SPATIAL ECONOMETRIC ANALYSIS OF THE MOLDAVIAN REAL ESTATE VALUE

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The objective of the paper is to investigate the current situation of land market and land fragmentation of family farms in Moldova in the context of sustainable agricultural development: relationship to family well-being, farm efficiency, partial productivities of land and labor. The actual use of various market mechanisms for land consolidation will be discussed, including buying and selling of land as well as leasing. In this discussion, survey data are supplemented with transaction information from state cadastre sources. Comparative statistics and regression analysis are used to examine the relationship between land fragmentation and farm size, agricultural production, farm and off-farm jobs, and the amount of land rented-in and-out. A key hypothesis investigated is that consolidation of agricultural land in Moldova has beneficial effects in terms of productivity and is desirable in the long run. Our analysis shows that the extent of parcel consolidation is directly correlated with relative efficiency of farms: consolidated family farms are more efficient than those with fragmented holdings

***Key words** : agricultural sector, spatial econometrics, Land Bank, Republic of Moldova.*

Introduction

Republic of Moldova, a former soviet country located in Eastern Europe, has been described by a transitional economy since its declaration of independence in 1991. The purpose is to determine the factors which influence the land market in Republic of Moldova. The paper aims to discover the determinants for land pricing using the spatial econometrics modeling, as it is widely used when the spatial component is present.

The country’s agricultural economy combined with the interest of international organizations and limited data availability directed the focus of this empirical study towards land for agricultural purposes. The factors which determine the land market (for agricultural purposes) in Republic of Moldova are mainly related to economic characteristics of land, such as field productivity, the position on the local landscape (characterized by angle and soil quality), proximity to local or national roads (due to storage and transportation reasons), and economic characteristics of owners. Also, another important role in land market price creation is the pressure of urban space to transform land for agricultural use close to cities and villages in spaces for industrial or residential purposes. This is characterized by the financial pressure from the urban centers which has become significant in land transactions [1].

Initially explorers the historical transactions and specifics of the land market in Republic of Moldova. Previous literature suggests the use of land banking as a financial and management tool to improve the transaction system.

The empirical study is mainly based on a survey performed by Academy of Science of Moldova and the National Cadastral Agency. The spatial modeling econometrics is applied in order to find the significant variables.

The paper has two main applications: it represents a *model for pricing* – which might be used by investment funds, or other organizations interested in the land market; the interest is in buy/sell transactions – a financial mechanism could be created to facilitate these transactions. For example, the creation of a Land Bank (as in Netherlands, or Romania) or to attract land banking investment funds, which would have the goal to improve the transaction system, develop financial tools necessary for increasing efficiency, improving financial structure and other [2].

Material and method

One of the objectives of this study is to investigate the market mechanism which governs individual transactions (buy/sell). The analysis of land markets in Central-European countries indicates specific macroeconomic procedures for land price formation. These procedures employ standardized contiguity (adjacency) matrices (SAM) as the principal component of spatial econometrics method [6].

In order to investigate the spatial nature of variables, several useful regression models have emerged during the last decades, in addition to the conventional Ordinary Least Squares model. The spatial econometrics models employ the spatial characteristics of variables to improve the models. These approaches incorporate the spatial lag into models. However, there is a lack of consensus on how to appropriately evaluate them.

According to James P. LeSage [5], two main issues emerge when sample data has a spatial (locational) component:

- Spatial dependency between observations
- Spatial heterogeneity occurs in the modeled relationships

Traditional econometrics disregards these two issues which violate the traditional Gauss-Markov assumptions used in regression modeling. Thus, alternative estimation procedures are necessary to model this type of variation and make appropriate inferences.

The spatial dependence in a sample data means that one observation associated with a location i, depends on other observations at locations $\mathbf{j \neq i}$. The main reason is that spatial dimension of economic characteristics is an important aspect of modeling. Regional science theory integrates this notion through spatial interaction, spatial spillovers and hierarchies of place.

Spatial heterogeneity means the variation in relationships over space. As a result, it might be expected a different relationship for every point in space. It can be formally written as:

$$\boldsymbol{y_i = X_i\beta_i + \varepsilon_i} \qquad \mathbf{i = 1,\ldots,n}$$

Where: X_i – vector of explanatory variables with the set of parameters β_i, y_i – dependent variable at location i; ε_i – represents a stochastic disturbance. Considering a sample of n observations, it is not possible to estimate a set of n parameters β_i due to degrees of freedom problem. There is simply not enough sample information to calculate estimates for every observation in space.

The proposed econometric model for the calculation of the optimal land price is Spatial Autoregressive Model (SAR):

$$\boldsymbol{y = \rho W y + X\beta + \varepsilon}$$
$$\boldsymbol{\varepsilon \subset N(0, \sigma^2 I_n)}$$

where: **y** – is the equivalent measure of land price;

X – set of exogenous variables which determine the economic characteristics of landowner;

W – standardized contiguity (adjacency) matrix (**SAM**);

ρ – spatial autocorrelation coefficient of parcels of land;

β – linear regression parameters, geographically weighted;

ε – stochastic component, normally distributed with mean equal to zero and variance σ^2;

I_n **–** identity matrix of order **n**.

It should be mentioned that in case **ρ** is equal to zero, there cannot be observed spatial dependency between endogenous variable y_i, and the linear regression parameters **β** can be calculated through Ordinary Least Squares (OLS). This is a special case of the **SAR** model.

This model is performed using MATLAB, including an add-on – Econometrics Toolbox developed by J. LeSage from the Department of Economics, Toledo University, USA [5].

The description of econometric model defines the specific notions of spatial regression analysis. In Table1 1 are presented the variables included in the model. According to this table, the initial data of causal factors are included in the variable results.total, while the value of endogenous variables obtained during the survey are included in the variable results.y. After the land price evaluation with the assistance of program SAR, the results are attributed to the structural variable results.yhat. which will be graphically presented as the comparison between the value of this two variables of the resulting factor.

Table 1. Variables description of Spatial Autoregressive Model

```
function results = sar(y,x,W,info)

PURPOSE: computes spatial autoregressive model estimates
y = p*W*y + X*b + e, using sparse matrix algorithms
 ---------------------------------------------------
%  USAGE: results = sar(y,x,W,info)
%  where:  y = dependent variable vector
%          x = explanatory variables matrix, (with intercept term in first
%             column if used)
%          W = standardized contiguity matrix
%       info = an (optional) structure variable with input options:
%       info.rmin  = (optional) minimum value of rho to use in search (default = -1)
%       info.rmax  = (optional) maximum value of rho to use in search (default = +1)
%       info.eig   = 0 for default rmin = -1,rmax = +1, 1 for eigenvalue calculation of these
%       info.convg = (optional) convergence criterion (default = 1e-8)
%       info.maxit = (optional) maximum # of iterations (default = 500)
%       info.lflag = 0 for full lndet computation (default = 1, fastest)
%                  = 1 for MC lndet approximation (fast for very large problems)
%                  = 2 for Spline lndet approximation (medium speed)
%       info.order = order to use with info.lflag = 1 option (default = 50)
%       info.iter  = iterations to use with info.lflag = 1 option (default = 30)
%       info.lndet = a matrix returned by sar, sar_g, sarp_g, etc.
%                containing log-determinant information to save time
%       info.ndraw = 1,000 by default
%       info.sflag = 1 if called from SDM, default not used
% ---------------------------------------------------
%  RETURNS: a structure
%         results.meth  = 'sar'
%         results.beta  = bhat (nvar x 1) vector
%         results.rho   = rho
%         results.tstat = asymp t-stat (last entry is rho)
%         results.bstd  = std of betas (nvar x 1) vector
%         results.pstd  = std of rho
%         results.total    = a 3-d matrix (ndraw,p,ntrs) total x-impacts
%         results.direct   = a 3-d matrix (ndraw,p,ntrs) direct x-impacts
```

```
%     results.indirect = a 3-d matrix (ndraw,p,ntrs) indirect x-impacts
%                 ndraw = 2,500 by default, ntrs = 101 default
%                 p = nvar-1 if there is a constant term which we skip
%     results.yhat  = yhat        (nobs x 1) vector
%     results.resid = residuals    (nobs x 1) vector
%     results.sige  = sige = (y-p*W*y-x*b)'*(y-p*W*y-x*b)/n
%     results.rsqr  = rsquared
%     results.rbar  = rbar-squared
%     results.lik   = log likelihood
%     results.nobs  = # of observations
```

The coefficient of determination $\mathbf{R^2}$**,** which defines how well the spatial model reflects the real situation, is attributed to the structural variable *results.rsqr.* The parameters of regression $\boldsymbol{\beta_i}$ can be extracted from the variable ***results.beta***, which is a vector of order k (the number of exogenous variables included in the model). The scalar $\boldsymbol{\rho}$ from *results.rho* reflects the influence of the spatial relationship on the transaction price.

Results and discussions

For the application of spatial econometrics model is selected data only from a region of Moldova, Calarasi District, commune of Sadova. The number of parcels of land is 199, which represents the number of included observations. Each landowner can have more parcels of land, while the total number of owners is 45. The primary data used regards the economic characteristics of parcels of land and its owners.

The spatial autoregressive model uses 3 main components:

1. The spatial (location) component
2. The endogenous variable
3. The explanatory or exogenous variables

As noted in methodology description, the location is calculated using the Geographic Information System (GIS), including the coordinates of the parcels of land. The unit of measure is calculated in meters. The spatial adjacent matrix is computed as distance from a strategic point. In this case, the town hall is considered the appropriate choice.

The choice of the endogenous variable is not necessarily the actual price in currency. Generally, in under-developed market economies a more abstract measure of real estate appraisal could be considered (actually it is encouraged). The main reason is that the transaction prices registered at the Cadastral Agency are not the „real" prices, as the participants try to evade payment of taxes or other commissions.

In this case, the endogenous variable is chosen an *equivalent measure of value (EMV)* which represents a more abstract notion of value – and is defined by an utility level. It is characterized by a coefficient measure, which can be transformed into the actual market prices by multiplying with another average national (or regional) coefficient. It will be denoted as EMV for this study.

The next step is description of exogenous variables, which define the causal factors. These variables were collected during same survey in the district. For the purpose of data description, these variables are limited to the ones which indicate significant contribution (higher than 10%) to the coefficient of determination R2 of the econometric model.

The following exogenous variables are considered:

I. Surface area – calculated in hectares (ha). One hectare is equivalent to 10000 square meters. This variable is included because it is assumed that the parcel size (in units) affects the land value.

II. Income – calculated in lei (national currency). It represents level of income of the respondents, the landowners. It seems obvious to include this variable as it seems to directly affect the land price.

III. Investments – calculated in lei. It represents an important variable because it represents the amount of expenses concerning land maintenance.

IV. Number of employed personnel – denoted in number of persons, usually including the owner and his family, and seasonal workers. It seems logical to include this variable because of the different productivity levels and specific agricultural production [4].

Data was filtered and processed, and blank observations were removed. Many of respondents did not perceive the questions to be appropriate and left many items uncompleted. As previously noted, the dependent variable EMV was estimated using the mixed autoregressive-regressive mode, with the assistance of the program SAR.

The value of exogenous factors X represents the matrix which contains explanatory variables. The standardized adjancency matrix W is calculated using the program XY2CONT(xc,yc). The spatial component in the EMV estimates is determined by the parameter ρ which can take values ranging from -1 to +1. This range was used for this modeling.

Table 2. Descriptive statistics of exogenous variables

Number of observations	199			
Exogenous variables	Surface	Income	Investment	Employees
Mean	0.26	7,020	10,641	4
Standard deviation	0.17	8,890	11,533	3
Median	0.22	5,000	6,000	3
Min	0.03	500	600	1
Max	0.86	50,000	60,000	15

Maximum likelihood estimation of the spatial model is based on a concentrated likelihood function. The following 5 steps are performed for parameters estimation of the linear spatial model, enumerated in Anselin [7]:

1. Performing OLS for the model: $y = X\beta_0 + \varepsilon_0$

2. Performing OLS for the model: $W_y = X\beta_L + \varepsilon_L$

3. Compute residuals $e_0 = y - X\hat{\beta}_0$ and $e_L = y - X\hat{\beta}_L$

4. Given e_0 and e_L, calculate ρ that maximizes the concentrated likelihood function: $L_C = C - (n/2)ln(1/n)(e_0 - \rho e_L)'(e_0 - \rho e_L) + \ln|I - \rho W|$

5. Given $\hat{\rho}$ that maximizes L_C, compute $\hat{\beta} = (\hat{\beta}_0 - \rho\hat{\beta})$ and $\hat{\sigma}_\varepsilon^2 = (1/n)(e_0 - \rho e_L)'(e_0 - \rho e_L)$

Total number of variables is 5:

X1 – Surface area;

X2 – Income;

X3 – Investments;

X4 – Personnel;

Y – EMV.

Total number of observations is 199. The spatial model fits the evaluated initial data well enough, with a coefficient of determination equal to **0.49**. This means that the variables included in the model – explain 49% of total variability. However, not including in explanatory variables other determinants as land quality, distance from household, lack of finance, taxes and other, impose a considerable stochastic ε component. The contribution of several other factors not included in the model is evaluated later through regression analysis.

Most of the explanatory variables are statistically significant and acceptable with a confidence interval of 95%. At the same time, considering the high value of coefficient of partial determination R^2_i, the t-statistic has an acceptable value.

The spatial of land value which is calculated through parameter ρ is equal to **-0.08**, which represents how much the value is influence if the land is situated 1km from the center of the town (the town hall). This result is significant because it has the following implications:

Conclusions

It is of no surprise that the land market in a transitional economy, as Republic of Moldova, is described by a buy-and-sell transaction mechanism functioning ineffectively and low land values due to poor efficiency. However, the statistics suggests improving land dynamics. The land development can favor several stakeholders, such as investors, government, citizens. This study is performed mostly from the investor's perspective and can have two main applications.

Firstly, the model discovers the significant variables which influence land value. It represents a pricing model, which might be used by investment funds or other organizations interested in the land market. For example, investors interested in purchasing cheaper land should look for low-income land owners, low maintenance expenses, larger parcels of land, and further away from the town hall.

Secondly, there exist financial and management tools to improve the land market dynamics. A financial mechanism, like a Land Bank (as in the Netherlands or Romania) could be created to facilitate these transactions. Another option would be attracting land banking investment funds, which would have the goal to improve the buy-and-sell transaction system, develop the financial tools necessary for increasing efficiency, improving the financial structure and others.

There are several ideas that might be studied in future research: replicate this study for land with different designations, change or add other explanatory variables, describe the urban pressure effect in a strategic region.

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