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SPATIAL PANEL MODELS FOR THE ANALYSIS OF LAND PRICES

Saguatti A.[1], Erickson K.[2] and Gutierrez L.[3]

[1] Department of Statistical Sciences “P. Fortunati”, University of Bologna
[2] United States Department of Agriculture, Economic Research Service
[3] Department of Economics and Woody Plant Ecosystems, University of Sassari

annachiara.saguatti@unibo.it

Outline

- Background and aims of the resesarch.
- Methodology and data.
- Exploratory spatial data analysis and model specification.
- Estimation results and discussion.
- Long-run elasticity analysis.
- Concluding remarks.

Background

- Farm real estate is a dominant asset on the farm sector balance sheet in the U.S.A. (it accounted for nearly 84% of total U.S. farm assets in 2009) and is usually the largest investment in the farmers' portfolio.

- The real values of agricultural land have been increasing dramatically starting from the second half of 2000s.

- The analysis of land values also raises a number of policy issues, regarding government support, taxation and environmental protection.

Aims

- Investigating the spatial effects that may characterize the determination of agricultural land values in selected Midwestern U.S.A. States.
- Testing the Ricardian Present Value Model (PVM) as a theoretical framework to address farm land values behavior in the long run.
- Estimating the elasticity of land value with respect to its determinants.

Methodology

- We adopt the **Ricardian Present Value Model** (PVM) as the theoretical framework to address farm land values behavior in the long run.

- We specify and estimate spatiotemporal model that includes a **spatial lag** of the dependent variable to account for spatial dependence, characterizes the **temporal dynamics** as an autoregressive process of first order and presents a **spatiotemporal lag** to account for all possible sources of autocorrelation in the data.

The PVM (1)

- The PVM is a financial model that relates the price of a stock to its expected future returns discounted to the present.

- We relate the value of cropland (CV) to the capitalized value of the current and future stream of cash rents (CR) received by the owner, assuming time-varying expected stock returns.

- We define $s_{t+1} = cr_{t+1} - cv_{t+1}$ (spread) as the log of the dividend-price ratio.

- If the agents are fully rational, then the asset prices (e.g. farmland values) and the dividends generated from that asset (e.g. cash rents) cannot drift persistently far apart from each other.

The PVM (2)

- According to the PVM, the value of an income-producing asset is the capitalized value of the current and future stream of earnings from owning that asset.
- The PVM has been tested in the literature by estimating and then testing for cointegration the following equation:

$$cv_t = \alpha + \beta cr_t + \varepsilon_t$$

or equivalently $s_t - \alpha = (1 - \beta)cr_t - \varepsilon_t$, where ε is a zero-mean disturbance.

- If $\beta = 1$, intuitively, the log prices move one-to-one with log dividends and their unit-root components cancel out, leaving the spread unaffected. On the contrary, if $\beta \neq 1$, then $(1 - \beta)cr_t$ does not disappear and the spread is non-stationary.

The PVM in the empirical literature

- Empirical results dos not fully support the PVM.
- Falk (1991): although highly correlated, farmland prices and rent movements in Iowa are not consistent with the PVM.
- Similar results for Illinois (Clark et al. 1993) and three U.S. regions (Tegene and Kuchler 1993; Engsted 1998).
- Gutierrez et al. (2007) find support for the PVM by allowing structural breaks in the cointegrated relationship.
- New scenarios: influence of urbanization (Hardie et al. 2001; Plantinga et al. 2002; Livanis et al. 2006); testing of the PVM in presence of transaction costs (Lence and Miller, 1999; de Fontnouvelle and Lence, 2001); distinctions among the streams of rents and different types of public subsidies (Clark et al., 1993; Weersink et al., 1999; Goodwin et al., 2003 among the others).

Spatial econometrics

- Spatial econometrics techniques are specifically designed in order to deal with the spatial dimensions of data, which can take the form of spatial interaction (*spatial dependence or autocorrelation*) and spatial structure (*spatial heterogeneity*).

- Dependence: existence of a functional relationship between what happens at one point in space and what happens elsewhere.

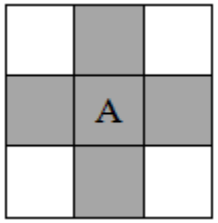
- Heterogeneity: lack of stability over space of the behavioral or other relationships under study.

- Spatial autocorrelation and heterogeneity might be "observationally equivalent" and spatial autocorrelation of the residuals may be provoked by unmodeled spatial heterogeneity.

The spatial weight matrix

- The spatial weight matrix is a square, non-stochastic and symmetric matrix, whose main diagonal comprises only zero elements and other elements measure the intensity of the spatial connection between spatial units and take on finite and non-negative values.

- We employ a row-standardized rook spatial weight matrix, **W**, whose elements, w_{ij}, take on the values of either 0 or 1 depending on whether States i and j share some positive portion of their boundaries or not.



- Results proved to be robust to the choice of different spatial weight matrices.

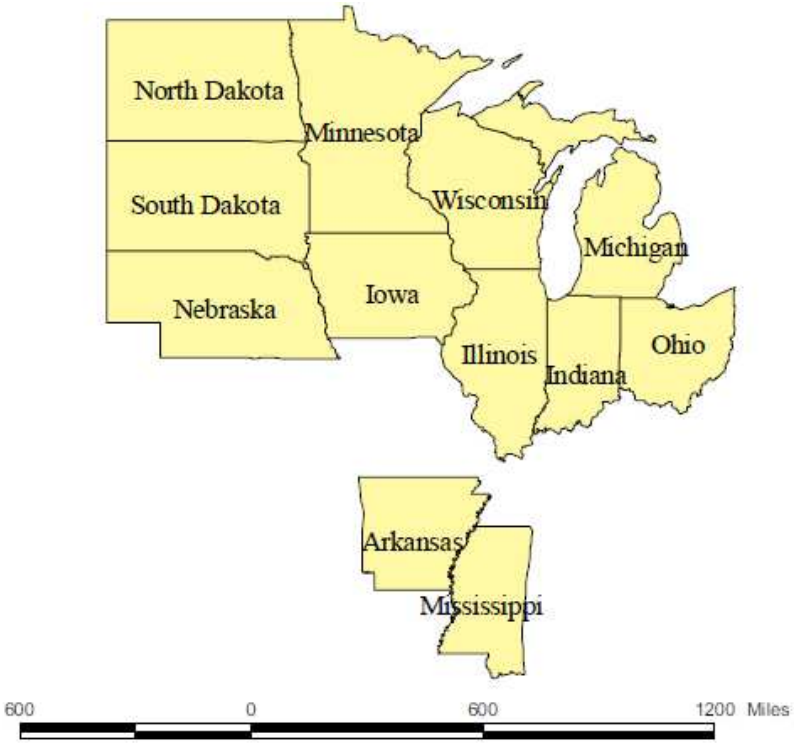
The data (1)

All the employed data for the agricultural sector were made available by the USDA-NASS and ERS.

- CV: cropland values (deflated).
  - Based on annual survey data
  - Report the market value per acre of cropland only (it includes the land used to grow field crops, vegetables or land harvested for hay; pastureland and buildings are excluded).
- CR: Net – rather that gross– cash rents per acre of cropland (deflated).
  - Reflect the net return to the landowner, measure returns to land from agricultural production and can be interpreted as a Ricardian land rent.
- PD: Population density (Bureau of Census).
  - Proxy for urban pressure and competing demand for land.
- GP: Direct government payments per acre of cropland.

The data (2)

- Panel of annual (1971-2009) observations for 12 Midwestern U.S. States.



- Homogeneous data: less affected by urban influence and more heavily surveyed by NASS for cash rents and data on cropland per acre.

- Advantages: a longer time-span than farm-level datasets, non-commonly considered variables (net cash rents, cropland value).

ESDA: positive spatial dependence

Year	Moran's I	p-value	Year	Moran's I	p-value	Year	Moran's I	p-value
1971	0.287	0.064	1984	0.414	0.021	1997	0.477	0.012
1972	0.322	0.047	1985	0.414	0.020	1998	0.489	0.011
1973	0.343	0.040	1986	0.460	0.012	1999	0.546	0.006
1974	0.297	0.059	1987	0.464	0.012	2000	0.601	0.003
1975	0.280	0.069	1988	0.356	0.034	2001	0.634	0.002
1976	0.277	0.073	1989	0.273	0.069	2002	0.657	0.002
1977	0.319	0.052	1990	0.291	0.062	2003	0.385	0.027
1978	0.301	0.057	1991	0.267	0.074	2004	0.637	0.002
1979	0.288	0.065	1992	0.279	0.067	2005	0.605	0.003
1980	0.297	0.062	1993	0.327	0.047	2006	0.597	0.003
1981	0.274	0.073	1994	0.286	0.053	2007	0.593	0.003
1982	0.265	0.076	1995	0.336	0.044	2008	0.572	0.004
1983	0.270	0.071	1996	0.327	0.044	2009	0.582	0.004

The model (1)

- Economic agents require time in order to collect information and make decisions and what happens in neighboring locations influences these decisions: we expect both serial and spatial dependence.

- Time-space dynamic model: first-order autoregressive lag model in both space and time. Fixed individual effect take into account unobserved time-invariant sources of heterogeneity such as climate and land quality.

$$cv_{it} = \lambda \boldsymbol{W} cv_{it} + \gamma cv_{it-1} + \varrho \boldsymbol{W} cv_{it-1} + \beta_1 cr_{it} + \beta_2 pd_{it} + c_i + \varepsilon_{it}\ ^*$$

- We expect net cash rents to have a positive impact on cropland values.

* Lower case letters indicate natural logarithm transformation.

Results

Coefficient	QML estimate	t-stat
λ	0.382	8.899***
γ	0.734	19.824***
ϱ	-0.182	-3.254***
β_1 (cr)	0.079	2.720***
β_2 (pd)	0.328	3.426***

- Significant, positive β_1 coefficient (0.079) is consitent with the PVM.
- Positive β_2 coefficient (0.328): increasing population density may increase the demand for agricultural goods and therefore agricultural land and, at the same time, it may be sign of increasing urban pressure that enhances competing demand for land for non-agricultural use.
- The high and highly significant estimates of λ and γ suggest that these may also absorb part of the effects of the covariates.

The inclusion of GP: discussion

Coeff.	Estimate	t-stat
λ	0.382	9.074***
γ	0.713	20.359***
ϱ	-0.187	-3.529***
β_1 (cr)	-0.012	-0.415
β_2 (pd)	0.548	5.659***
β_3 (gp)	-0.048	-6.906***

The inclusion of GP: discussion

- The estimate of β_3 indicates a negative impact of public subsidies on *cv*.
- The spatial and temporal effects are not significantly affected.
- The impact of *pd* is enhanced, while, remarkably $\hat{\beta}_1$ turns negative and not significant.

- Possible explanations:
  - Agricultural support policy instruments are thought to be highly correlated with land rents and this may cause multicollinearity.
  - A distinction between the programs of support appears to be necessary: Lence and Mishra (2003) find that alternative farm programs have different effects on cash rents in Iowa; Goodwin et al. (2003) argue that they do not reflect the long-term expected stream of cash flows; Phipps (2003) argues that program payments do not have the stability that should characterize expectations of returns to land.

Stationarity testing

- We define the $N \times N$ matrix

$$\boldsymbol{A} = (\boldsymbol{I} - \lambda \boldsymbol{W})^{-1}(\gamma \boldsymbol{I} + \varrho \boldsymbol{W})$$

and re-write our model as:

$$cv_{it} = \boldsymbol{A} cv_{t-1} + (\boldsymbol{I} - \lambda \boldsymbol{W})^{-1}(\beta_1 cr_{it} + \beta_2 pd_{it} + c_i + \varepsilon_{it}).$$

- The eigenvalues of matrix $\boldsymbol{A}$, obtained by using $\hat{\gamma} = 0.734$; $\hat{\lambda} = 0.382$; $\hat{\varrho} = -0.182$, are all <1.

- We conclude that the stability conditions of the process hold.

Long-run value effect analysis

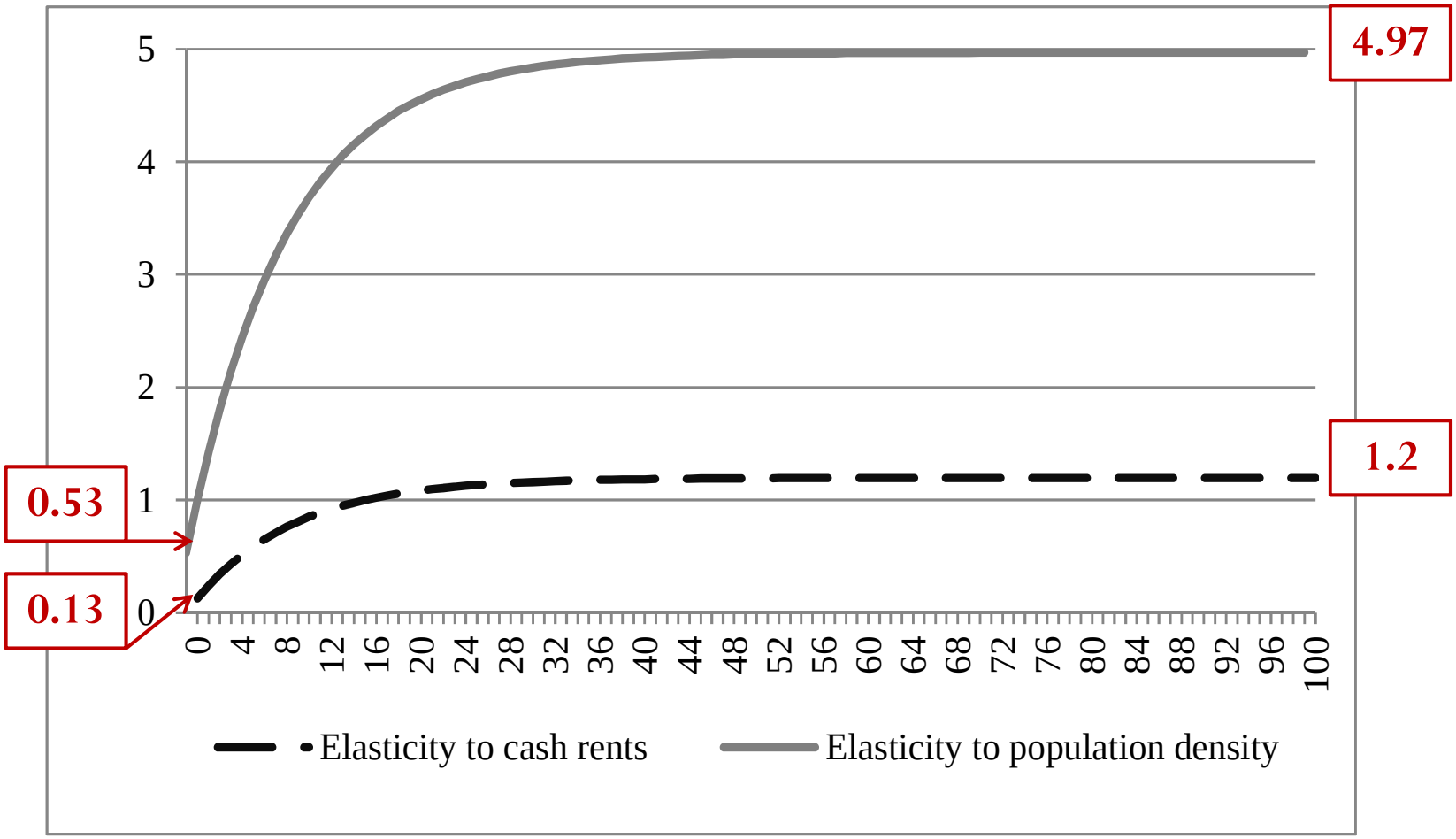
- The computation of elasticities for cash rents and population density can be done by solving the dynamic equation:

$$cv_{it} = (\boldsymbol{I} - \boldsymbol{A}\mathrm{L})^{-1}(\boldsymbol{I} - \lambda \boldsymbol{W})^{-1}(\beta_1 cr_{it} + \beta_2 pd_{it} + c_i + \varepsilon_{it})$$

where L is the lag operator, that operates on an element of a time series to produce the previous element, such that, given $X = \{X_1, X_2, X_3, \dots\}$, $X_{it}L = X_{t-1}$, for all $t > 1$.

- Using the estimates $\hat{\beta}_1$=0.079 and $\hat{\beta}_2$=0.328 and $t = 0, \dots, 100$, we find that the impact elasticity of cropland value is equal to **0.13** with respect to cash rents and **0.53** with respect to population density.

Long-run elasticity analysis (1)



Long-run elasticity analysis (2)

- In the long-run, the effect of population density is significantly higher than that of cash rents in determining cropland values.

- Such a close-to-unity estimated long-run elasticity of cropland values to cash rents is close to what one would expect according to the PVM and that is usually not verified in empirical analyses.

- Previous empirical contributions, mainly based on time-series analysis, lead to different conclusions and, as previously said, end up rejecting the PVM and generally finding evidence of divergence between the present value of future cash flows and the market price of farmland (Falk, 1991; Clark et al., 1993a; Engsted, 1998).

Concluding remarks

- Relevant field of study given the importance of farm real estate on the farm balance sheet and the great number of policy issues that it raises.
- Fairly new empirical field for spatial econometrics techinques.
- Fairly new dataset: only cropland was taken into consideration when collecting data on land value and cash rents.

- The presence of significant spatio-temporal dependence is confirmed.
- The estimate of the long-run elasticity of cropland value with respect to net cash rents (close to unity) supports the PVM assumptions.
- Both variables appear to exert the biggest part of their influence on land values in about 20 years.
- The effect of cash rents in determining land values is smaller than that of population density.

Future developments

- We consider running precise specification tests as a priority in order to complete the present analysis
- The model should also be tested for structural breaks that may occur in the time series, following Gutierrez et al. (2007).
- A deeper reasoning on the role of government payments and the best way to treat available data on policy intervention is also a path that should be followed.

THANK YOU FOR YOUR ATTENTION