# Impact of Capital Gains and Urban Pressure on Farmland Values: A Spatial Correlation Analysis

Charles B. Moss (*University of Florida*), Ashok K. Mishra (*United States Department of Agriculture*), and Grigorios Livanis (*Northeastern University*)

Presented at the American Agricultural Economics Association Meetings
in Portland, Oregon 2007

# Impact of Capital Gains and Urban Pressure on Farmland Values: A Spatial Correlation Analysis

Charles B. Moss (*University of Florida*), Ashok K. Mishra (*United States Department of Agriculture*), and Grigorios Livanis (*Northeastern University*)

*Abstract:* Farmland is a major component of wealth in the farm sector as well as wealth of farm households. This study contributes to our knowledge of variations in farmland prices by examining the extent to which farmland values are spatially correlated and to what extent that this spatial correlation can be explained by income to farmland.

*Keywords*: land values, spatial correlation

## Introduction

This study examines changes in the spatial correlation of farmland values over time using the spatial correlation measure proposed by Theil, Moss, and Chen (1996). The stability of the agricultural balance sheet in the United States since World War II has been intimately linked to farmland values. Over this time period, farmland values have accounted for on average 70 percent of all agricultural asset values. In addition, financial crises such as the one occurring in the mid 1980s have been linked to weaknesses in the agricultural balance sheet resulting from falling farmland values coupled with the shortfalls in operating returns. Thus, analysis of factors contributing to the variation in farmland values is important in predicting the economic viability of the sector and potential need for policy response. Changes in farmland values may have a major impact not only on farm sector wealth, but also on the economic well-being of farm households through its linkages to consumption and investment. Further, large changes in farmland values may also affect the overall level of risk on farm sector investment. This research is closely related to the dynamics of farm and rural economy and in particular the economic well-being and agricultural market and factor markets. Results from this research will identify methods to improve measurement of farmland values at the farm and sector level.

Our results indicate that the spatial correlation fallen by 50 percent since the 1950s. Given this decline, we examine the possibility that this decline could be explained by market fundamentals. Specifically, we examine whether changes in returns to farmland have also decline through time. Again, our results indicate that the spatial correlation fell by 35 percent over the same time period. Thus, the decline in spatial correlation of farmland values is consistent with the decline in spatial correlation in returns.

## Measure and Data

Theil, Moss, and Chen (1996) suggest that

$$\sum_{i=1}^{N}\sum_{j=1}^{N} p_i p_j \left(x_i - x_j\right)^2 = 2\sigma^2 \qquad (1)$$

where $p_i$ is the share of the population in state $i$, $x_i$ is the variable of interest (in Theil, Moss, and Chen income per capita or in our application farmland values per acre), and $\sigma^2$ is the variance of that variable. To demonstrate their conjecture we start from the conclusion and work backwards

$$\begin{aligned}\sum_{i=1}^{N}\sum_{j=1}^{N} p_i p_j \left(x_i - x_j\right)^2 &= \sum_{i=1}^{N} p_i \sum_{j=1}^{N} p_j \left(x_i^2 - 2x_i x_j + x_j^2\right) \\ &= \sum_{i=1}^{N} p_i \left(\sum_{j=1}^{N} p_j x_i^2 - 2x_i \sum_{j=1}^{N} p_j x_j + \sum_{j=1}^{N} p_j x_j^2\right) \\ &= \sum_{i=1}^{N} p_i \left(x_i^2 - 2x_i \bar{x} + \left[\sigma^2 + \bar{x}^2\right]\right) \qquad (2) \\ &= \sum_{i=1}^{N} p_i x_i^2 - 2\bar{x} \sum_{i=1}^{N} p_i x_i + \left[\sigma^2 + \bar{x}^2\right] \\ &= \left[\sigma^2 + \bar{x}^2\right] - 2\bar{x}^2 + \left[\sigma^2 + \bar{x}^2\right] \\ &= 2\sigma^2\end{aligned}$$

where $\bar{x}$ is the population weighted mean of the sample.

Theil, Moss, and Chen and Moss (1996) then propose a decomposition of the variance based on that result. Specifically, they propose two measures

$$\begin{aligned} MSBD &= \frac{1}{\theta_B}\sum_B p_i p_j (x_i - x_j)^2 \ni: \theta_B = \sum_B p_i p_j \\ MSNB &= \frac{1}{\theta_N}\sum_N p_i p_j (x_i - x_j)^2 \ni: \theta_N = \sum_N p_i p_j \end{aligned} \qquad (3)$$

where $B$ denotes regions that share a common boarder or are contiguous and $N$ denotes those regions that are not contiguous; hence, $MSBD$ denotes the mean square error across contiguous regions, $MSND$ denotes the mean square difference across non-contiguous regions, $\theta_B$ is the share of the population in contiguous regions, and $\theta_N$ is the population share in non-contiguous regions. This specification decomposes into unit sum rule

$$\theta_B + \theta_N + H = 1 \qquad (4)$$

where $H$ is the Hirshman-Hefindahl concentration measure ($H = \sum_{i=1}^{N} p_i^2$). Hence, given that $(x_i - x_i)^2 = 0$ for all $i$, Equations 1 and 3 imply that

$$\sum_{i=1}^{N}\sum_{j=1}^{N} p_i p_j (x_i - x_j)^2 = \theta_B MSBD + \theta_N MSNB = 2\sigma^2 . \qquad (5)$$

Based on the implicit decomposition of the overall variance in Equation 5, Theil, Moss, and Chen and Moss use the ratio

$$r = \frac{MSBD}{MSNB} \qquad (6)$$

as a measure of the significance of spatial correlation. Intuitively, the higher $r$, the more dissimilar contiguous counties are compared to non-contiguous counties. Thus, the higher $r$, the less spatial correlation.

This study uses U.S. Department of Agriculture, Economic Research Service state-level data for 48 states (excluding Alaska and Hawaii) across 10 farm production regions from 1950 to 2005. These annual data on land values, interest rates, returns to farm assets, government payments, and debt servicing ratios are derived from a variety of sources such as the Census of Agriculture, various USDA agencies, Federal Deposit Insurance Corporation (FDIC) call reports, and the Farm Credit System. All prices and income are deflated using the Personal Consumption Expenditure Component of the Implicit Gross Domestic Product deflator. This study defines the return to farmland as the gross revenues per acre less the expenditures on variable inputs as described by Erickson, Mishra, and Moss (2003). This definition is less complete than the alternative specification (i.e., the definition of returns offered by Melichar [1979]). However, as demonstrated by Mishra, Moss, and Erickson (2004), these more complete formulations of imputed returns may introduce measurement error problems if other quasi-fixed assets or labor are trapped in agriculture. Average real interest rate is the average interest rate on farm business debt (i.e., ratio of interest expenses minus interest expenses associated with operators dwelling expenses to average farm debt).

## Results

Table 1 presents the spatial correlation results for both farmland values and returns to farmland using the definition by returns. The results in Columns (2) through (4) of Table 1 show a slight concentration of farmland across contiguous states with $\theta_B$ increasing from 0.116 in 1950 to 0.136 in 2003. These results also indicate that most of this gain comes from non-contiguous shares ($\theta_N$). This limited change is consistent with the slow change in overall distribution of farmland. Changes in the distribution of farmland result primarily from the loss of farmland to urban growth, but other factors such as the conversion of farmland to environmental set asides.

The results depicted in Table 1 are consistent with the effect of inflation on farmland values (Moss 1997). Specifically, the both $MSBD$ and $MSND$ are based on nominal asset values. However, given that we are primarily interested in the ratio between $MSBD$ and $MSND$, the spatial correlation coefficient itself is unaffected. Turning to spatial correlation measure, we see that share of spatial correlation in farmland values fell by fifty percent between 1950 and 2003. Given our discussion above, this implies that the overall spatial correlation in farmland values has increased radically since 1950.

The increase in spatial correlation in farmland values could be the result of numerous factors including as discussed by Livanis et al. 2006. Specifically, the increased spatial correlation could be the result of increased spatial correlation in returns to agriculture or increased spatial correlation in urban pressures. To examine the significant of both of these alternatives, we next computed the change in spatial correlation in returns to farmland over time. As depicted in Table 1, the measure of spatial correlation fell from 0.777 in 1950 to 0.505 in 2003, or to 65 percent of 1950 level. Thus, the evidence suggests that large portion of the increase in spatial correlation could be explained by changes in agricultural returns.

To compare the spatial correlation results for farmland values and returns with urban growth, we computed the spatial correlation coefficient for the logarithmic change in each state's residential population divided by the number of acres in agriculture. These results are presented in Table 2. Regressing the spatial correlation coefficient of farmland values on the spatial correlation coefficient for agricultural returns and urban pressure yields

$$\begin{array}{ll} r_L = 0.1589 + 0.6217 r_I - 0.1138 r_u & R^2 = 0.57 \\ \quad (0.0790)\ (0.0941) \quad (0.0529) & \end{array} . \qquad (7)$$

Hence, the regression results suggest that the spatial correlation in farmland values is driven primarily by both the spatial correlation in agricultural returns and the spatial correlation in urban pressure. Numerically, the effect of agricultural returns appears somewhat larger than the effect of urban pressure, but further analysis such as the decomposition into the bits of information (Theil 1987, Moss 1997) would be required to develop the contribution of each variable. Further, the direction of the effects is appropriate. Increases in $r$ coefficient are associated with relatively higher differences in adjacent states. Thus, as the border differences in returns on farmland increases, so does the border differences in farmland values.

## Conclusions and Implications

Our results indicate that the spatial correlation in farmland values fell by 50 percent from 0.582 in 1950 to 0.281 in 2003. Undoubtedly this decline can be attributed to several factors. One possibility is that the decline in spatial differences can be explained by changes in factor returns (or by market fundamentals). Focusing on returns to farmland, we again see that the spatial dispersion of in returns to farmland have also declined over time. In 1950, the spatial correlation in returns was 0.777 which by 35 percent of this value (to 0.505 in 2003). Regressing the spatial correlation in farmland values on the spatial correlation in agricultural returns and the spatial correlation in urban growth indicates that the spatial nature of farmland values by both agricultural returns and urban growth. However, the relative magnitude of the estimated coefficient and the statistical significance indicates that agricultural returns are somewhat more important in determining the spatial correlation in farmland prices. This result is somewhat askew from the growing consensus that the spatial dimension of urbanization is a significant factor in determining farmland values. However, this divergence may be primarily attributed to the level of aggregation used in this study. Specifically, the urban variable used by Livanis et al. focuses on the population within a fifty mile radius of a piece of farmland. This degree of specificity is far below the state-level data used in this study.

## References

Erickson, K., A.K. Mishra, and C.B. Moss. (2003) "Cash Rents, Imputed Returns, and the Valuation of Farmland Revisited." In *Government Policy and Farmland Markets: The Maintenance of Farmer Wealth* Edited by Moss, C.B. and A. Schmitz Ames, Iowa: Iowa State University Press, 223–35.

Livanis, G., C.B. Moss, V.E. Breneman, and R.F. Nehring. (2006) "Urban Sprawl and Farmland Prices." *American Journal of Agricultural Economics* 88(4), 915–29.

Mishra, A.K., C.B. Moss, and K. Erickson. (2004) "Valuing Farmland with Multiple Quasi-Fixed Inputs." *Applied Economics* 36(15)(2004): 1655–69.

Moss, C.B. (1996) "The Spatial Correlation of Presidential Elections." In *Festschrift Honoring Johan Koerts* Edited by Bode, B., van Dalen, J., and Klomp, L., Rotterdam: Erasmus University, 15–18.

Moss, C.B. (1997) "Returns, Interest Rates, and Inflation: How They Explain Changes in Farmland Values." *American Journal of Agricultural Economics* 79(4), 1311–8.

Theil, H., C.B. Moss, and D. Chen. (1996) "The Spatial Autocorrelation of Per Capita GDPs." In *Studies in Global Econometrics* by Theil, H. Boston: Kluwer Academic Publisher, Inc., 47–52.

Table 1. Spatial Correlation of Farmland Values and Income to Farmland

| Year (1) | Contiguous (x100) (2) | Hirschman-Herfindahl (x100) (3) | Non-Contiguous (x100) (4) | *MSBD* (5) | *MSNB* (6) | *r* (7) | $\sigma^2$ (8) | *MSBD* (9) | *MSNB* (10) | *r* (11) | $\sigma^2$ (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 11.6 | 4.0 | 84.4 | 2414.1 | 4147.4 | 0.582 | 1890.1 | 46.8 | 60.2 | 0.777 | 28.1 |
| 1955 | 11.8 | 4.1 | 84.1 | 4641.5 | 7742.8 | 0.599 | 3530.1 | 25.5 | 42.6 | 0.600 | 19.4 |
| 1960 | 12.0 | 4.2 | 83.8 | 9709.6 | 16041.0 | 0.605 | 7302.2 | 48.4 | 66.7 | 0.725 | 30.8 |
| 1965 | 12.3 | 4.2 | 83.4 | 16125.9 | 27972.6 | 0.576 | 12663.9 | 125.7 | 185.8 | 0.676 | 85.3 |
| 1970 | 12.6 | 4.3 | 83.1 | 18321.1 | 38952.9 | 0.470 | 17339.2 | 142.5 | 180.1 | 0.791 | 83.8 |
| 1975 | 12.9 | 4.4 | 82.7 | 72051.7 | 152406.0 | 0.473 | 67673.8 | 930.6 | 1553.0 | 0.599 | 702.2 |
| 1980 | 12.9 | 4.5 | 82.6 | 363028.3 | 721713.8 | 0.503 | 321560.9 | 1915.7 | 3019.7 | 0.634 | 1371.1 |
| 1985 | 13.0 | 4.5 | 82.5 | 168158.2 | 375306.0 | 0.448 | 165714.1 | 3397.2 | 5528.0 | 0.615 | 2500.8 |
| 1990 | 13.3 | 4.5 | 82.2 | 229481.0 | 640367.9 | 0.358 | 278346.1 | 3999.9 | 7266.4 | 0.550 | 3251.1 |
| 1995 | 13.5 | 4.7 | 81.9 | 291154.1 | 934829.3 | 0.311 | 402239.1 | 3812.3 | 8916.5 | 0.428 | 3906.4 |
| 2000 | 13.6 | 4.7 | 81.8 | 493265.1 | 1644427.6 | 0.300 | 705645.2 | 924.9 | 1972.9 | 0.469 | 869.2 |
| 2001 | 13.6 | 4.7 | 81.7 | 550518.7 | 1866739.4 | 0.295 | 800249.2 | 871.3 | 1879.1 | 0.464 | 827.1 |
| 2002 | 13.6 | 4.7 | 81.7 | 614648.0 | 2125961.2 | 0.289 | 910572.9 | 760.4 | 1531.2 | 0.497 | 677.4 |
| 2003 | 13.6 | 4.7 | 81.7 | 707249.4 | 2515028.3 | 0.281 | 1075051.1 | 734.9 | 1455.2 | 0.505 | 644.1 |

Table 2. Spatial Correlation for Urban Pressure

| Year (1) | Contiguous (x100) (2) | Hirschman-Herfindahl (x100) (3) | Non-Contiguous (x100) (4) | *MSBD* (x10000) (5) | *MSNB* (x10000) (6) | *r* (7) | $\sigma^2$ (x10000) (8) |
|---|---|---|---|---|---|---|---|
| 1951 | 11.7 | 4.0 | 84.3 | 4.3 | 6.7 | 0.634 | 6.2 |
| 1955 | 11.8 | 4.1 | 84.1 | 2.8 | 5.8 | 0.488 | 5.2 |
| 1960 | 12.0 | 4.2 | 83.8 | 2.8 | 4.5 | 0.630 | 4.1 |
| 1965 | 12.3 | 4.2 | 83.4 | 1.5 | 3.3 | 0.470 | 2.9 |
| 1970 | 12.6 | 4.3 | 83.1 | 1.0 | 1.7 | 0.575 | 1.5 |
| 1975 | 12.9 | 4.4 | 82.7 | 9.6 | 21.8 | 0.440 | 19.3 |
| 1980 | 12.9 | 4.5 | 82.6 | 2.2 | 2.7 | 0.788 | 2.5 |
| 1985 | 13.0 | 4.5 | 82.5 | 2.0 | 3.9 | 0.518 | 3.5 |
| 1990 | 13.3 | 4.5 | 82.2 | 1.5 | 2.6 | 0.589 | 2.4 |
| 1995 | 13.5 | 4.7 | 81.9 | 1.7 | 2.2 | 0.800 | 2.0 |
| 2000 | 13.6 | 4.7 | 81.8 | 5.4 | 6.0 | 0.911 | 5.6 |
| 2001 | 13.6 | 4.7 | 81.7 | 1.2 | 1.3 | 0.897 | 1.2 |
| 2002 | 13.6 | 4.7 | 81.7 | 0.7 | 1.0 | 0.691 | 0.9 |
| 2003 | 13.6 | 4.7 | 81.7 | 9.3 | 11.3 | 0.821 | 10.5 |