034
$\log(\text{Gov't payments})_{t-1}$	-0.0003*	0.0001	0.0008	0.0007	-0.0015*	-0.0010*

Significance Level: * 0.05; ** 0.01; *** 0.001

Agricultural variables are weighted averages.

†: MSAs with base land share greater than 30%.

††: MSAs with base land share greater than 40%.

Table 6.18: The Impact of Agricultural Variables on Population Growth:1978-1990

Variables	All Obs	Southern Seaboard Excluded	1990 Excluded	Declining MSA Excluded	Simple Averages	Dollar Value
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(\text{Revenue})_{t-1}$	-0.0055	-0.0125***	-0.0158***	-0.0137***	-0.008	-0.00003***
$\log(\text{Cost})_{t-1}$	0.0040	0.0094**	0.0120***	0.0106**	0.0127*	0.00003**
$\log(\text{Gov't payments})_{t-1}$	-0.0009*	-0.0007	-0.0011*	-0.0011*	-0.0007	0.0005**
$\Delta\log(\text{population})_{t-1}$	0.3352***	0.3824***	0.3721***	0.3700***	0.4008***	0.3559***
$\log(\text{populations})_{t-1}$	-0.0094	0.0042	-0.022*	-0.0118***	0.0001	0.0201
College_{t-1}	-0.0147	-0.1252**	-0.0547	-0.0686	-0.0723	-0.1442*
Black_{t-1}	0.1953***	0.1894*	0.0570	0.2018*	0.3084**	0.2010*
Elder_{t-1}	0.1848**	0.2900***	0.2026**	0.2554**	0.0864	0.2208**
$\text{Poverty rate}_{t-1}$	0.2499***	0.1796**	0.1513*	0.1074	0.0630	0.0403
Manufacture_{t-1}	-0.0764***	-0.0614**	-0.0651**	-0.0861***	-0.0764**	-0.0629**
Immigrants_{t-1}	0.2862***	0.2418***	0.2053***	0.2621***	0.2740***	0.2502***
$\text{Population densit}_{t-1}$	-0.0344***	-0.0273**	-0.0357***	-0.038 0***	-0.0360**	-0.0344**
†Low income farmilies	-0.4478***	-0.4139***	-0.4506***	-0.3369***	-0.2762***	-0.2547***
††High inc Families	-0.1268***	-0.1062**	-0.1204**	-0.1128**	-0.0758	-0.0191

Significance Level:* 0.05; ** 0.01; *** 0.001

† Below national 20 percentile

†† Above national 80 percentile

Table 6.19: The Number of MSAs by Regions (1990-2000): Base Land Share>30%

Region	Number	Per cent
Heartland	40	29
Northen Crescent	28	21
Northern Great Plains	5	4
Prairie Gateway	11	8
Eastern Uplands	15	11
Southern Seaboard	5	3
Fruitful Rim	22	16
Basin and Range	5	4
Mississippi Portal	5	5
Total	136	100

Table 6.20: Summary Statistics of MSAs (1990-2000): Base Land Share > 30%

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Revenue	187.14	95.64	6.63	712.47
Cost	161.73	102.65	3.74	708.11
Gov Payment	10.97	8.56	0.00	51.34
popu	503875	911026	56507	8291553
Δlog(population)	0.009	0.012	-0.041	0.094
popu dencity	0.644	0.554	0.018	3.450
Share of Bach Degree	0.207	0.062	0.109	0.417
†Low income families	0.193	0.050	0.101	0.365
††High income families	0.161	0.047	0.075	0.330
Share of Manu workers	0.193	0.075	0.042	0.426
Unemployment rate	0.055	0.013	0.026	0.109
Poverty rate	0.120	0.033	0.052	0.266
Share of immigrants	0.030	0.021	0.004	0.172
Share of elder	0.161	0.023	0.086	0.239
Share of black	0.096	0.095	0.001	0.515

†: Share of families below national 20 income percentile

††: Share of families above national 80 income percentile

N=95, T=11

Table 6.21: The Impact of Agricultural Variables on Population: 1990-2000 †

	All Obs		Declining MSAs Excluded					
	Weighted Averges		Weighted Averges		Simple Averages		Ag Variables in Dollars	
Variables	1990-2000	1990-1999	1990-2000	1990-1999	1990-2000	1990-1999	1990-2000	1990-1999
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Revenue)$_{t-1}$	-0.0116**	-0.0176***	-0.0140***	-0.0176***	-0.0115**	-0.0133***	0.0000	-0.0001***
log(Cost)$_{t-1}$	0.0024	0.0085*	0.0028	0.0085*	0.0090	0.0170***	-0.0001*	0.0000
log(Gov't payments)$_{t-1}$	-0.0008	-0.0010	0.0012	-0.0010	0.0019*	-0.0012	-0.0001	-0.0001*
log(population)$_{t-1}$	0.9190***	0.8391***	0.9076***	0.8391***	0.9043***	0.8334***	0.9198***	0.8483***
College$_{t-1}$	0.0571	0.3431***	0.0330	0.3431***	0.0376	0.3527***	0.0055	0.2897***
Black$_{t-1}$	-0.0483	0.1183*	-0.1206	0.1183*	-0.1407*	0.0913	-0.1738**	0.1068
Elder$_{t-1}$	0.0294	0.1508**	-0.0267	0.1508**	-0.0570	0.1155	-0.0664	0.1423*
Poverty rate$_{t-1}$	-0.1439	-0.1879	0.0206	-0.1879	0.0389	-0.1751	0.0755	-0.1592
Manufacture$_{t-1}$	-0.0726*	-0.0874**	-0.0810**	-0.0874**	-0.0778**	-0.0773**	-0.0721*	-0.0676*
Immigrants$_{t-1}$	0.6078***	0.6060***	0.5488***	0.6060***	0.5252***	0.5818***	0.4639***	0.5479***
Popu Density$_{t-1}$	-0.0714***	-0.0499**	-0.0680***	-0.0499**	-0.0590***	-0.0400**	-0.0612***	-0.0362*
Low income Families$_{t-1}$	0.0002	-0.1854*	-0.1082	-0.1854*	-0.1174	-0.1859*	-0.1110	-0.1848*
High income Families$_{t-1}$	0.2377**	-0.0122	0.2555***	-0.0122	0.2485**	-0.0250	0.2334**	-0.0261
N	95	89	89	89	89	89	89	89
T	9	8	9	8	9	8	9	8

Significance Level: *0.10; **0.05; ***0.01

† Base Land Share > 30%

Table 6.22: The Impact of the Agricultural Variable Change on Population:1990-2000

	Lagged	Contemporaneous	Forward
Δlog(Revenue)$_{t-1}$	-0.0035		
Δlog(Cost)$_{t-1}$	0.0035		
Δlog(Gov't payments)$_{t-1}$	0.0000		
log(Revenue)$_{t-2}$	-0.0072**		
log(Cost)$t-2$	0.0080*		
log(Gov't payments)$_{t-2}$	0.0002		
Δlog(Revenue)$_{t}$		-0.0029	
Δlog(Cost)$_{t}$		-0.0067	
Δlog(Gov't payments)$_{t}$		0.0000	
log(Revenue)$_{t-1}$		-0.0079**	
log(Cost)$_{t-1}$		0.0006	
log(Gov't payments)$_{t-1}$		0.0001	
Δlog(Revenue)$_{t+1}$			0.0016
Δlog(Cost)$_{t+1}$			-0.0015
Δlog(Gov't payments)$_{t+1}$			-0.0001
log(Revenue)$_{t}$			-0.0027
log(Cost)$_{t}$			-0.0012
log(Gov't payments)$_{t}$			-0.0001

Significance Level:*0.10;**0.05;***0.01

Table 6.23: The Impact of Agricultural Variables on Population Growth:1990-2000

	All Obs		Declining MSAs Excluded					
	Weighted Averges		Weighted Averages		Simple Averages		Ag Variables in Dollars	
Variables	1990-2000	1990-1999	1990-2000	1990-1999	1990-2000	1990-1999	1990-2000	1990-1999
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Revenue)$_{t-1}$	-0.0080	-0.0140***	-0.0102**	-0.0140***	-0.0076	–0.0099***	0.0000	-0.0001***
log(Cost)$_{t-1}$	-0.0015	0.0050	-0.0015	0.0050	0.0047	0.0129**	-0.0001***	-0.0000
log(Gov't payments)$_{t-1}$	-0.0008	-0.0012*	0.0011	-0.0012*	0.0019*	-0.0015*	-0.0002**	0.0000
Δlog(population)$_{t-1}$	0.1090**	0.0792**	0.1038**	0.0792**	0.1089**	0.0857***	0.1147**	0.0798**
log(population)$_{t-1}$	-0.0920***	-0.1898***	-0.1022***	-0.1898***	-0.1048***	-0.1948***	-0.0900***	-0.1780***
College$_{t-1}$	0.1319*	0.4819***	0.1027	0.4819***	0.1051	0.4894***	0.0906	0.4340***
Black$_{t-1}$	-0.0536	0.1177*	-0.1267	0.1177*	-0.1424	0.0943	-0.1871**	0.1043
Elder$_{t-1}$	0.0281	0.1549**	-0.0338	0.1549**	-0.0588	0.1255*	-0.0767	0.1419**
Poverty rate$_{t-1}$	-0.1691	-0.2768**	-0.0035	-0.2768**	0.0191	-0.2564**	0.0279	-0.2649**
Manufacture$_{t-1}$	-0.0705*	-0.0954***	-0.0798*	-0.0954***	-0.0790*	-0.0893***	-0.0748*	-0.0812**
Immigrants$_{t-1}$	0.6428***	0.6804***	0.5862***	0.6804***	0.5591***	0.6520***	0.5172***	0.6322***
Population Density$_{t-1}$	-0.0690***	-0.0438**	-0.0679***	-0.0438**	-0.0588**	-0.0346*	-0.0702***	-0.0380*
Low income Families$_{t-1}$	0.0735	-0.0925	-0.0309	-0.0925	-0.0405	-0.0946	-0.0124	-0.0643
High income families	0.2143**	-0.0621	0.2348**	-0.0621	0.2325**	-0.0671	0.2226**	-0.0686
N	95	89	89	89	89	89	89	89
T	8	7	8	7	8	7	8	7

Table 6.24: Time Structure of Agricultural Variables on Growth: 1990-2000

	Lagged	Contemporaneous	Forward
log(Revenue)	-0.0049**	-0.0003	0.0038*
log(Cost)	0.0056	-0.0057	-0.0148***
log(Gov't payments)	0.0000	0.0000	-0.0002

Significance Level: *0.10;**0.05;***0.01

Agricultural variables are single year measures.

Table 6.25: The Impact of Agricultural Variables Change on Growth: 1990-2000[†]

	Lagged	Contemporaneous	Forward
Δlog(Revenue)$_{t-1}$	-0.0031		
Δlog(Cost)$_{t-1}$	0.0045		
Δlog(Gov't payments)$_{t-1}$	0.0000		
log(Revenue)$_{t-2}$	-0.0068**		
log(Cost)$_{t-2}$	0.0080		
log(Gov't payments)$_{t-2}$	0.0001		
Δlog(Revenue)$_{t}$		-0.0032	
Δlog(Cost)$_{t}$		-0.0009	
Δlog(Gov't payments)$_{t}$		0.0000	
log(Revenue)$_{t-1}$		-0.0064**	
log(Cost)$_{t-1}$		0.0065	
log(Gov't payments)$_{t-1}$		0.0000	
Δlog(Revenue)$_{t+1}$			0.0039*
Δlog(Cost)$_{t+1}$			-0.0143***
Δlog(Gov't payments)$_{t+1}$			-0.0002
log(Revenue)$_{t}$			0.0012
log(Cost)$_{t}$			-0.0114**
log(Gov't payments)$_{t}$			-0.0002

Significance Level:*0.10;**0.05;***0.01

[†] Agricultural variables are in single year measures.

Table 6.26: Summary Statistics of Agricultural MSAs*

Variable	Mean	s.d.	Min	Max
Revenue	217.659	114.936	2.666	716.827
Cost	162.628	98.620	1.657	708.114
Gov't Payments	15.793	18.611	0	128.752
Base land share	0.549	0.16	0.303	0.851
Population	497596	823598	56507	8291553
Population Growth Rate	0.009	0.013	-0.044	0.097
College	0.192	0.064	0.087	0.44
Poverty Rate	0.118	0.034	0.049	0.266
Manufacture	0.202	0.083	0.041	0.447
Population Density	0.63	0.552	0.033	3.445
Low income families	0.19	0.049	0.094	0.365
High income families	0.175	0.054	0.075	0.429
Black	0.088	0.087	0.001	0.515
Elder	0.158	0.034	0.084	0.424

N=119, Avg. T = 18.25

* Base land share > 30%

Table 6.27: Sensitivity to Other Determinants: Population

	Baseline	(1)	(2)	(3)	(4)	(5)
log(Revenue)$_{t-1}$	-0.0153***	-0.0143***	-0.0124***	-0.0153***	-0.0151***	-0.0152***
log(Cost)$_{t-1}$	0.0105***	0.0097***	0.0093***	0.0103***	0.0130***	0.0108***
log(Gov't payment)$_{t-1}$	-0.0001	-0.0002	-0.0002	-0.0004	-0.0006	-0.0005
log(population)$_{t-1}$	0.9549***	0.9573***	0.9386***	0.9710***	0.9398***	0.9451***
College$_{t-1}$	0.0699*	0.0499				
Black$_{t-1}$	0.0079		-0.2113***			
Elder$_{t-1}$	0.0304			0.0969*		
Poverty rate$_{t-1}$	0.0493				-0.1361***	
Manufacture$_{t-1}$	-0.0380*					-0.0063

		(6)	(7)	(8)	(9)	(10)
log(Revenue)$_{t-1}$	-0.0153***	-0.0189***	-0.0164***	-0.0120***	-0.0166***	-0.0189***
log(Cost)$_{t-1}$	0.0105***	0.0142***	0.0131***	0.0083*	0.0139***	0.0146***
log(Gov't payment)$_{t-1}$	-0.0001	-0.0002	-0.0008*	-0.0002	-0.0005	0.0001
log(population)$_{t-1}$	0.9549***	0.9162***	0.9546***	0.9546***	0.9311***	0.9316***
Immigrants$_{t-1}$	0.2525***	0.2975***				
unemployment$_{t-1}$	-0.1347***		-0.2113***			
Popu density$_{t-1}$	-0.0242***			-0.0123*		
Low income families$_{t-1}$	-0.2917***				-0.2114***	
High income families$_{t-1}$	-0.1279***					0.1602***

Significance Level: *0.05 **0.01 ***0.001

Table 6.28: Sensitivity to Other Determinants: Population Growth

	Baseline	(1)	(2)	(3)	(4)	(5)
$\log(\text{Revenue})_{t-1}$	-0.0130***	-0.0108***	-0.0117***	-0.0120***	-0.0136***	-0.0135***
$\log(\text{Cost})_{t-1}$	0.0084***	0.0062*	0.0074*	0.0065*	0.0098*	0.0100***
$\log(\text{Gov't payment})_{t-1}$	0.0000	-0.0001	-0.0002	-0.0004	-0.0005	-0.0005
$\log(\text{population})_{t-1}$	-0.0431***	-0.0375***	-0.0549***	-0.0287***	-0.0494***	-0.0536***
$\Delta(\text{population})_{t-1}$	0.2734***	0.2832***	0.2242***	0.3037***	0.2393***	0.2114***
College_{t-1}	0.0265	0.0062				
Black_{t-1}	-0.0443		-0.1872***			
Elder_{t-1}	0.0273			0.0452		
$\text{Poverty rate}_{t-1}$	0.0513				-0.0883*	
Manufacture_{t-1}	-0.0337*					-0.0076

		(6)	(7)	(8)	(9)	(10)
$\log(\text{Revenue})_{t-1}$	-0.0130***	-0.0135***	-0.0136***	-0.0098*	-0.0151***	-0.0160***
$\log(\text{Cost})_{t-1}$	0.0084***	0.0090*	0.0103***	0.0054	0.0107***	0.0107***
$\log(\text{Gov't payment})_{t-1}$	0.0000	-0.0000	-0.0006	-0.0003	-0.0004	0.0001
$\log(\text{population})_{t-1}$	-0.0431***	-0.0659***	-0.0386***	-0.0396***	-0.0568***	-0.0567***
$\Delta(\text{population})_{t-1}$	0.2734***	0.2367***	0.2358***	0.2574***	0.2402***	0.2591***
Immigrants_{t-1}	0.1737***	0.1803***				
L.unemployrate	-0.0867*		-0.1339***			
$(\text{Popu density})_{t-1}$	-0.0230*			-0.0145*		
$\text{Low income families}_{t-1}$	-0.2081***				-0.1626***	
$\text{High income families}_{t-1}$	-0.0542					0.1261***

SignificanceLevel:*0.05 **0.01 ***0.001

Table 6.29: Stepwise Regression: Population Level

	Baseline	(1)	(2)	(3)	(4)	(5)
log(Revenue)$_{t-1}$	-0.0153***	-0.0143***	-0.0130***	-0.0153***	-0.0143***	-0.0142***
log(Cost)$_{t-1}$	0.0105***	0.0097***	0.0088***	0.0110***	0.0104***	0.0098***
log(Gov't payment)$_{t-1}$	-0.0001	-0.0002	-0.0001	-0.0003	-0.0001	-0.0001
log(population)$_{t-1}$	0.9549***	0.9573***	0.9550***	0.9705***	0.9658***	0.9694***
College$_{t-1}$	0.0699*	0.0499	0.0465	0.0778*	0.0550*	0.0286
Black$_{t-1}$	0.0079		-0.1768***	-0.1489***	-0.1363***	-0.1316***
Elder$_{t-1}$	0.0304			0.0673	0.0368	0.0307
Poverty rate$_{t-1}$	0.0493				-0.1054***	-0.1013***
Manufacture$_{t-1}$	-0.0380*					-0.0207

		(6)	(7)	(8)	(9)	(10)
log(Revenue)$_{t-1}$	-0.0153***	-0.0150***	-0.0154***	-0.0144***	-0.0164***	-0.0153***
log(Cost)$_{t-1}$	0.0105***	0.0107***	0.0104***	0.0095***	0.0109***	0.0105***
log(Gov't payment)$_{t-1}$	-0.0001	-0.0001	-0.0001	-0.0001	0.0000	-0.0001
log(population)$_{t-1}$	0.9549***	0.9557***	0.9550***	0.9636***	0.9513***	0.9549***
College$_{t-1}$	0.0699*	0.0060	0.0137	0.0629*	0.0370	0.0699*
Black$_{t-1}$	0.0079	-0.0859*	-0.0462	-0.0238	-0.0222	0.0079
Elder$_{t-1}$	0.0304	0.0212	0.0075	0.0066	0.0262	0.0304
Poverty rate$_{t-1}$	0.0493	-0.1442***	-0.1009***	-0.1140***	0.0705	0.0493
Manufacture$_{t-1}$	-0.0380*	-0.0237	-0.0108	-0.0268*	-0.0387*	-0.0380*
Immigrants$_{t-1}$	0.2525***	0.1779***	0.1945***	0.2328***	0.2011***	0.2525***
unemployment$_{t-1}$	-0.1347***		-0.1908***	-0.1861***	-0.1520***	-0.1347***
Popu density$_{t-1}$	-0.0242***			-0.0289***	-0.0215*	-0.0242***
Low income families$_{t-1}$	-0.2917***				-0.2180***	-0.2917***
High income families$_{t-1}$	-0.1279***					-0.1279***

Significance Level: *0.05 **0.01 ***0.001

Table 6.30: Stepwise Regression: Population Growth

	(1)	(2)	(3)	(4)	(5)
$\log(\text{Revenue})_{t-1}$	-0.0108***	-0.0114***	-0.0119***	-0.0118***	-0.0114***
$\log(\text{Cost})_{t-1}$	0.0062*	0.0071*	0.0074*	0.0073*	0.0072*
$\log(\text{Gov't payment})_{t-1}$	-0.0001	-0.0000	-0.0001	0.0000	-0.0001
$\Delta(\text{population})_{t-1}$	0.2832***	0.2758***	0.3005***	0.2955***	0.2842***
$\log(\text{population})_{t-1}$	-0.0375***	-0.0412***	-0.0307***	-0.0327***	-0.0335***
College_{t-1}	0.0062	0.0133	0.0366	0.0138	-0.0128
Black_{t-1}		-0.1537***	-0.1497***	-0.1346*	-0.1430***
Elder_{t-1}			0.0336	0.0190	0.0133
$\text{Poverty rate}_{t-1}$				-0.0723*	-0.0816*
Manufacture_{t-1}					-0.0168

	(6)	(7)	(8)	(9)	(10)
$\log(\text{Revenue})_{t-1}$	-0.0119***	-0.0122***	-0.0116***	-0.0133***	-0.0130***
$\log(\text{Cost})_{t-1}$	0.0079*	0.0081*	0.0075*	0.0086***	0.0084***
$\log(\text{Gov't payment})_{t-1}$	-0.0000	-0.0000	-0.0000	0.0000	0.0000
$\Delta(\text{population})_{t-1}$	0.2887***	0.2724***	0.2788***	0.2764***	0.2734***
$\log(\text{population})_{t-1}$	-0.0425***	-0.0422***	-0.0339***	-0.0450***	-0.0431***
College_{t-1}	-0.0226	-0.0145	0.0331	0.0124	0.0265
Black_{t-1}	-0.1112*	-0.0813*	-0.0596	-0.0584	-0.0443
Elder_{t-1}	0.0081	0.0030	0.0059	0.0238	0.0273
$\text{Poverty rate}_{t-1}$	-0.1112***	-0.0762*	-0.0866*	0.0667	0.0513
Manufacture_{t-1}	-0.0192	-0.0101	-0.0241	-0.0330*	-0.0337*
Immigrants_{t-1}	0.1202***	0.1335***	0.1699***	0.1496***	0.1737***
$\text{unemployment}_{t-1}$		-0.1239***	-0.1196***	-0.0925*	-0.0867*
$\text{Popu density}_{t-1}$			-0.0277***	-0.0221*	-0.0230*
$\text{Low income families}_{t-1}$				-0.1806***	-0.2081***
$\text{High income families}_{t-1}$					-0.0542

Significance Level:*0.05 **0.01 ***0.001

Table 6.31: Simulated Impact of Government Payment on Population in 1988

MSA/PMSA	Population	Simulated Change %	Simulated Change	Base Land Share
Provo-Orem, UT MSA	254,274	0.97%	2,467	0.30
Harrisburg-Lebanon-Carlisle, PA MSA	578,886	1.64%	9,509	0.30
Wilmington-Newark, DE-MD PMSA	499,209	1.61%	8,021	0.31
Dothan, AL MSA	131,148	1.13%	1,480	0.31
Santa Rosa, CA PMSA	367,893	0.96%	3,533	0.31
Texarkana, TX-Texarkana, AR MSA	120,789	0.96%	1,165	0.32
Sacramento, CA PMSA	1,245,576	1.44%	17,912	0.32
Akron, OH PMSA	652,814	1.62%	10,608	0.32
Huntsville, AL MSA	283,769	1.29%	3,650	0.32
Decatur, AL MSA	129,017	1.14%	1,467	0.33
Rochester, NY MSA	1,047,237	1.61%	16,823	0.34
Goldsboro, NC MSA	102,269	1.50%	1,533	0.36
Fort Smith, AR-OK MSA	174,978	0.42%	736	0.36
Bloomington, IN MSA	105,324	1.49%	1,564	0.36
Hagerstown, MD PMSA	118,237	1.57%	1,856	0.38
Syracuse, NY MSA	730,011	1.60%	11,659	0.38
San Jose, CA PMSA	1,472,234	0.61%	8,948	0.38
Vallejo-Fairfield-Napa, CA PMSA	416,178	0.02%	104	0.38
Chico-Paradise, CA MSA	171,909	1.68%	2,888	0.39
Memphis, TN-AR-MS MSA	993,254	1.25%	12,411	0.39
Cincinnati, OH-KY-IN PMSA	1,513,847	1.22%	18,484	0.39
Jackson, MI MSA	148,357	1.63%	2,422	0.40
Benton Harbor, MI MSA	163,001	1.54%	2,509	0.41
York, PA MSA	330,944	1.54%	5,097	0.41
Ann Arbor, MI PMSA	472,981	1.60%	7,562	0.42
Canton-Massillon, OH MSA	393,752	1.56%	6,154	0.42
Nashville, TN MSA	964,521	0.91%	8,810	0.42
Jackson, TN MSA	90,160	1.44%	1,302	0.42
Green Bay, WI MSA	190,270	1.61%	3,057	0.42
Fayetteville-Springdale-Rogers, AR MSA	202,656	0.47%	944	0.43
St Barbara-St Maria-Lompoc, CA MSA	355,810	0.24%	855	0.43
Fresno, CA MSA	709,420	1.54%	10,924	0.44
Clarksville-Hopkinsville, TN-KY MSA	163,843	1.38%	2,256	0.44
Minneapolis-St. Paul, MN-WI MSA	2,467,274	1.61%	39,754	0.44
Gary, IN PMSA	597,140	1.66%	9,917	0.44
St. Louis, MO-IL MSA	2,502,635	1.39%	34,833	0.44
Kenosha, WI PMSA	123,794	1.69%	2,095	0.46
San Francisco, CA PMSA	1,593,098	1.03%	16,372	0.46
Salt Lake City-Ogden, UT MSA	1,053,397	1.02%	10,720	0.46
Milwaukee-Waukesha, WI PMSA	1,409,602	1.69%	23,772	0.48
La Crosse, WI-MN MSA	114,981	1.52%	1,748	0.48
Grand Rapids-Muskegon-Holland, MI MSA	913,462	1.57%	14,296	0.49
Eau Claire, WI MSA	136,125	1.53%	2,088	0.49
Lansing-East Lansing, MI MSA	429,673	1.59%	6,825	0.50
Appleton-Oshkosh-Neenah, WI MSA	309,604	1.66%	5,150	0.52
Racine, WI PMSA	171,934	1.65%	2,829	0.53
Dover, DE MSA	106,965	1.66%	1,773	0.54
Hamilton-Middletown, OH PMSA	283,064	1.62%	4,576	0.54
South Bend, IN MSA	243,656	1.67%	4,064	0.54

Table 6.31: Simulated Impact of Government Payment on Population in 1988

MSA/PMSA	Population	Simulated Change %	Simulated Change	Base Land Share
Oakland, CA PMSA	2,010,342	0.50%	10,068	0.55
Columbus, OH MSA	1,315,229	1.55%	20,420	0.56
Sheboygan, WI MSA	102,018	1.65%	1,682	0.56
St. Cloud, MN MSA	144,873	1.56%	2,260	0.56
Kalamazoo-Battle Creek, MI MSA	424,341	1.57%	6,660	0.57
Kansas City, MO-KS MSA	1,561,876	1.15%	17,904	0.58
San Luis-Atascadero-Paso, CA MSA	204,261	0.44%	905	0.58
Elkhart-Goshen, IN MSA	153,917	1.66%	2,562	0.58
Indianapolis, IN MSA	1,355,368	1.64%	22,284	0.60
Lancaster, PA MSA	410,152	1.83%	7,499	0.60
Madison, WI MSA	356,383	1.70%	6,060	0.60
Joplin, MO MSA	133,670	0.93%	1,239	0.60
Chicago, IL PMSA	7,357,678	1.69%	124,393	0.61
Salinas, CA MSA	345,947	0.18%	635	0.63
Janesville-Beloit, WI MSA	136,588	1.68%	2,298	0.63
Columbia, MO MSA	109,331	1.08%	1,186	0.63
Springfield, MO MSA	257,863	0.72%	1,856	0.63
Dayton-Springfield, OH MSA	950,632	1.62%	15,383	0.63
Grand Forks, ND-MN MSA	104,341	1.51%	1,576	0.65
Jonesboro, AR MSA	66,788	1.71%	1,141	0.67
Fort Wayne, IN MSA	454,540	1.58%	7,178	0.68
Rochester, MN MSA	102,923	1.66%	1,707	0.69
Rockford, IL MSA	325,254	1.75%	5,676	0.70
Toledo, OH MSA	616,985	1.60%	9,874	0.71
Iowa City, IA MSA	92,566	1.63%	1,511	0.73
Des Moines, IA MSA	381,462	1.56%	5,970	0.73
Lima, OH MSA	154,898	1.57%	2,430	0.74
Dubuque, IA MSA	87,351	1.61%	1,408	0.74
Lexington, KY MSA	399,394	0.81%	3,242	0.75
Sioux City, IA-NE MSA	114,224	1.52%	1,732	0.75
Lincoln, NE MSA	207,785	1.40%	2,913	0.75
Modesto, CA MSA	336,063	1.44%	4,835	0.75
Cedar Rapids, IA MSA	165,979	1.64%	2,715	0.76
Springfield, IL MSA	188,519	1.62%	3,063	0.77
Merced, CA MSA	167,749	1.49%	2,493	0.77
Lafayette, IN MSA	159,002	1.66%	2,632	0.79
Omaha, NE-IA MSA	630,342	1.54%	9,738	0.79
Fargo-Moorhead, ND-MN MSA	150,478	1.44%	2,173	0.81
Champaign-Urbana, IL MSA	174,411	1.66%	2,899	0.84
Stockton-Lodi, CA MSA	457,138	1.47%	6,699	0.85
Bloomington-Normal, IL MSA	126,021	1.66%	2,096	0.85
Average	563,841	1.38%	6,775	0.53

Table 6.32: Simulated Impact of Government Payment on Population Growth in 1988

MSA/PMSA	Population Growth Rate %	Simulated Change %	Base Land Share
Provo-Orem, UT MSA	1.60	0.10	0.30
Harrisburg-Lebanon-Carlisle, PA MSA	0.81	0.16	0.30
Wilmington-Newark, DE-MD PMSA	1.97	0.16	0.31
Dothan, AL MSA	1.19	0.11	0.31
Santa Rosa, CA PMSA	3.25	0.09	0.31
Texarkana, TX-Texarkana, AR MSA	0.57	0.10	0.32
Sacramento, CA PMSA	3.50	0.14	0.32
Akron, OH PMSA	0.77	0.16	0.32
Huntsville, AL MSA	2.52	0.13	0.32
Decatur, AL MSA	0.68	0.11	0.33
Rochester, NY MSA	0.66	0.16	0.34
Goldsboro, NC MSA	0.96	0.15	0.36
Fort Smith, AR-OK MSA	0.52	0.04	0.36
Bloomington, IN MSA	1.17	0.15	0.36
Hagerstown, MD PMSA	0.26	0.15	0.38
Syracuse, NY MSA	0.43	0.16	0.38
San Jose, CA PMSA	1.69	0.06	0.38
Vallejo-Fairfield-Napa, CA PMSA	3.50	0.00	0.38
Chico-Paradise, CA MSA	2.92	0.17	0.39
Memphis, TN-AR-MS MSA	1.45	0.12	0.39
Cincinnati, OH-KY-IN PMSA	0.52	0.12	0.39
Jackson, MI MSA	0.40	0.16	0.40
Benton Harbor, MI MSA	0.02	0.15	0.41
York, PA MSA	1.53	0.15	0.41
Ann Arbor, MI PMSA	1.53	0.16	0.42
Canton-Massillon, OH MSA	0.41	0.15	0.42
Nashville, TN MSA	1.52	0.09	0.42
Jackson, TN MSA	0.46	0.14	0.42
Green Bay, WI MSA	1.27	0.16	0.42
Fayetteville-Springdale-Rogers, AR MSA	1.82	0.05	0.43
St Barbara-St Maria-Lompoc, CA MSA	1.07	0.02	0.43
Fresno, CA MSA	3.09	0.15	0.44
Clarksville-Hopkinsville, TN-KY MSA	1.19	0.14	0.44
Minneapolis-St. Paul, MN-WI MSA	2.24	0.16	0.44
Gary, IN PMSA	0.28	0.16	0.44
St. Louis, MO-IL MSA	0.39	0.14	0.44
Kenosha, WI PMSA	1.90	0.17	0.46
San Francisco, CA PMSA	0.21	0.10	0.46
Salt Lake City-Ogden, UT MSA	0.69	0.10	0.46
Milwaukee-Waukesha, WI PMSA	0.82	0.17	0.48
La Crosse, WI-MN MSA	0.70	0.15	0.48
Grand Rapids-Muskegon-Holland, MI MSA	1.80	0.15	0.49
Eau Claire, WI MSA	0.66	0.15	0.49
Lansing-East Lansing, MI MSA	0.71	0.16	0.50
Appleton-Oshkosh-Neenah, WI MSA	1.55	0.16	0.52
Racine, WI PMSA	1.02	0.16	0.53
Dover, DE MSA	0.66	0.16	0.54
Hamilton-Middletown, OH PMSA	1.08	0.16	0.54
South Bend, IN MSA	0.59	0.16	0.54
Oakland, CA PMSA	2.06	0.05	0.55

Table 6.32: Simulated Impact of Government Payment on Population Growth in 1988

MSA/PMSA	Population Growth Rate %	Simulated Change %	Base Land Share
Columbus, OH MSA	1.82	0.15	0.56
Sheboygan, WI MSA	0.66	0.16	0.56
St. Cloud, MN MSA	1.78	0.15	0.56
Kalamazoo-Battle Creek, MI MSA	0.75	0.15	0.57
Kansas City, MO-KS MSA	1.10	0.11	0.58
San Luis Obispo-Atas-Paso Robles, CA MSA	2.44	0.04	0.58
Elkhart-Goshen, IN MSA	1.80	0.16	0.58
Indianapolis, IN MSA	0.72	0.16	0.60
Lancaster, PA MSA	2.06	0.18	0.60
Madison, WI MSA	1.80	0.17	0.60
Joplin, MO MSA	0.29	0.09	0.60
Chicago, IL PMSA	0.19	0.17	0.61
Salinas, CA MSA	1.36	0.02	0.63
Janesville-Beloit, WI MSA	0.70	0.17	0.63
Columbia, MO MSA	1.80	0.11	0.63
Springfield, MO MSA	1.58	0.07	0.63
Dayton-Springfield, OH MSA	0.73	0.16	0.63
Grand Forks, ND-MN MSA	0.88	0.15	0.65
Jonesboro, AR MSA	1.76	0.17	0.67
Fort Wayne, IN MSA	0.69	0.16	0.68
Rochester, MN MSA	2.80	0.16	0.69
Rockford, IL MSA	0.29	0.17	0.70
Toledo, OH MSA	0.63	0.16	0.71
Iowa City, IA MSA	2.26	0.16	0.73
Des Moines, IA MSA	1.26	0.15	0.73
Lima, OH MSA	0.56	0.15	0.74
Dubuque, IA MSA	0.26	0.16	0.74
Lexington, KY MSA	1.08	0.08	0.75
Sioux City, IA-NE MSA	0.73	0.15	0.75
Lincoln, NE MSA	1.26	0.14	0.75
Modesto, CA MSA	3.85	0.14	0.75
Cedar Rapids, IA MSA	1.00	0.16	0.76
Springfield, IL MSA	0.49	0.16	0.77
Merced, CA MSA	2.90	0.15	0.77
Lafayette, IN MSA	0.92	0.16	0.79
Omaha, NE-IA MSA	0.71	0.15	0.79
Fargo-Moorhead, ND-MN MSA	1.27	0.14	0.81
Champaign-Urbana, IL MSA	0.32	0.16	0.84
Stockton-Lodi, CA MSA	2.53	0.14	0.85
Bloomington-Normal, IL MSA	1.36	0.16	0.85
Average	1.27	0.14	0.54

Table 6.33: Simulated Impact of Biofuel Demand: 2000-2007

MSA/PMSA	Population	Simulated Annual change	Simulated Total Change
Appleton-Oshkosh-Neenah, WI MSA	439176	112	784
Bloomington-Normal, IL MSA	169657	132	923
Cedar Rapids, IA MSA	228981	151	1057
Champaign-Urbana, IL MSA	291830	217	1518
Chicago, IL PMSA	8291553	5965	41752
Davenport-Moline-Rock Island, IA-IL MSA	452807	313	2190
Dayton-Springfield, OH MSA	1063752	567	3969
Decatur, IL MSA	196270	134	941
Des Moines, IA MSA	647524	450	3153
Elkhart-Goshen, IN MSA	359340	161	1130
Evansville-Henderson, IN-KY MSA	339093	210	1468
Gary, IN PMSA	631644	446	3124
Grand Rapids-Muskegon-Holland, MI MSA	1151741	349	2446
Indianapolis, IN MSA	1613258	1086	7605
Iowa City, IA MSA	179148	123	858
Janesville-Beloit, WI MSA	337715	159	1111
Kalamazoo-Battle Creek, MI MSA	525877	265	1854
Kankakee, IL PMSA	163947	117	820
Kenosha, WI PMSA	150074	72	503
Kokomo, IN MSA	260343	158	1108
Lafayette, IN MSA	291906	211	1480
Lancaster, PA MSA	471776	96	674
Madison, WI MSA	498080	216	1512
Milwaukee-Waukesha, WI PMSA	1588266	451	3158
Muncie, IN MSA	338017	183	1280
Omaha, NE-IA MSA	795368	477	3336
Peoria-Pekin, IL MSA	404834	295	2066
Racine, WI PMSA	188974	93	648
Rochester, MN MSA	268374	140	978
Rochester, NY MSA	1102134	364	2547
Rockford, IL MSA	421044	295	2066
Sioux City, IA-NE MSA	175003	98	689
South Bend, IN MSA	411393	272	1901
Springfield, IL MSA	345877	246	1722
Terre Haute, IN MSA	224680	150	1051
Waterloo-Cedar Falls, IA MSA	252742	174	1216
Average	702006	415	2907

Chapter 7 Conclusion

7.1 Contributions

Previous studies of urban growth have mainly focused on factors within urban areas, e.g., local productivity growth, amenities, infrastructures, and public services. The impact of opportunity cost of land has long been ignored even though the theory has a clear prediction about its impact on growth. Even in studies focusing on urban land uses, for example, the literature of urban sprawl, the opportunity cost of land has not attracted serious attention. In these studies, measures of the land cost were either imprecise[1] or endogeneous.[2] Therefore, it is not surprising that empircal results regarding the opportunity cost of land are limited and ambiguous. Questions such as whether and to what extent the opportunity cost of land affects urban growth, and, as the opportunity cost of land is not consistent over time, whether the growth respond to short term changes in land cost, have not been answered.

Answers to these questions, however, are important. As agricultural productions are distributed unevenly in this country, changes in the agricultural sector will have different impacts in different regions or metropolitan areas. This is especially true in analyzing the incidence of federal policies such agricultural subsidies and price supports. As these programs should change the value of agricultural land, or the opportunity cost of land, urban growth will also be affected by these programs. Simulation results in this study show that nullifying agricultural subsidies would have increased the population of "agricultural" MSAs[3] by as much as 1.38%, or 6,775, in 1988. The opportunity cost of land also affects the population growth rate. According to these simulation results, the growth rate of those

[1] For example, as in McGrath [2005], the opportunity cost of land was measured by state level agricultural land value.

[2] For example, as in Mills and Lubuele [1997], Wassmer [2008], and Spivey [2008] among others, the opportunity cost of land was measured by the market value of agricultural land from census directly.

[3] The share of crop land and grazing land in metropolitan areas is greater than 30%. See Table 6.31.

MSAs would have been 0.14 percent higher (11% of the average population growth rate) without agricultural subsidies.

In addition to the agricultural policies, fiscal and monetary policies can also affect agricultural land values, and urban growth in turn, by affecting the interest rate, which is an important component of agricultural costs. From 1986 to 1993, for example, when the U.S. agricultural sector recovered from the previous crisis, nearly half of the decrease in agricultural cost can be attributed to the decrease in interest expenditures. As found by this study, urban population is responsive to changes in agricultural costs. For example, the study estimates that population growth rate would increase by 0.53% when the cost of the previous year doubles.

The commodity price is another important factor affecting agricultural land value. The variable of agricultural revenue created in this study captures the impact of price changes. According to the estimation of this study, the population growth rate will be 0.45% lower if the agricultural revenue of the previous year doubles, and will be 1.25% lower if the 3-year moving average of revenue of the previous year doubles. According to another set of simulations, the increase of corn price driven by the biofuel demand had increased the agricultural revenues by 13% from 2000 to 2007 in MSAs major in corn production[4], which had reduced the population by 2,907on average, or 0.4% of the total population, for these areas in this period.

Academically, this study provides a test for the prediction of the traditional Alonso–Mills-Muth model that urban growth is hindered by the increase of agricultural rent. The measure of the agricultural rent used in this study, based on a unique data set composed of extensive information on agricultural production, is more precise and exogenous than those used in previous studies. Moreover, as the data set contains information of overtime changes in agricultural prices and costs, this study is capable of examining the impact of agricultural rent in the short run. As the opportunity cost of land affects the growth by affecting the housing cost, this study is also a complement to the literature of the housing supply and urban growth that emerged in the past ten years.

[4]MSAs with a minimum of 40% of agricultural land for corn.

Chapter Review

In Chapter 1, changes in agricultural prices were reviewed for 1978-2000. Two periods stood out, i.e., the early 1980s featured by the farm crisis and the mid 1990s featured by a price spike. Casual observations show that correlations between the agricultural prices and population growth do exist.

Chapter 2 reviews two lines of literature that can be related to this dissertation. The first line is the literature on urban growth based on the intercity spatial equilibrium. Guided by the traditional Alonso–Mills–Muth model, studies along this line do consider agricultural rents. But because their measures of the agricultural rent were either imprecise or endogeneous to the growth, their results regarding the agricultural rent were rather limited, which calls for better measures of the opportunity cost of land. The second line is the literature on housing supply and urban growth which emerged in the past decade. Various studies have shown the supply conditions of the housing market is indeed important, and two aspects of the shifters of the housing supply have been examined: regulations of land uses and geographic characteristics of urban areas. The opportunity cost of land, however, has not been examined.

Based on the intercity spatial equilibrium framework, Chapter 3 provides a model to analyze the impact of opportunity cost of land on urban populations. According to this model, local wages must increase to compensate higher cost of land, which leads employment or population to decrease.

Chapter 4 discusses data issues, including sources and quality of the data, imputation of the agricultural variables, the validity of the imputation, aggregation of the county-level variables, and measures of the dependent variable and other determinants of growth.

Based on the county-level agricultural data of prices, yields, costs, and land used on selected agricultural products, I first imputed the average revenues, costs, and government payments per acre of land, weighted by the land used by each product, for each county and each year. To verify the validity of the imputation, I regressed the value of farmland from the census, for each agricultural region, on those three variables with a sample of counties out of metropolitan areas. Results show that the correlation between the land value and revenue is positive, and the correlation between the land value and cost is negative. The overall R^2 is 50% for dollar to dollar regressions, and is 60% for log–log regressions.[5] These results show that the imputed agricultural variables are valid in measuring the value of agricultural land. In a similar set of regressions by using the sample of counties within metropolitan areas, the correlation is much weaker (Table 4.2), suggesting that the value of farmland within metropolitan areas are affected by unobserved urban factors. These results justify my choice of using agricultural prices rather than the market land value as a measure of the opportunity cost of land.

Before aggregating those county-level agricultural variables to MSA levels, component of MSAs must be determined first. To address possible spillover effects, counties close enough to the city center but not in MSAs were also included into aggregation. To determine which counties to include, I used GIS software to create a buffer of 30 miles in radius about the center of the principal city of each MSA. All counties touching this buffer were included. Figure 4.10 shows that the choice size of the buffer is appropriate for inland MSAs such as Lexington and Louisville.

Chapter 5 discusses the empirical methodology, including methods of aggregating county-level agricultural variables to MSA levels, the choice of subsamples, regression specifications, and the choice of estimation techniques. To obtain a measure of agricultural land value, I first discussed the implications and differences in simple averages and weighted averages of county-level agricultural variables. The weighted average is presumably superior to simple averages because counties with more agricultural land are more insulated to unobserved urban impacts and have less unobserved agricultural products. Regarding the regression model specifications, the high frequency annual data used by this study requires a dynamic set up which calls the use of Arellano–Bond estimator to handle the dynamic panel bias.

Chapter 6 presents and analyzes empirical results. To get preliminary results, I first used the entire sample of 269 MSAs. The results show that all agricultural variables have significant impacts on both population level and growth with correct signs. I then examined

[5] In the set of region by region regressions, the R^2 ranges from 21.6% (for Southern Seaboard) to 80.3% (for the Northern Great Plains). Table 4.3.1 reports these results.

the impact of agricultural variables for two shorter periods: 1978 to 1990, and 1990 to 2000. The reason of splitting the sample is that these two periods provide two different patterns of price change: while the former contains a period of long and drastic price drop, the latter contains a period of short price spike.

For the period of 1978 to 1990, significant results regarding the population level and growth rate retain for all measures of agricultural variables. As observations were restricted to more agricultural MSAs, say, with a minimum base land share[6] of 20% and 30% respectively, both the size and significance of the coefficients increased. I also split the sample by agricultural regions to examine the possible influential region. Results show that the Southern Seaboard, which has the lowest share of base land, is influential, bluring the results in several cases.[7] To examine the short term impact of price changes, I further split the sample at 1986 where the price decline ended. Results show that the impact of agricultural variables is stronger in the period prior to 1986. By using single year measures, I also examined the impact of contemporaneous and future agricultural variables where no significant impacts were found. Finally, I examined the impact of the changes of agricultural variables. While the impacts of first order lagged revenue and cost are significant for population levels, they are not significant for population growth rate.

For the second period, 1990 to 2000, I conducted a similar set of regressions. No significant results were obtained when all observations were included, but as I restricted observations to MSAs with a minimum base land share of 30%, significant results emerged for both population levels and growth rates. Moreover, as the observations were further restricted to the period of the price spike, say, 1994 to 1996 or 1997, the impacts became stronger. I also examined the time structure, the results of which show that only the lagged revenue is significant. Finally, no significant impacts of the changes in agricultural variables were found.

For each period, I also conducted a set of panel cointegration tests. Testing results show

[6]The share of crop land and grazing land with respect to the total land area of the metropolitan area.

[7]Results without the Southern Seaboard are close to results with the sample with a minimum base land share of 30%, suggesting the influence of the Southern Seaboard is more likely due to the lack of agricultural land rather than regional heterogeneities.

that the panel is not cointegrated when all MSAs are included. However, as I restricted observations to MSAs with base land share greater than 30%, the tests were passed.

There were several general conclusions based on the empirical analysis of the two periods. First, spurious correlation may arise in metropolitan areas with restricted agricultural land. This is because the agricultural variables poorly measure the opportunity cost of land in these areas. Second, observations in decennial census years are influential. The series of population growth rate with 2000 are not even stationary. Third, contemporaneous and future impact of agricultural variables do not exist. And fourth, weighted averages of agricultural variables are superior to single averages in the sense that estimation results are more consistent.

Guided by lessons learnt from the two periods, I pooled observations in both periods, restricting observations to MSAs with base land share greater than 30%, to provide a final estimation of the impact of agricultural variables. Based on the estimation results, I also the simulated the impact of government payment and a series of hypothesized price shock of corn for selected MSAs.

7.2 Caveats with Suggested Improvement on Future Work

Although the primary goal of study has been accomplished, there are still opportunities for improvement. First, the measure of agricultural rents can be improved. As has been mentioned in Section 4.3, the imputed revenues, costs, and government payments for the Northern Crescent and the Southern Seaboard do not fit the market value as well as other regions. However, when milk was removed from calculation, the R^2 was raised to about 50%.[8] Because milk cows in the North depend more on feed grains, including milk cows for this area may overstate the value of land. As more data on cattle on feed are available, say, after the mid of 1990s, we can get better measures.

Another issue is the unobserved products. As has been discussed in Chapter 4, the wood land accounts for about 30% of the total agricultural land. Unfortunate, data on wood products are not available. One solution may be using commercial data provided by

[8]This result does not apply to other regions, however.

regional wood product associations. Another set of unobserved products are the unobserved crops, such as beans, tobaccos, potatoes, vegetables, and fruits. Data for these crops are more available in recent Annual County Crop surveys, say, after 1990. Therefore, the study can be updated with the new data with a focus on periods after 1990. The most recent price spike since 2006 will be especially interesting because the supply of agricultural land is far more tight than the 1990s, which suggests stronger impacts of the commodity prices on urban growth.

Regardless of measurement issues, the study will be more complete if the impact of agricultural variables on income can be examined. The appeal of the intercity spatial equilibrium framework, after all, is its capability of endogenizing the labor market. While time series data on income are not available for 1980s, they are more available in recent years. We can update this study by using more recent data and examine whether income respond to changes in opportunity cost of land.

One more interesting question to ask is who will be affected more by the shock in land cost. When the commodity price increase, there are two reasons why the growth should slow down: first, local residents find it is time to leave; and second, potential immigrants postpone their plan of moving in. Do the change in land cost affect different people the same or affect more for margin residents? Furthermore, as the opportunity cost of land has a stronger impact on the edge of the metropolitan areas, we may expect the latter is true, therefore it is interesting to know who are those marginal residents. Answers to this question certainly require more information on the behavior of migrants.

Bibliography

D. Albouy. Are big cities really bad places to live? improving quality-of-life estimates across cities. *NBER Working Paper Series 14472*, 2008.

W. Alonso. *Location and Land Use*. Harvard University Press, 1964.

J. Altonji and D. Card. The effects of immigration on the labor market outcomes of less-skilled natives. 1991.

C. H. Barnard, G. Whittaker, D. Westenbarger, and M. Ahearn. Evidence of capitalization of direct government payments into U.S. cropland values. *Amercian Journal of Agricultural Economics*, 79(5):1642–1650, 1997.

G. Blomquist, M. Berger, and J. Hoehn. New estimates of quality of life in urban areas. *The American Economic Review*, pages 89–107, 1988.

J. K. Brueckner. *Handbook of Regional and Urban Economics, Vol. II*, chapter 20: The structure of urban equilibria: A unified treatement of the Muth–Mills model, pages 821–45. Elsevier Science Publisher B.V, 1987.

J. K. Brueckner and D. A. Fansler. The economics of urban sprawl: Theory and evidence on the spatial size of cities. *The Review of Economics and Statistics*, 65(3):479–82, August 1983.

J. K. Brueckner and H.-A. Kim. Urban sprawl and the property tax. *International Tax and Public Finance*, 10(1):5–23, 2003.

J. K. Brueckner, J.-F. Thisse, and Y. Zenou. Why is central Paris rich and downtown Detroit poor? An amenity-based theory. *European Economic Review*, 43(1):91–107, 1999.

M. Burchfield, H. G. Overman, D. Puga, and M. A. Turner. Causes of sprawl: A protrait from space. *The Quarterly Journal of Economics*, May:587–633, 2006.

C. Calomiris, R. Hubbard, J. Stock, and B. Friedman. The farm debt crisis and public policy. *Brookings Papers on Economic Activity*, 1986(2):441–485, 1986.

D. R. Capozza and R. W. Helsley. The fundamentals of land prices and urban growth. *Journal of Urban Economics*, 26(3):295 – 306, 1989.

CBO. The impact of ethanol use on food prices. *Congressional Budget Office*, April, 2009.

J. Cullen and S. Levitt. Crime, urban flight, and the consequences for cities. *Review of Economics and Statistics*, 81(2):159–169, 1999.

A. B. Daugherty. U.s. grazing lands: 1950-82. *Statistical Bulletin Number 771, Economic Research Service, USDA*, 1989.

B. Gardner. Us commodity policies and land prices. *Working Papers*, 2002.

E. Glaeser and J. Gyourko. Housing dynamics. *NBER Working Paper Series*, 2006.

E. Glaeser and K. Tobio. The rise of the sunbelt. *Southern Economic Journal*, 74(3): 610–643, 2008.

E. Glaeser, J. Kolko, and A. Saiz. Consumer city. *Journal of Economic Geography*, 1(1): 27, 2001.

E. Glaeser, A. Saiz, G. Burtless, and W. Strange. The rise of the skilled city. *Brookings-Wharton Papers on Urban Affairs*, pages 47–105, 2004.

E. L. Glaeser. *Cities, Agglomeration and Spatial Equilibrium.* Oxford University Press, 2008.

E. L. Glaeser and J. Gyourko. Urban decline and durable housing. *Journal of Political Economy*, 113 (2):345–75, 2005.

E. L. Glaeser and J. M. Shapire. Urban growth in the 1990s: Is city living back? *Journal of Regional Science*, 43:139–165, 2003.

E. L. Glaeser, J. A. Seheinkman, and A. Shleifer. Economic growth in a cross-section of cities. *Journal of Monetary Economics*, 36:117–143, 1995.

E. L. Glaeser, J. Gyourko, and R. Saks. Why have housing price gone up? *American Economic Review*, 95(2):329–333, 2005.

E. L. Glaeser, J. Gyourko, and R. E. Saks. Urban growth and housing supply. *Journal of Economic Geography*, 6:71–89, 2006.

B. K. Goodwin, A. K. Mishra, and F. Ortalo-Magn. The buck stops where? the distribution of agricultural subsidies. Working Paper 16693, National Bureau of Economic Research, January 2011. URL http://www.nber.org/papers/w16693.

P. Graves. Migration and climate. *Journal of regional Science*, 20(2):227–237, 1980.

J. Gyourko and A. Saiz. Construction costs and the supply of housing structure. *Journal of Regional Science*, 46(4):661–680, 2006.

J. Gyourko and J. Tracy. The structure of local public finance and the quality of life. *Journal of Political Economy*, 99(4):774–806, 1991.

J. Gyourko, C. Mayer, and T. Sinai. Superstar cities. (12355), July 2006. URL http://www.nber.org/papers/w12355.

R. E. Heimlich and W. D. Anderson. Development at the urban fringe and beyond: Imapcts on agriculture and rural land. *Agricultural Economic Report No. 803 (USDA)*, June, 2001.

J. Hoehn, M. Berger, and G. Blomquist. A hedonic model of interregional wages, rents, and amenity values. *Journal of Regional Science*, 27(4):605–620, 1987.

H. Hoyt. *One Hundred Years of Land Values in Chicago*. Chicago: The University of Chicago Press, 1933.

M. Kahn. Smog reductions impact on california county growth. *Journal of Regional Science*, 40(3):565–582, 2000.

B. E. Kirwan. The incidence of US agricultural subsidies on farmland rental rates. *Journal of Political Economy*, 117(1):138–164, 2009.

D. M. Lambert and T. W. Griffin. Analysis of government farm subsidies on farmland cash rental rates using a fixed effect spatial distributed lag model and a translog cost model. In *Agricultural and Applied Economics Association 2004 Annual Meeting, Denver*, 2004.

P. G. Lewis. Retail politics: Local sales taxes and the fiscalization of land use. *Economic Development Quarterly*, 15(1):21, 2001.

R. N. Lubowski, M. Vesterby, S. Bucholtz, A. Baez, and M. J. Roberts. Major uses of land in the Uinited States, 2002. *Economic Information Bulletin Nov. 14, Economic Research Services*, May 2006.

J. McDonald. *Fundamentals of Urban Economics.* Upper Saddle River, NJ: Prentice-Hall, 1997.

D. T. McGrath. More evidence on the spatial scale of cities. *Journal of Urban Economics*, 58:1–10, 2005.

D. P. McMillen. One hundred fifty years of land values in Chicago: a nonparametric approach. *Journal of Urban Economics*, 40:100–24, 1996.

P. Mieszkowski and E. S. Mills. The causes of metropolitan suburbanization. *Journal of Econoic Perspectives*, 7(3):135–147, 1993.

E. S. Mills. An aggregative model of resource allocation in a metropolitan area. *American Economic Review*, 57:197–210, 1967.

E. S. Mills. *Studies in the Structure of the Urban Economy.* Baltimore: The Johns Hopkins Press, 1972.

E. S. Mills and L. S. Lubuele. Inner cities. *Journal of Economic Literature*, 35(2):727–756, 1997.

D. Mitchell. A note on rising food prices. *Policy Research Working Paper*, WP4682, 2008.

E. Moretti. *Handbook of Regional and Urban Economics, Vol. IV*, chapter 51: Human capital externalities in cities, pages 2244–2291. Amsterdam: North-Holland, 2004.

R. F. Muth. *Cities and Housing*. The University of Chicago Press, 1969.

S. Nickell. Biases in dynamic models with fixed effects. *Econometrica: Journal of the Econometric Society*, pages 1417–1426, 1981.

M. Peters, S. Langley, and P. Westcott. Agricultural commodity price spikes in the 1970s and 199s: valuable lessons for today. *Amber Waves Magazine*, 3, 2009.

J. Roback. Wages, rents, and the quality of life. *Journal of Political Economy*, 90(6): 1257–1278, 1982.

M. Roberts and M. Setterfield. Endogenous regional growth: a critical survey. *Cambridge Centre for Economic and Public Policy, Department of Land Economy, University of Cambridge, mimeo*, 2006.

M. J. Roberts, B. Kirwan, and J. Hopkins. The incidence of government payments on agricultural land rents: The challenges of identification. *Amercian Journal of Agricultural Economics*, 85(3):762–769, 2003.

D. Roodman. How to do xtabond2: An introduction to difference and system GMM in Stata. *Center for Global Development*, 2006.

M. Rosegrant. *Biofuels and grain prices: impacts and policy responses*. International Food Policy Research Institute Washington, DC, 2008.

S. Rosen. *Current Issues in Urban Economics*, chapter Wage-Based Indexes of Urban Quality of Life, pages 74–104. Johns Hopkins University Press, 1979.

A. Saiz. The geographic determinants of housing supply. *Forthcoming: Quarterly Journal of Economics*, 2010.

R. Saks. Job creation and housing construction: Constraints on metropolitan area employment growth. *Journal of Urban Economics*, 64:178–195, 2007.

J. Shapiro. Smart cities: Quality of life, productivity, and the growth effects of human capital. *The Review of Economics and Statistics*, 88(2):324–335, 2006.

S. D. Short. Characteristics and production costs of u.s. cow-calf operations. *Electronic Report from the Economic Reseach Service*, Statistical Bulletin No. 974-3, 2001.

Y. Song and Y. Zenou. Property tax and urban sprawl: Theory and implications for US cities. *Journal of Urban Economics*, 60(3):519–534, 2006.

C. Spivey. The Mills Muth model of urban spatial structure: Surviving the test of time? *Urban Studies*, 45(2):295–312, 2008.

R. Wassmer. Causes of urban sprawl in the United States: Auto reliance as compared to natural evolution, flight from blight, and local revenue reliance. *Journal of Policy Analysis and Management*, 27(3):20, 2008.

W. C. Wheaton. A comparative statics analysis of urban spatial structure. *Journal of Economic Theory*, 9:223–37, 1974.

Vita

Bo Jiang

Date of Birth: Apr. 3, 1975

Harbin, China

MAJOR FIELD OF CONCENTRATION

Public Economics, Industrial Organization, Urban and Regional Economics

EDUCATION

Ph.D	Economics	University of Kentucky	Aug 2011
M.A.	Economics	University of Kentucky	May 2006
M.A.	Public Adminstration	Harbin Institute of Technology	Jul 2004
B.Sc.	International Finance	Harbin Institute of Technology	Jul 1997

TEACHING EXPERIENCE

Instructor	Business Statistics	2006-2009
Instructor	Principle of Economics II (Macro)	2008
Teaching Assistant	Econometrics I (graduate)	2007
Teaching Assistant	Quantitative Method (graduate)	2006

PRESENTATION

"Waiting cost, heterogeneous preference and policy implications in bus industry"
China Economics Annual Conference (2009). Dec 12, 2009
"Opportunity cost of lands and urban growth"
Department of Economics, University of Kentucky. Nov 3, 2010

PUBLICATION

Public Monopoly, Deregulation, and Competitive Tendering: Regulation Theories and Practices in Urban Bus Transportation. Harbin Institute of Technology Press 2006. [Ch 2-4, 6, 9, 10(first two sections), Appendix I]

SCHOLARSHIPS AND AWARDS

KGS Scholarship	2005-2011	Graduate School, University of Kentucky
Department Scholarship	2006	Dept of Econ, University of Kentucky
Samsung Scholarship	2004	Harbin Institute of Technology
People's Scholarship	1993-1997	Harbin Institute of Technology