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Impacts of Regional Growth on Farmland Development in the Northeast U.S.

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by

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Abstract: This study models the relationship between regional growth and agricultural land development in the Northeast United States. A system of simultaneous equations is estimated using three-stage-least squares on county-level data. Results indicate that regional growth puts upward pressure on agricultural land values and downward pressure on the stock of agricultural land. Farm performance and some farmland protection policies were not effective in limiting farmland development.

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Introduction

A loss of agricultural land affects rural economies, environmental quality, and other socio-economic activities. Urbanization of rural land raises issues at state and local levels with regard to protecting watersheds, maintaining air quality, providing open space, preserving rural lifestyles, managing urban growth, and supporting local economies (Kline and Wichelns 1996). As a result, many states have initiated some type of land use policy to manage the loss of farmland and its associated private and public benefits (Nickerson and Hellerstein 2003).

In recent decades, many factors have altered demographic and economic land use patterns of rural areas. Some of these reasons are a shifting economic base and a change in employment opportunities (Dissart and Deller 2000; Lewis, Hunt and Plantinga 2002). Fleming (1989) noted that the increasing proximity of urban sprawl to agricultural activities caused changes in the farming community. As the influence of the city raises opportunity costs, some farmers must decide if they can afford to continue to use their land for agriculture. When farmers become uncertain about the future viability of agriculture in their area, farmland production falls. Ultimately, the critical mass of farming needed to sustain the local agricultural economy may collapse (Daniels and Nelson 1986; Lynch and Carpenter 2003).

A number of other factors have also been identified in the land use change literature. Rising per capita income associated with growth of communities may result in shifts in the demand for location-specific amenities. Since changes in consumption of location-specific amenities can only be possible through relocation (Knapp and Graves 1989), in the long run, these changing demands may lead to migration to more desirable locations (Graves 1983). Deller et al. (2001) argue that in addition to local characteristics like taxes and income, a significant relationship between amenities, quality of life, and local economic performance exists. Similarly, Gottlieb (1994), English, Marcouiller, and Cordell (2000), Roback (1988), and Henry et al. (1999) indicate that the inclusion of amenity factors in explaining regional growth differences appears powerful. Aldrich and Kusmin (1997) briefly discussed determinants of suburban and rural growth to include variables such as taxation, public spending, the unemployment rate, urbanization, minority population concentration, and local fire protection rates. Bell and Irwin (2002) mention factors like proximity to employment and other activities, natural features, surrounding land use patterns, and land use policies that may affect the pattern of land use change. The forces that shape regional land use change could be aggregated into population growth, household formation, income growth (Heimlich and Anderson 2001) and employment growth.

The main objective of this study is to analyze the relationship between changes in regional growth and agricultural land development. Specifically, to develop a growth equilibrium model that captures the relationships between regional growth patterns, agricultural land prices, farmland protection policies, and farmland development.

Methodology

To capture the impact of inter-temporal employment density, population density, per capita income, and agricultural land value changes on farmland stocks, a growth equilibrium model is further developed and applied in this study.

It is assumed that households maximize utility by consuming a vector of goods and services as well as location and non-market amenities. Households will migrate until marginal utilities are equalized across locations. Households are assumed to be drawn to regions with high income growth and employment opportunities. Producers are assumed to maximize profit from the production of goods and services. Firms select locations to capture locational cost and revenue advantages, including transportation cost savings, agglomeration benefits and regional labor cost savings as well as labor quality benefits. Firms enter and leave regions until competitive profits are equalized across regions. It is also assumed that firms and households adjust to disequilibrium over time. In a general equilibrium framework, population, employment, and income are affected not only by each other, but also by a variety of other variables. In principle, many such variables might be simultaneously determined along with population, employment (Carlino and Mills 1987) and income. Agricultural land values and changes in stocks of farmland are also assumed to adjust with lags.

Following these assumptions, a simultaneous relationship between farmland development and employment growth, population growth, changes in per capita income, and agricultural land values can be specified as:

(1) $$P^* = f_P(E^*, I^*, V^* | \Omega^P)$$

(2) $$E^* = f_E(P^*, I^*, V^* | \Omega^E)$$

(3) $$I^* = f_I(P^*, E^*, V^* | \Omega^I)$$

(4) $$V^* = f_V(P^*, E^*, I^*, L^* | \Omega^V)$$

(5) $$L^* = f_L(P^*, E^*, I^*, V^* | \Omega^L)$$

where P^*, E^*, I^*, V^*, and L^* refer to equilibrium levels of population, employment, per capita income, value of agricultural land, and stock of agricultural land, respectively. Vectors of exogenous variables have direct or indirect impacts on population, Ω^P, employment, Ω^E, per capita income, Ω^I, value of agricultural land, Ω^V, and stock of agricultural land, Ω^L.

Population and employment (Mills and Price 1984), income levels, farmland values, and stocks of agricultural land are likely to adjust to their equilibrium values with substantial lags.

Equilibrium levels of farmland adjust to previous period conversion patterns, and thus are influenced by agricultural land conversion in the current year, *t*, leading to distributed lag adjustment equations:

(6) $P_t = P_{t-1} + \lambda_P (P^* - P_{t-1})$

(7) $E_t = E_{t-1} + \lambda_E (E^* - E_{t-1})$

(8) $I_t = I_{t-1} + \lambda_I (I^* - I_{t-1})$

(9) $V_t = V_{t-1} + \lambda_V (V^* - V_{t-1})$

(10) $L_t = L_{t-1} + \lambda_L (L^* - L_{t-1})$

where λ_P, λ_E, λ_I, λ_V, and λ_L are speed-of-adjustment coefficients with values between zero and one (Carlino and Mills 1987), and $t-1$ is a one period lag. Thus, current population, employment, per capita income, farmland prices, and agricultural land stocks are dependent on their one period lagged levels and on the change between equilibrium values and one period lagged values, adjusted at their respective speed-of-adjustment rates. Rearranging terms and using Δ to represent change between the two periods in the respective variables, results in the following equations:

(11) $\Delta P = P_t - P_{t-1} = \lambda_P (P^* - P_{t-1})$

(12) $\Delta E = E_t - E_{t-1} = \lambda_E (E^* - E_{t-1})$

(13) $\Delta I = I_t - I_{t-1} = \lambda_I (I^* - I_{t-1})$

(14) $\Delta V = V_t - V_{t-1} = \lambda_V (V^* - V_{t-1})$

(15) $\Delta L = L_t - L_{t-1} = \lambda_L (L^* - L_{t-1})$.

The right hand side equilibrium variables are not observable in equations (11) through (15); however, they can be solved from equations (6) through (10). Including the impact of the exogenous variables from equations (1) through (5) and following Deller et al. (2001), the econometric equations can be linearly expressed as:

(16) $$\Delta P = \alpha_P + \beta_{1P} P_{t-1} + \beta_{2P} \Delta E + \beta_{3P} \Delta I + \beta_{4P} \Delta V + \sum_i \delta_{iP} \Omega^P + \varepsilon$$

(17) $$\Delta E = \alpha_E + \beta_{1E} E_{t-1} + \beta_{2E} \Delta P + \beta_{3E} \Delta I + \beta_{4E} \Delta V + \sum_i \delta_{iE} \Omega^E + \mu$$

(18) $$\Delta I = \alpha_I + \beta_{1I} I_{t-1} + \beta_{2I} \Delta P + \beta_{3I} \Delta E + \beta_{4I} \Delta V + \sum_i \delta_{iI} \Omega^I + \tau$$

(19) $$\Delta V = \alpha_V + \beta_{1V} V_{t-1} + \beta_{2V} \Delta P + \beta_{3V} \Delta E + \beta_{4V} \Delta I + \beta_{5V} \Delta L + \sum_i \delta_{iV} \Omega^V + \gamma$$

(20) $$\Delta L = \alpha_L + \beta_{1L} L_{t-1} + \beta_{2L} \Delta P + \beta_{3L} \Delta E + \beta_{4L} \Delta I + \beta_{5L} \Delta V + \sum_i \delta_{iL} \Omega^L + \psi ,$$

where $\sum_i \delta_{ij} \Omega^j$ refers to *i* exogenous variables, and ε, μ, τ, γ, and ψ are the error terms.

This simultaneous equation system is estimated using three-stage least squares, which is preferred to two-stage least squares because it is a full-information estimation procedure that estimates all parameters simultaneously and provides asymptotically more efficient results than that of two-stage least squares (Ma and Hoshino 2003).

Data

County-level data for the Northeast states (Connecticut, Delaware, the District of Colombia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia[1]) are used to estimate the econometric model. The northeastern region is used for a number of reasons. First, the region has some of the highest land development and economic growth rates in the country. Second, this study area also contains significant agricultural activity, which enables testing of the relationship between regional

[1] This study uses the Northeastern U.S. states as listed by the Northeast Regional Center for Rural Development (see http://www.cas.nercrd.psu.edu/Toolbox/index.htm).

economic growth and agricultural land development. Third, the region has heterogeneous land use policy implementation with some of the earliest farmland preservation policies (Maryland and New York) as well as states with limited or no statewide farmland protection initiatives (West Virginia). This range of implemented agricultural land protection policies provides a policy rich environment under which the effect of these policies on farmland development can be tested.

Definitions for the endogenous, initial-condition, and employment variables are given in table 1. Changes in population density, employment density, and per capita income were computed from the Regional Economic Information System (REIS) (U.S. Census 2001). County-level changes in per acre farmland values, and agricultural land density were calculated from the U.S. Census of Agriculture (NASS 2004). Data from the REIS measure the contribution of different sectors of the economy to regional growth using number of persons employed in construction, farming, mining, and services.

The median value of owner-occupied housing, unemployment rate, and number of hospital beds per 100,000 people represent county characteristics which reflect the attractiveness of moving to a county or staying there based on access to affordable housing, economic opportunities and healthcare services. These variables help measure the indirect impact of these local characteristics on farmland development. The percentage of a county's population (age 25 and above) with a bachelor's degree and higher, along with the percentage of persons in a county below the federal poverty line reflect county characteristics regarding the degree of human capital formation and distribution of poverty. These variables may have significant bearing on county income and employment growth, which consequently may affect the extent of farmland development. Definitions for these county characteristics are presented in table 2. Per capita taxes, property taxes, local government expenditures, the unemployment rate, median housing values, number of hospital beds, and education and poverty levels are from the County and City Data Book (C&CDB 1994).

State and interstate road density reflect the degree of infrastructure development, which could have a significant impact on county economic growth, demographic change, and consequent farmland development. These variables were calculated by the West Virginia University Natural Resources Analysis Center using Geographic Information System (GIS) software (NRAC 2005) and definitions are given in table 2. The urban influence code (table 2), developed by the USDA Economic Research Service (2003), measures the extent of development pressure from urbanized places and ranges from 1 to 9. A code of 1 indicates a county that is in a metro area with at least 1 million residents or more; 2 indicates a metro area with fewer than 1 million residents; 3 means the county is in a micropolitan area adjacent to a large metro area; 4 indicates a non-core county adjacent to a large metro area; and 5 represents a micropolitan area adjacent to a small metro area. A code of 6 indicates a non-core county which is adjacent to a small metro area and which contains a town of at least 2,500 residents; 7 is for a non-core county adjacent to a small metro and which does not contain a town of at least 2,500; 8 indicates a micropolitan area not adjacent to a metro area; and code 9 represents a non-core county which is adjacent to a micro area and which contains a town of 2,500 to 9,999 residents.

Agricultural characteristic and farmland protection program variables are defined in table 2. Agricultural income per farm and average government payment per farm were computed from the U.S. Census of Agriculture (NASS 2004). The percentage of county land in farms (NASS 2004) is included to test whether concentration of farming activity influences the value of land or the extent of farmland development. Farmland protection policies are included to determine their impact on farmland density compared to states without these programs. Because county-level data was not available for these policies, a dummy variable is used which indicates the presence or absence of these policies at the state level. All policy data are from the Northeast Sustainable Agriculture Working Group (NSAWG 2003). Purchase of development rights (PDR) is excluded from the analysis as almost all states in the Northeast have adopted this policy.

Descriptive statistics for all the variables are reported in tables 3 and 4. There are 299 counties in the northeastern states; however, the descriptive statistics are based on 290 counties. Baltimore, Maryland was excluded because it is not included in the Census of Agriculture. The other 8 counties excluded from this study are: Suffolk, Massachusetts; Hudson, New Jersey; Bronx, New York; Kings, New York; New York, New York; Queens, New York; Richmond, New York; and Philadelphia, Pennsylvania. Each of these counties, except Philadelphia, reported zero agricultural employment for the study period. Seven of the counties had less than 26 acres of farmland, and by 2002, Philadelphia had only 31 acres of farmland. Although these counties are fast growth centers, attempting to measure the impact of their growth on the negligible amount of farmland in these counties will be misleading as there will be almost no change. The urban influence code for each of the included counties should capture some of the missing information due to the excluded counties.

Discussion of Results

Population Density Change

The coefficient estimates for all variables in the model are provided in tables 5, 6 and 7. Population density change (ΔP) is significantly and positively associated with employment density change (ΔE). This result reinforces similar conclusions in other studies that regions with employment growth attract population. The relationship with per capita income change (ΔI) is negative and significant. Even though it is expected that counties with income growth will experience higher population growth, this result for the Northeast U.S. indicates that population density is growing in counties with declining per capita income. This result may be picking up an increase in population in suburban and rural locations where income is not growing very fast. It was expected that increases in farmland prices (ΔV) would lead to a decline in population density; however, this result is statistically insignificant.

The initial population level (P_{t-1}) is negatively and significantly related to population density change. Counties with higher initial population experienced negative growth. This result confirms a similar conclusion by Deller et al. (2001) that counties with higher population density have lower population growth.

Population growth is also significantly affected by the distribution of the tax burden and local government expenditures. Consistent with prior expectations, counties with a higher per capita tax burden ($PerCapTax_{t-1}$) and higher proportion of government income coming from property taxes ($PropTaxPct_{t-1}$) experienced significantly lower population growth. The per capita local government expenditures variable ($GovtExpPC_{t-1}$) is positively and significantly related to population density change. Differences in local government spending may affect the provision of local public goods overtime, which can affect people's migration decisions. Increases in population density are higher in areas with higher median housing values ($MedHsVal_{t-1}$) and lower unemployment rates ($UnEmpRate_{t-1}$), however, the latter is not significant. Number of hospital beds ($HospBd100K_{t-1}$) is significant, but contrary to prior expectation has an inverse relationship with changes in population density. This variable could be a weak proxy for county health care facilities, but the result indicates that population growth is higher in counties with a relatively lower number of hospital beds. Population density appears to be higher in counties with higher state ($StatHwyDen_{t-1}$) and interstate highway densities ($InterstateDen_{t-1}$); however, neither variable was significant.

Employment Density Change

Employment density change (ΔE) is positively and significantly related with population density change (ΔP). Other things being equal, a 1 person per square mile increase in county population attracts 0.538 jobs per square mile. This result reinforces the argument that jobs follow population movements. Change in employment density is also positively and significantly related with growth in per capita income (ΔI). This may be due to the fact that, from a regional perspective, places with higher income (economic) opportunities attract investment and jobs. Counties with higher farmland values (ΔV) experienced slower employment growth, perhaps because counties with high land values are less attractive for building manufacturing facilities or office or shopping complexes. Moreover, initial employment density (E_{t-1}) is not significant in determining employment density change.

Counties with a greater emphasis on property taxes ($PropTaxPct_{t-1}$) experienced slower increases in employment, however, this result was not significant. Counties with a higher unemployment rate ($UnEmpRate_{t-1}$) experienced slower employment increases. The unemployment rate may be measuring the local business climate with higher unemployment rates indicating a less attractive place to do business. The positive influences of state ($StatHwyDen_{t-1}$) and interstate highway densities ($InterstateDen_{t-1}$) on employment growth confirm previous findings (e.g., Carlino and Mills 1987) that development of road infrastructure accelerates job creation. A one mile of road per square mile increase results in an increase of 41.6 jobs per square mile for interstate highways and 59.2 jobs for state roads.

Mining sector employment ($MineEmp_{t-1}$) and service sector employment ($ServEmp_{t-1}$) are positively and significantly related with overall employment growth; however, the construction employment ($ConstEmp_{t-1}$) coefficient is negative. Counties with more construction jobs experienced slower employment creation, which may reflect construction and development activities in rural counties where overall job growth is usually slower.

Per Capita Income Change

Change in per capita income (ΔI) is negatively and significantly related to population growth (ΔP), indicating that counties with faster population growth experienced slower per capita income growth. Average county income with a growing population may decline if income growth does not keep pace with population growth. Per capita income growth is positively and significantly related with growth in employment density (ΔE). Counties with more employment expansion see more growth in income. Other things being equal, for a one unit increase in employment per square mile, per capita income is expected to grow by $21.50. Positive changes in farmland values (ΔV) have a positive and significant impact on per capita income growth. This result may be reflecting rapidly growing regions that have higher per acre agricultural land values. The negative and significant relationship between per capita income change and initial per capita income (I_{t-1}) suggests that counties with initially lower income experienced greater income growth than counties with higher income in the earlier period. This may suggest a trend in regional growth towards development in rural areas (Deller et al. 2001).

The per capita tax burden ($PerCapTax_{t-1}$) is negatively but not significantly related to per capita income change. The relationship between the proportion of a county's population with a bachelor's degree or higher ($\%BDPlus_{t-1}$), as a measure of human capital, and per capita income growth indicates that counties with high human capital endowments experienced higher income growth. Other things being equal, a one percent increase in the percentage of the population with a higher degree would raise per capita income by $387.98. The proportion of county population below the poverty line (%BelowPov$_{t-1}$) is negatively and significantly related to per capita income change. A one percent increase in the percentage of the population below poverty results in an overall decline in per capita income of $924.69. These two results suggest that while a better human capital endowment accelerates income growth, a high degree of poverty in a region may slow it down.

Accessibility within counties, measured by road density, is used to understand the impact of access on income growth. Both state (StatHwyDen$_{t-1}$) and interstate (InterstateDen$_{t-1}$) road density are positively related with income growth, however, only interstate road density is significant. Other things being equal, an increase of one mile of interstate per square mile in the county is expected to result in a per capita income increase of $5,219.97. This reaffirms earlier findings by Carlino and Mills (1987) that infrastructure development accelerates economic growth.

Per Acre Agricultural Land Value Change

Per acre change in agricultural land value (ΔV) is significantly and positively associated with population density change (ΔP). This result confirms a prior expectation that in counties with high population growth, pressures are put on existing land uses to accommodate the growing population. Some of the land used for growth comes from agriculture, hence its per acre value increases. This is consistent with prior studies that found that fast growing areas have significantly higher increases in land prices (Plantinga and Miller 2001; Nelson 1992; Shi, Phipps, and Colyer 1997). Change in the value of land is significantly and negatively related with employment density change (ΔE). This is contrary to prior expectations that employment growth exerts pressure on existing land uses and results in higher land values. This result may indicate that significant employment density changes are occurring in rural areas where agricultural land values per acre are lower.

Agricultural land value is positively and significantly related with per capita income change (ΔI). This confirms prior thinking that regions with high per capita income growth will have increasing land values. With growing income, environmental and amenity factors may enter into quality of life considerations leading to increased demand for first or second homes in suburban and rural areas. Overall increases in income may also have an impact on farm income and the value of agricultural land based on expected farm income through the creation of local markets for high-value agricultural products. The negative coefficient associated with the stock of agricultural land (ΔL) indicates that counties with farmland losses have higher per acre agricultural land values, however, this result was not statistically significant.

Change in per acre value of agricultural land is positively and significantly related with initial land values (V_{t-1}). Counties with higher land values in the earlier period experience positive change in land values, indicating upward momentum in farmland prices. The initial stock of agricultural land (L_{t-1}) was not significant in explaining agricultural land value changes.

Accessibility has a significant influence on the value of farmland in a county as shown by the positive coefficients associated with state ($StatHwyDen_{t-1}$) and interstate ($InterstateDen_{t-1}$) highway densities. Other things being equal, a one mile of road per square mile increase for interstate or state highways is expected to increase the per acre value of agricultural land in a county by $15,598.15 and $5,548.98, respectively. A positive relationship is as expected, and the result further indicates that interstate development will have a much stronger impact on marginal land values than a similar change in state roads. The urban influence code (UrbanInfCode), used as a proxy for development pressure, was not significant in the land value change equation.

Agricultural income per farm ($AgIncPFarm_{t-1}$) is positively and significantly related with the per acre value of agricultural land. Other things being equal, a $1,000 increase in agricultural income per farm would increase the value of land by $30 per acre. The proportion of county land in farms ($\%FrmLnd_{t-1}$) was not significant in determining value of agricultural land per acre.

Agricultural Land Density Change

The endogenous variable population density change (ΔP) is inversely related with agricultural land density, such that population growth may contribute to agricultural land development, but it was not statistically significant. Change in employment density (ΔE) is significantly and positively related with changes in agricultural land density. This result is contrary to a prior expectation that expansion of jobs demands more farmland for development. Employment growth can have a positive and a negative effect on agricultural land – more demand for farm products helps to maintain farming in the area, while demand for land for development makes farming more difficult. The former effect appears to dominate in this study. Per capita income growth (ΔI) is negatively and significantly related with agricultural land density change. Confirming prior expectations, counties with increases in per capita income experienced more farmland development. Other things being equal, a $1,000 increase in per capita income would reduce the amount of farmland by 4 acres. Change in per acre value of agricultural land (ΔV) was not significant in explaining agricultural land density change.

The initial stock of farmland (L_{t-1}) is positively and significantly related with the change in agricultural land density. Counties with a high initial endowment of farmland gained agricultural acreage while counties with a low initial endowment lost farmland. This may indicate the existence of a threshold density, a critical mass of farms, below which it may not be feasible to maintain farmland for agricultural use. Farmland losses could in part be a function of the endowment of productive farmland acres (Lynch and Carpenter 2003).

The effect of accessibility on agricultural land density change indicates that while state road density ($StatHwyDen_{t-1}$) has a negative and significant impact on agricultural land density change, interstate road density ($InterstateDen_{t-1}$) does not have a significant effect. Other things being equal, an increase of one mile of state road per square mile results in approximately a 77 acre loss in the amount of farmland per square mile. Not surprisingly, agricultural lands that are more accessible face more development pressure.

The initial level of farm employment ($FarmEmp_{t-1}$) in a county, as well as per farm agricultural income ($AgIncPFarm_{t-1}$) and government payments ($GovtPmt_{t-1}$) were not significant in explaining agricultural land density change.

A number of land use policy dummy variables are included in the agricultural land density change equation to capture the impact of these policies on farmland conversion. Tax easements (TaxEasement), agricultural districts (AgDistrict), agricultural protection zoning (AgProZone), and transfer of development rights (TDR) are among the widely applied farmland protection measures used today. Prior expectations suggest that farmland protection policies should decrease agricultural land losses in states that institute these policies compared to states that do not. Data on the types of farmland protection polices which are in place were available by state and not at the county level so comparisons are made between states and not counties. The results for these variables suggest that counties in states with at least two of these farmland protection programs have comparatively higher farmland losses. Counties in states with a tax break for the donation of an agricultural conservation easement lose about 190 acres per square mile more than those in states without this program. Similarly, counties in states that have a transferable development rights (TDR) program lose about 150 acres per square mile more compared to states without this program. One possible explanation for this unexpected result could be that these farmland protection policies were not introduced early enough to decrease growth, but rather as a response to already existing rapid growth and farmland losses. Similarly, in areas where development pressure is severe, these farmland protection programs may not be sufficient to reduce farmland losses. It could be the case that tax breaks for easement donation are no match for the high price a farmer can receive when selling the land for development in a fast growing region. TDR programs may reduce farmland loss in one part of the state only to accelerate it in another part of the state resulting in a net loss in agricultural land statewide. There was no significant difference in agricultural land development patterns in states with agricultural districts or agricultural zoning compared to states that have not implemented these policies, indicating the lack of an impact from these land use policies.

Conclusions

This paper tested the relationship between regional growth (in population density, employment density, and per capita income) and value of agricultural land per acre and the change in agricultural land density. It was hypothesized that rapidly growing regions would experience increases in agricultural land values per acre and development of agricultural lands. Results from this study indicated that county population change is accelerated by county employment expansion and local government spending, while local taxes can slow population change. County employment change is positively influenced by county population and per capita income changes and the development of state and interstate road densities. Increase in value of agricultural land per acre tends to slow down employment growth, perhaps by discouraging development of agricultural lands. Per capita income change is positively influenced by county employment growth, human capital formation, and interstate road density (county accessibility). However, county population growth and a high proportion of persons in poverty results in slower or negative per capita income growth.

Change in agricultural land value per acre accelerates in counties with rapid population and per capita income growth, in high state and interstate road density counties, and in counties with high per acre farm income. This result indicates that regional growth increases agricultural land values. Agricultural land development is high in counties with rapid population growth (though not significant) and in high per capita income growth counties. Accessibility of counties also increases agricultural land development. The result shows that states with land use policies did not see a significant decline in agricultural land development. Agricultural income per acre and the contribution of agriculture to county employment were not significant predictors of agricultural land development.

Thus, the results of this study indicate that regional growth puts upward pressure on land values and agricultural land stock losses. Development of agricultural land responds more to regional growth factors than to the performance of the sector itself in terms of agricultural income and employment creation.

The implication of these results is multifaceted. One, integration of the agricultural land development issue within a regional growth framework provides encouraging results. Considering regional growth factors in local and regional land use policy initiatives would be helpful. Two, agricultural land development is interrelated with multiple county-level economic factors like taxation, government spending, road infrastructure, human capital formation, level of poverty, and land use policy. All these factors have an effect on regional growth, and hence indirectly on the level of agricultural land development. Thus, a regional policy framework for managing land use would harmonize land use policies with other local economic development policies. Three, current land use policies do not appear to have a significant effect on reducing farmland development in this study. There are limitations to this result which only included four types of land preservation policies. Time series data may be more appropriate for analyzing the impact these policies have had over an extended period of time beyond the one period examined here. As such, conclusions regarding the effect of these farmland protection policies on reducing the extent of agricultural land development should be made cautiously. However, the general result from this study questions the effectiveness of the included land use policy tools for curbing development of farmland. Further discussion and research in the area of existing farmland protection policy effectiveness should be undertaken in future research.

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Table 1. Definitions: Endogenous, Initial Condition, and Employment Variables

Variable	Definition
Endogenous variables	
ΔP	Change in population density from 1987 to 1999
ΔE	Change in employment density from 1987 to 1999
ΔI	Change in per capita income from 1987 to 1999
ΔV	Change in per acre value of farmland from 1987 to 2002
ΔL	Change in agricultural land density from 1987 to 2002
Initial condition variables	
P_{t-1}	Persons per square mile (1987)
E_{t-1}	Jobs per square mile (1987)
I_{t-1}	Per capita income (1987)
V_{t-1}	Average per acre value of farmland (1987)
L_{t-1}	Number of farmland acres per square mile (1987)
Employment variables	
ConstEmp_{t-1}	Number of persons employed in construction (1987)
FarmEmp_{t-1}	Number of persons employed in farming (1987)
MineEmp_{t-1}	Number of persons employed in mining (1987)
ServEmp_{t-1}	Number of persons employed in the service sector (1987)

Table 2. Definitions: Independent Variables

Variable	Definition
County characteristics	
$PerCapTax_{t-1}$	Per capita taxes - total taxes paid / county population (1987)
$PropTaxPct_{t-1}$	Property taxes as a percentage of total taxes (1987)
$GovtExpPC_{t-1}$	Local government expenditures per capita (1987)
$UnEmpRate_{t-1}$	County unemployment rate (1987)
$MedHsVal_{t-1}$	Median owner-occupied housing value (1990)
$HospBd100K_{t-1}$	Number of hospital beds per 100,000 population (1991)
$\%BDPlus_{t-1}$	Percentage of population with bachelors degree or higher (1990)
$\%BelowPov_{t-1}$	Percentage of population with income below poverty line (1989)
$InterstateDen_{t-1}$	Miles of interstate highway per square mile (2000)
$StatHwyDen_{t-1}$	Miles of state highway per square mile (2000)
UrbanInfCode	Urban Influence Code (2003)
Agricultural characteristics	
$AgIncPFarm_{t-1}$	Agricultural income per farm (1987)
$GovtPmt_{t-1}$	Average federal government payment per farm (1987)
$\%FrmLnd_{t-1}$	Percentage of total land in farming (1987)
Farmland protection programs	
TaxEasement	Tax incentive for donation of farmland preservation easement (2002)
AgDistrict	Designation of an agricultural district (2002)
AgProZone	Protective farmland zoning (2002)
TDR	Transferable Development Rights program (2002)

Table 3. Descriptive Statistics: Endogenous, Initial Condition, and Employment Variables

Variable	Mean	Std. Dev.	Minimum	Maximum
Endogenous variables				
ΔP	16.87	55.28	-494.91	326.32
ΔE	22.55	44.67	-240.37	265.28
ΔI	8015.08	4465.55	2027.00	29382.00
ΔV	2904.74	6328.51	-492.00	74107.00
ΔL	-7.69	24.49	-143.92	115.14
Initial condition variables				
P_{t-1}	361.14	711.11	2.89	6426.30
E_{t-1}	194.75	414.46	1.34	3656.26
I_{t-1}	14847.90	3879.12	7311.00	27680.00
V_{t-1}	2131.66	2740.89	385.00	29697.00
L_{t-1}	157.64	105.84	0.67	478.84
Employment variables				
$ConstEmp_{t-1}$	5083.02	7893.12	48.00	48511.00
$FarmEmp_{t-1}$	1008.19	927.60	0.00	8337.00
$MineEmp_{t-1}$	376.32	717.65	0.00	5479.00
$ServEmp_{t-1}$	22594.19	41970.38	53.00	326659.00

Table 4. Descriptive Statistics: Independent Variables

Variable	Mean	Std. Dev.	Minimum	Maximum
County characteristics				
$PerCapTax_{t-1}$	602.16	318.44	90.00	2503.00
$PropTaxPct_{t-1}$	83.94	13.67	50.10	99.90
$GovtExpPC_{t-1}$	1.38	0.49	0.65	3.54
$UnEmpRate_{t-1}$	7.89	2.93	2.90	22.00
$MedHsVal_{t-1}$	86228.28	49036.48	15800.00	299400.00
$\%BDPlus_{t-1}$	17.01	7.94	4.60	49.90
$\%BelowPov_{t-1}$	12.14	6.39	2.60	39.20
$InterstateDen_{t-1}$	0.08	0.10	0.00	0.63
$StatHwyDen_{t-1}$	0.36	0.16	0.00	0.91
UrbanInfCode	4.10	2.73	1.00	9.00
Agricultural characteristics				
$AgIncPFarm_{t-1}$	50475.71	39302.73	1695.00	260507.00
$GovtPmt_{t-1}$	5492.16	4498.59	0.00	24741.00
$\%FrmLnd_{t-1}$	24.06	15.92	0.40	75.00
Farmland protection programs				
TaxEasement	0.33	0.47	0.00	1.00
AgDistrict	0.63	0.48	0.00	1.00
AgProZone	0.32	0.47	0.00	1.00
TDR	0.67	0.47	0.00	1.00

Table 5. Econometric Estimation Results: Endogenous and Initial Condition Variables

	ΔP Equation		ΔE Equation		ΔI Equation		ΔV Equation		ΔL Equation	
Variable	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**
Endogenous variables										
ΔP	-	-	**0.538**	**0.000**	**-21.70**	**0.000**	**9.23**	**0.091**	-0.052	0.520
ΔE	**0.582**	**0.003**	-	-	**21.50**	**0.002**	**-42.25**	**0.000**	**0.331**	**0.037**
ΔI	**-0.005**	**0.035**	**0.003**	**0.001**	-	-	**0.28**	**0.000**	**-0.004**	**0.049**
ΔV	0.002	0.282	**-0.003**	**0.000**	**0.26**	**0.000**	-	-	0.000	0.781
ΔL	-	-	-	-	-	-	-5.49	0.625	-	-
Initial condition variables										
P_{t-1}	**-0.042**	**0.000**	-	-	-	-	-	-	-	-
E_{t-1}	-	-	-0.010	0.475	-	-	-	-	-	-
I_{t-1}	-	-	-	-	**-0.59**	**0.003**	-	-	-	-
V_{t-1}	-	-	-	-	-	-	**1.20**	**0.000**	-	-
L_{t-1}	-	-	-	-	-	-	-10.65	0.620	**0.130**	**0.080**

Bold indicates a statistically significant parameter estimate at the 0.10 level or better.

Table 6. Econometric Estimation Results: County Characteristics

	ΔP Equation		ΔE Equation		ΔI Equation		ΔV Equation		ΔL Equation	
Variable	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**
$PerCapTax_{t-1}$	**-0.064**	**0.061**	-	-	-0.81	0.509	-	-	-	-
$PropTaxPct_{t-1}$	**-0.909**	**0.060**	-0.075	0.744	-	-	-	-	-	-
$GovtExpPC_{t-1}$	**43.880**	**0.025**	-	-	-	-	-	-	-	-
$UnEmpRate_{t-1}$	-0.949	0.659	**-2.294**	**0.016**	-	-	-	-	-	-
$MedHsVal_{t-1}$	**0.001**	**0.005**	-	-	-	-	-	-	-	-
$HospBd100K_{t-1}$	**-0.303**	**0.000**	-	-	-	-	-	-	-	-
$\%BDPlus_{t-1}$	-	-	-	-	**387.98**	**0.000**	-	-	-	-
$\%BelowPov_{t-1}$	-	-	-	-	**-924.69**	**0.000**	-	-	-	-
$InterstateDen_{t-1}$	73.730	0.277	**41.596**	**0.092**	**5219.97**	**0.015**	**15598.15**	**0.000**	53.933	0.192
$StatHwyDen_{t-1}$	87.380	0.289	**59.152**	**0.071**	3791.59	0.218	**5548.98**	**0.097**	**-76.655**	**0.014**
UrbanInfCode	-	-	-	-	-	-	231.76	0.203	-	-

Bold indicates a statistically significant parameter estimate at the 0.10 level or better.

Table 7. Econometric Estimation Results: Employment, Agricultural and Farmland Protection Variables

	ΔP Equation		**ΔE Equation**		**ΔI Equation**		**ΔV Equation**		**ΔL Equation**	
Variable	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**	**Coef.**	**p-value**
$ConstEmp_{t-1}$	-	-	**-0.004**	**0.013**	-	-	-	-	-	-
$FarmEmp_{t-1}$	-	-	-	-	-	-	-	-	-0.002	0.687
$MineEmp_{t-1}$	-	-	**0.027**	**0.009**	-	-	-	-	-	-
$ServEmp_{t-1}$	-	-	**0.001**	**0.000**	-	-	-	-	-	-
$AgIncPFarm_{t-1}$	-	-	-	-	-	-	**0.03**	**0.000**	0.000	0.139
$GovtPmt_{t-1}$	-	-	-	-	-	-	-	-	-0.005	0.183
$\%FrmLnd_{t-1}$	-	-	-	-	-	-	34.82	0.803	-	-
TaxEasement	-	-	-	-	-	-	-	-	**-189.84**	**0.001**
AgDistrict	-	-	-	-	-	-	-	-	-42.003	0.268
AgProZone	-	-	-	-	-	-	-	-	-20.104	0.274
TDR	-	-	-	-	-	-	-	-	**-149.85**	**0.000**
Constant	**127.766**	**0.017**	-6.418	0.465	**8954.27**	**0.002**	**-4437.10**	**0.002**	**232.31**	**0.000**

Bold indicates a statistically significant parameter estimate at the 0.10 level or better.