

THE EFFECTS OF URBAN DEVELOPMENT PRESSURE ON AGRICULTURAL LAND PRICE: APPLICATION OF A MIXED GWR MODEL*

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Abstract

This study examines the effects of urban development pressure on agricultural land prices in Korea. It investigates the determinants of agricultural land prices, focusing particularly on urban planning variables on agricultural land use. Since agricultural land price is in general closely related to the spatial characteristics of an area, it adopts a mixed GWR (geographically weighted regression) model in order to identify local and global effects of independent variables on agricultural property values. Results of a mixed GWR model prove to be superior to those of a global model (OLS) and standard spatial econometrics models (SAR, SEM, SAC) in terms of model fits and stability of the parameters estimated. The model notes that spatial dependency and heterogeneity are particularly important in examining the variations of agricultural land price. The empirical results provide strong evidences that such factors as man-made and natural features are closely relevant in determining agricultural property values.

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I. Introduction

Determinants of agricultural land price have long been an issue among researchers. Farmland comprises the largest portion of a farming family's assets and thus, it is critically important to understand factors influencing its value. Rent derived from agricultural income has always been considered as the major land price determinant, however, potential nonfarm uses of agricultural land has received increasing attention in recent years. Due to urbanization, urban demands for farmland are substantial and the present and expected shifts from agricultural to urban uses are a major market phenomenon of these days. Generally, the interaction of agricultural and urban market forces results in increased values accruing to farmland owners.

Urban economists(e.g. Capozza and Helsley, Brueckner) model the value of farmland as the discounted present value of future rents from a combined stream of agriculture and nonfarm uses. Using their theoretical model, Capozza and Helsley(1989) showed that the value of expected future rent increase may easily account for half of the average price of land and may create a large gap between the price of agricultural land at the urban boundary and the value of agricultural land rent. The idea behind the urban growth model of urban economists is that current farmland values represent the current value of future agricultural and potential development rents. The model has been used to empirically estimate the effect of urbanization on farmland values(Cavailles and Wavresky, 2003; Hardie, Narayan, and Gardner, 2001; Plantinga, Lubowski, and Stavins, 2002; Plantinga and Miller, 2001). Land prices often exceed the reasonably expected future returns from farming, even in the absence of a speculative agricultural land boom(Hardie, Narayan, and Gardner, 2001).

This study investigates the determinants of agricultural land prices, focusing particularly on urban development pressure. We employ several proxy measures of urban development pressure in county-level as explanatory variables of analysis. However, the issue of spatial heterogeneity centers on whether the marginal influence of characteristics is constant throughout the study area or varies over space. Since agricultural land prices are in general closely related to the spatial characteristics of an area, there is a need to incorporate these area characteristics in our statistical model. There is also the likelihood that some determinants exert influence on agricultural land prices differently across re-

gions while others do to the same degree across the regions. A failure to incorporate spatial heterogeneity will result in biased coefficient and a loss of explanatory power and may obscure important dynamics relating to the agricultural land prices. To model this eventuality, the present study adopts the strategy of mixed Geographically Weighted Regression model.

The remainder of this paper is organized as follows. We begin with a review of the literature. Next, the data and methodology employed in the study are detailed. We then compare the results of the models and discuss the spatial patterns observed in the data. Finally, a summary of the paper and conclusions are provided.

II. Literature review

Agricultural land values and factors that affect such values continue to be of interest. Since the market for land violates the homogeneous products assumption underlying the conventional supply and demand approach, hedonic pricing theory has been the theoretical basis for many empirical analysis of agricultural land prices. In hedonic pricing theory, a class of differentiated products is completely described by an array of objectively measurable characteristics (Rosen, 1974). Due to their ability to capture the effects on property value of a change in individual characteristics, hedonic pricing models are widely used in measuring the willingness to pay for a change in environmental characteristics.

Early studies of agricultural land prices can be divided into two broad categories: those which concentrate on rent derived from agricultural income as the major land prices determinant and those which utilize not only agricultural factors but also nonfarm factors such as distance from urban areas.

In the first category are the rent capitalization models in which net returns to agricultural activities or proxies are used in conjunction with other explanatory variables. Studies such as Alston(1986) and Chavas and Shumway (1982) have explained prices in terms of the discounted expected future returns from farming the land, with elaboration concerning expected interest rates, inflation, and speculative bubbles. Macroeconomic factors were brought in to explain prices that could not be readily explained in terms of observed or reasonably expected returns to farming.

However, agricultural land prices often exceed the reasonably expected future returns from farming, even in the absence of a speculative agricultural land boom. The second approach focuses on potential non-farm uses of agricultural land. Variables such as farm income, soil characteristics and other land characteristics were used as agricultural factors while distance from urban areas, location, highway frontage, and other urban/industrial variables as nonfarm factors. Chicoine(1981) hypothesized agricultural land price to be a function of access to points of economic and social attraction, amenity and physical properties, the availability of public services, and institutional factors that influence the land market and its participants. Benirschka and Binkley (1994) used proxies of net returns to agricultural activities and also nonfarm factors as variables to test whether land prices variability increased with distance to markets.

Urban economists model the value of farmland as the discounted present value of future rents from a combined stream of agriculture and nonfarm uses and the model served as the theoretical basis for a number of econometric analysis. In a competitive market, the price of land will equal the discounted sum of expected net returns obtained by allocating the land to its most profitable use. If agricultural production is currently the most profitable use, but development for some other purpose is expected to yield even greater net returns in the future, then the current land price should reflect the returns to both uses in a simple additive form: the sum of the discounted stream of rents from agriculture up until the time of conversion plus the discounted stream of expected rents from development from that time onward (Brueckner 1990, Capozza and Helsley, 1989). With their theoretical model, Capozza and Helsley showed that in rapidly growing cities, the growth premium may create a large gap between the price of land at the boundary and the value of agricultural land rents so the growth premium may easily account for half of the average price of land.

In Korea, many agricultural economists conducted studies on agricultural land price. However, most of their studies focused on determinants of price change and usually used time series data. For example, Lee and Cho (1996) studied the causality between farm land price and agricultural rent. Chae, Lee and Kim (2005) also performed Granger causality tests of farmland price, rent, rice income and debt/property ratio. However, there are little studies containing influence of farmland conversion and nonfarm factors in Korea. However, Kwon (2008) is an exception. He constructed a multilevel/hierarchical Bayesian hedonic price function and his model employed not only parcel-spezif-

ic characteristics but also region-specific variables such as population size, acreage, degree of industrialization and urbanization.

Though many of those hedonic models are estimated using traditional regression analysis, alternative methods have also been attempted. Spatial dependency and spatial heterogeneity are one of the econometric issues that has received attention in recent analysis of farmland prices. Because land parcels located in proximity to one another are prone to have similar unobservable characteristics, spatial error correlation is often present in land-use models. Hardi, Narayan and Gardner (2001) used spatial econometrics in their simultaneous equation model of farmland prices to test and correct for possible spatial autocorrelation between land values in neighboring counties. Jeanty et al. (2002) and Varrion-Flores and Irwin (2004) also adopted spatial models and the results indicated that ignoring the spatial configuration of the data and the presence of outliers would produce different inferences. Even though there are many spatial econometrics models abroad, lack of data has prohibited empirical spatial econometrics analysis on Korean farmland price. In this study, we tried to step up for better understanding determinants of Korean agricultural land price by using spatial econometrics models, especially by the mixed Geographically Weighted Regression approach.

III. Methodology

1. Mixed GWR

In this study, we examine a hedonic price model with variables selected based on previous studies. What most differs this study from other researches is that we are able to examine a varying effect of the same variable across the region by adopting a mixed GWR approach.

Suggested and developed by Brundsdon, Fotheringham and Charlton (1999), a GWR model can be defined as belows:

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^m \beta_k(u_i, v_i) x_{ik} + \epsilon_i \quad i = 1, 2, \dots, n \quad (1)$$

where $\beta_k(u_i, v_i)$ represents the regression coefficient for variable k at regression point i . In matrix notation, the parameters of a GWR model are estimated as follows:

$$\hat{\beta}(u_i, v_i) = [X^T W(u_i, v_i) X]^{-1} X^T W(u_i, v_i) Y \quad (2)$$

where $W(u_i, v_i)$ is a spatial weighting matrix. There are several ways to determine $W(u_i, v_i)$ like Bi-square, Tri-cube, and Gaussian, etc. and the present study selects exponential function shown in Eq.(3).

$$w_j(u_i, v_i) = \sqrt{e^{-d_{ij}^\theta}}, \text{ where } d_{ij} \text{ is distance between } i \text{ and } j \quad (3)$$

The GWR model in Eq.(1) can be expressed as in Eq.(4), a mixed GWR version suggested by Brunson, Fotheringham and Charlton (1996).

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^l \beta_k x_{ik} + \sum_{k=l+1}^m \beta_k(u_i, v_i) x_{ik} + \epsilon_i \quad (4)$$

$\beta_k(1, \dots, l)$ s are global coefficients and $\beta_k(l+1, \dots, m)$ s are local coefficients. In matrix notation,

$$Y = X_G \beta_G + m + \epsilon \quad (5)$$

where $m = \sum_{k=l+1}^m \beta_k(u_i, v_i) x_{ik}$.

Assuming that β_G is known, we can use basic GWR procedure to estimate m .

$$\hat{m} = L(Y - X_G \beta_G) \quad (6)$$

$$L = \begin{pmatrix} X_1^T [X^T W(u_1, v_1) X]^{-1} X^T W(u_1, v_1) \\ X_2^T [X^T W(u_2, v_2) X]^{-1} X^T W(u_2, v_2) \\ \vdots \\ X_n^T [X^T W(u_n, v_n) X]^{-1} X^T W(u_n, v_n) \end{pmatrix}$$

Thus, the global coefficients are defined as

$$\widehat{\beta}_G = [X_G^T(I-L)^T(I-L)X_G]^{-1}X_G^T(I-L)^T(I-L)Y \quad (7)$$

If we apply Eq.(7) to Eq.(6), then we can derive local coefficients.

Mei, He and Fang (2004) suggested a test statistic that can verify the validity of the local and global coefficients. The coefficient $\beta_k(u_i, v_i)$ for each variable $x_k (k=1, 2, \dots, m)$ is estimated by the basic GWR model in Eq.(1) to identify its role as local or global variable. The test statistic suggested by Mei, He and Fang (2004) is as follows.

$$\begin{cases} H_0 : \beta_k(u_1, v_1) = \beta_k(u_2, v_2) = \dots = \beta_k(u_n, v_n) \\ H_1 : \text{the value of } \beta_k(u_i, v_i) \text{ are unequal at least two different locations} \end{cases}$$

$$F(k) = \frac{\widehat{\beta}_k^T(I - \frac{1}{n}J)\widehat{\beta}_k}{\widehat{e}^T\widehat{e}} = \frac{Y^TB^T(I - \frac{1}{n}J)BY}{Y^T(I-L)^T(I-L)Y} \quad (8)^1$$

where $F(k)$ can be approximated by an F -distribution such as $F_\alpha(\frac{\gamma_1^2}{\gamma_2}, \frac{\delta_1^2}{\delta_2})$ for a given significance level α .

Leung, Mei and Zhang (2000a; 2000b) showed that the p-value of Eq.(8) can be approximated by the three-moment chi-square approximation as the following Eq.(9).

$$p(k) \approx \begin{cases} P\left\{\chi_d^2 > d - \frac{1}{b}tr[M_1 - f(k)M_2]\right\}, & \text{if } tr[M_1 - f(k)M_2]^3 > 0 \\ P\left\{\chi_d^2 < d - \frac{1}{b}tr[M_1 - f(k)M_2]\right\}, & tr[M_1 - f(k)M_2]^3 < 0 \end{cases} \quad (9)^2$$

$$\text{where, } b = \frac{tr[M_1 - f(k)M_2]^3}{tr[M_1 - f(k)M_2]^2}, \quad d = \frac{\{tr[M_1 - f(k)M_2]^3\}^2}{\{tr[M_1 - f(k)M_2]^2\}^3},$$

$$M_1 = B^T(I - \frac{1}{n}J)B \quad \text{and} \quad M_2 = (I-L)^T(I-L)$$

¹⁾ Refer to Leung, Mei and Zhang (2000a) pp.21-23 for specific notations.

²⁾ Refer to Leung, Mei and Zhang (2000b) pp.880-883 for detailed explanations

Since $p(k)$ approximately follows chi-square with d degrees of freedom, based on Eq.(9), given null hypothesis can be tested. By using this test statistic, the present study identified global and local coefficients.³⁾

2. SAR, SEM, SAC

Spatial autoregressive model(SAR) assumes that observation that are near should reflect a greater degree of spatial dependence than those more distant from each other(LeSage, 1999).

$$\begin{aligned} M &= \rho W(M) + X\beta + \epsilon \\ \epsilon &\sim N(0, \sigma^2 I_n) \end{aligned} \quad (13)$$

M is an $n \times 1$ vector of dependent variable and X denotes an $n \times k$ matrix of explanatory variables. W represents spatial weight matrix containing contiguity relations or functions of distance. The scalar ρ is a coefficient on the spatially lagged dependent variable, and β denotes a parameter vector estimated from explanatory variables.

The second model we utilize is the spatial autoregressive error model (SEM); it is based on the assumption that the disturbances exhibit spatial dependence.

$$\begin{aligned} M &= X\beta + u \\ u &= \lambda Wu + \epsilon \\ \epsilon &\sim N(0, \sigma^2 I_n) \end{aligned} \quad (14)$$

The scalar λ is a coefficient on the spatially correlated errors.

General spatial model(SAC) includes both spatial lag term and a spatially correlated error term.

³⁾ For the validity of the test statistic, see simulation results of Leung, Mei and Zhang (2000b) pp.883-888.

$$M = \rho W(M) + X\beta + u \quad (15)$$

$$u = \lambda Wu + \epsilon$$

$$\epsilon \sim N(0, \sigma^2 I_n)$$

In this study, first-order rook contiguity, defining $W_{ij}=1$ for regions that share a common side with the regions of interest, is an adopted weighting method of spatial weighted matrix and it is standardized.

IV. Data and Variables

1. Data

The data used in this study are basically from “Annual Report of the Declared Land Price” published by the Ministry of Land, Transport and Maritime Affairs of Korea, “a statistical yearbook” published by each province, 2005 Korea Census Data (2% sample), and statistics by Korean National Statistics Office.

The ‘declared land price’ is the standard land price of 500,000 parcels, which are carefully selected from the nation’s 27 million parcels of land to represent the average land price of the county a parcel is located in and appraised by Korea Appraisal Board. Since land use in Korea is regulated by zoning, the ‘declared land price’ is provided for each urban planning zone and non-urban lands which are not subject to urban planning zone. The “Annual Report of the Declared Land Price” provides a maximum and a minimum of ‘declared land price’ of 247 counties of the nation, and we regard the median of the maximum and minimum of non-urban lands as an average price of agricultural lands in a county, which is the dependent variable of this study.

This study utilized the ‘declared land price’ in 2005. Since the main focus is on agricultural land prices, we excluded main metropolitan areas since they do not have non-urban lands in the counties. Island areas are also excluded. Ultimately, we utilized 112 county-level aggregate data for analysis.

2. Variables

In this study we made the choice of the variables on four criteria: the purpose of the study, theoretical relevance, empirical evidence, and data availability on the characteristics of the properties in the sample.

Average rate of change in population density is used as a proxy variable for urban growth rate. Capozza and Helsley(1989)'s theoretical model of land prices showed that the average price of land is an increasing, convex function of the rate of population growth and Plantinga, Lubowski and Stavins (2002) used the average change in population density as a proxy measure for the growth rate.

They also showed in their price expression based on a spatial city model that the current price of recently developed land is positively related to the current average price of agricultural land. However, since we do not have data on recently developed land for each county, five other variables are included to measure urban development pressure's influence on agricultural land prices instead. Average transactions in urban planning zone - residential sites, commercial sites and industrial sites - are used as proxies of urban development pressure in the county. Average transactions of paddy and forest field in the county are also included. Jeanty et al.(2002) used the proportion of neighboring land sold in the previous years to control the neighbor's influence and their result indicated the variable has a strong positive influence on the value of the land.

Length of paved road is used as a proxy variable of accessibility. Access has long been recognized as important in determining agricultural land values(Chicoine, 1981; Shonkwiler and Reynolds, 1986). Higher road density is expected to reduce travel cost and increase the land prices(Plantinga, Lubowski and Stavins, 2002). Agricultural rent or agricultural productivity is measured by average agricultural sales per farmhouse, and it is expected to be positively related to the agricultural land value.

Since Korea's biggest agricultural product has been rice, traditionally, we employed the cultivated acreage for rice as a variable which stands for a characteristic of land. If agricultural productivity of a county with larger cultivated acreage for rice is higher than others, then it may be positively related to land price. The relationship may also be negative if being a more traditional agricultural region negatively affects the probability of urban development or

TABLE 1. Explanation of Variable

| Variable | Explanation |
|----------------------|---|
| Dependent Variable | |
| Price | Log of average land price of non-urban area (won/m ²) |
| Independent Variable | |
| Density | Log of average rate of change in population density for 2001-2005 |
| Road | Log of length of paved road in 2005 (km) |
| Sales | Log of average agriculture sales per farmhouse in 2005 (won) |
| Area | Log of cultivated acreage for rice (ha) |
| Paddy | Log of average transactions of paddy field for 2001-2005 |
| Forest | Log of average transactions of forest field for 2001-2005 |
| Dwelling | Log of average transactions of residential sites in urban planning zone for 2001-2005 |
| Business | Log of average transactions of commercial sites in urban planning zone for 2001-2005 |
| Industrial | Log of average transactions of industrial sites in urban planning zone for 2001-2005 |
| Water | Log of ratio of water supply in 2005 |
| Econ_devlp | Log of expenditures of economic development in 2005 (million won) |

TABLE 2. Descriptive Statistics

| Variable | Mean | Standard Deviation | Max | Min |
|----------------------|-------|--------------------|-------|-------|
| Dependent Variable | | | | |
| Price | 11.99 | 0.70 | 14.35 | 10.23 |
| Independent Variable | | | | |
| Density | -0.01 | 0.02 | 0.09 | -0.06 |
| Road | 5.84 | 0.42 | 6.69 | 3.99 |
| Sales | 7.14 | 0.37 | 7.99 | 5.92 |
| Area | 8.64 | 0.86 | 10.20 | 5.73 |
| Paddy | 7.51 | 0.60 | 8.89 | 6.30 |
| Forest | 6.85 | 0.68 | 8.78 | 5.54 |
| Dwelling | 6.50 | 1.76 | 9.99 | 0.69 |
| Business | 4.59 | 1.39 | 8.81 | 0.00 |
| Industrial | 3.17 | 1.76 | 7.48 | 0.00 |
| Water | 0.48 | 0.12 | 0.68 | 0.23 |
| Econ_devlp | 11.18 | 0.77 | 12.23 | 4.38 |

farmland conversion. The relationship is therefore uncertain.

We employed proxy variables such as the ratio of water supply and government expenditures of economic development to account the cost of conversion. Where the expected cost of conversion to urban use is relatively low, higher returns from conversion is expected and it may enhance the expected future rent increase.

In regression of the agricultural land prices, the logarithmic transformation of both dependent and explanatory variables is executed to estimate the percentage change in dependent variable for a one percent change in independent variables.

V. Results

Table 3 presents the result of global/local coefficient test incorporating the three-moment chi-square test statistics suggested by Mei, He and Fang (2004). Among the eleven independent variables, we identify four variables as local parameters and seven independent variables as global at significance level 10%. One variable was identified as a local variable at significance level 5%.

TABLE 3. Testing Results of Global / Local Parameter

| Variable | P-value | Significance at 10% | Significance at 5% | Significance at 1% |
|------------|---------|---------------------|--------------------|--------------------|
| Intercept | 0.8370 | | | |
| Density | 0.0485 | Local | Local | |
| Road | 0.9749 | | | |
| Sales | 0.7729 | | | |
| Area | 0.0219 | Local | Local | |
| Paddy | 0.0722 | Local | | |
| Forest | 0.8821 | | | |
| Dwelling | 1.0000 | | | |
| Business | 1.0000 | | | |
| Industrial | 0.0520 | Local | | |
| Water | 0.6912 | | | |
| Econ_devp | 0.3741 | | | |

TABLE 4. Results of OLS, SAR, SEM, SAC, GWR, and Mixed GWR

| Variable | OLS | SAR | SEM | SAC | GWR | | Mixed GWR | |
|-------------------|------------|------------|------------|------------|-------------|--------|-------------|--------|
| | | | | | Mean | Stdv. | Mean | Stdv. |
| intercept | 7.9424 *** | 7.6756 *** | 7.8794 *** | 7.6913 *** | 6.8375 L | 1.3977 | 0.0119 *** | |
| Density | 7.8301 ** | 7.6569 ** | 7.9640 ** | 7.8150 ** | 1.5896 L | 9.1783 | -4.3229 L | 9.5147 |
| Road | -0.3934 ** | -0.3785 ** | -0.3792 ** | -0.3706 ** | -0.3945 L | 0.1193 | -0.2234 * | |
| Sales | 0.0164 | 0.0223 | 0.0156 | 0.0201 | 0.1022 L | 0.1675 | 0.7249 | |
| Area | -0.0459 | -0.0391 | -0.0431 | -0.0385 | -0.1546 L | 0.2756 | -0.2427 L | 0.4040 |
| Paddy | 0.4579 ** | 0.4443 ** | 0.4522 ** | 0.4431 ** | 0.4784 L | 0.3831 | 0.5173 L | 0.5111 |
| Forest | 0.1668 | 0.1665 | 0.1698 | 0.1691 | 0.2387 L | 0.1048 | 0.3220 * | |
| Dwelling | 0.0096 | 0.0113 | 0.0090 | 0.0103 | 0.0468 L | 0.0299 | 0.0283 | |
| Business | -0.0091 | -0.0098 | -0.0134 | -0.0132 | 0.0032 L | 0.0215 | -0.0522 | |
| Industrial | -0.0551 | -0.0541 | -0.0586 | -0.0573 | -0.1028 L | 0.0857 | -0.1431 L | 0.0996 |
| Water | 0.2944 | 0.3187 | 0.3275 | 0.3402 | 0.4594 L | 0.5801 | 2.3061 * | |
| Econ_devlp | 0.1919 ** | 0.1925 ** | 0.1923 ** | 0.1927 ** | 0.2367 L | 0.1265 | 0.3096 ** | |
| rho | | 0.0129 | | 0.0096 | | | | |
| lambda | | | 0.0480 | 0.0409 | | | | |
| N | 112 | 112 | 112 | 112 | 112 | | 112 | |
| R ² | 0.3944 | 0.3947 | 0.3956 | 0.3960 | 0.5964 | | 0.4729 | |
| AdjR ² | 0.3277 | 0.3281 | 0.3292 | 0.3295 | 0.5520 | | 0.4149 | |
| Sigma_sq | 0.3300 | 0.2943 | 0.294 | 0.2939 | | | | |
| Log Likelihood | | -51.6066 | -51.5966 | 12.5488 | | | | |
| Durbin-Watson | 1.8446 | | | | | | | |
| Decay Type | | | | | exponential | | exponential | |
| Bandwidth | | | | | 1.1334 | | 1.0165 | |

* p<0.1, ** p<0.05, *** p<0.01

L: local parameter

Based on the results, we set up a mixed GWR model using four local variables and seven global variables. In addition, we conduct four more estimation using the same data but different approaches such as OLS, SAR, SEM, SAC and a basic GWR model for comparison. The estimation results are shown in Table 4.

Among all models, the GWR model and the mixed GWR have the highest adjusted R-squared statistic: 0.5520 in the GWR model and 0.4149 in the mixed GWR model. However, the intercept in the GWR model is estimated far larger than that in the mixed GWR model. When considering that, the mixed GWR has merit in being more stable and providing a better explanation.

Among the seven variables identified as global parameters, length of paved road(Road) is negatively related with the agricultural land prices and significant at .10 level. It is contrary to the expectation that increased accessibility opens up prospects for development and therefore elevates the land price. Similar results were shown in Son and Kim(1998). They pointed out that roads might be built in order to alleviate congestion in cities where the land use is already predominantly urban, rather than to encourage the development of the areas where conversion of rural land is desired.

Increased average agriculture sales per farm family(Sales) show an expected positive sign reflecting the fact that increased agricultural productivity elevates agricultural land prices, but was not statistically significant. Average transactions of forest field(Forest) is positively associated with agricultural land prices and significant at .10 level. Average transactions of residential sites(Dwelling) and average transactions of commercial sites(Business) had small and insignificant coefficients. Two variables which are proxy variables for the cost of conversion, ratio of water supply(Water) and expenditure of economic development(Econ_devlp) were both statistically significant and positive. Higher level of social infrastructure would reduce cost of agricultural land, therefore elevating the possibility of urban development and the premium as well.

The sign and magnitude of four local parameters for each region are presented in Figure 1 and Figure 2. The effect of average rate of change in population density(Density) changes across the regions. Furthermore, the sign of coefficient varies from minus to plus according to regions. It may imply that the effect of urban growth is not always positive to land prices. As seen in Figure 1, higher population density change is positively associated in SMA (Seoul Metropolitan Area including Seoul, Incheon and Gyeonggi) and central

FIGURE 1. Estimated local parameters for each region : Density and Area

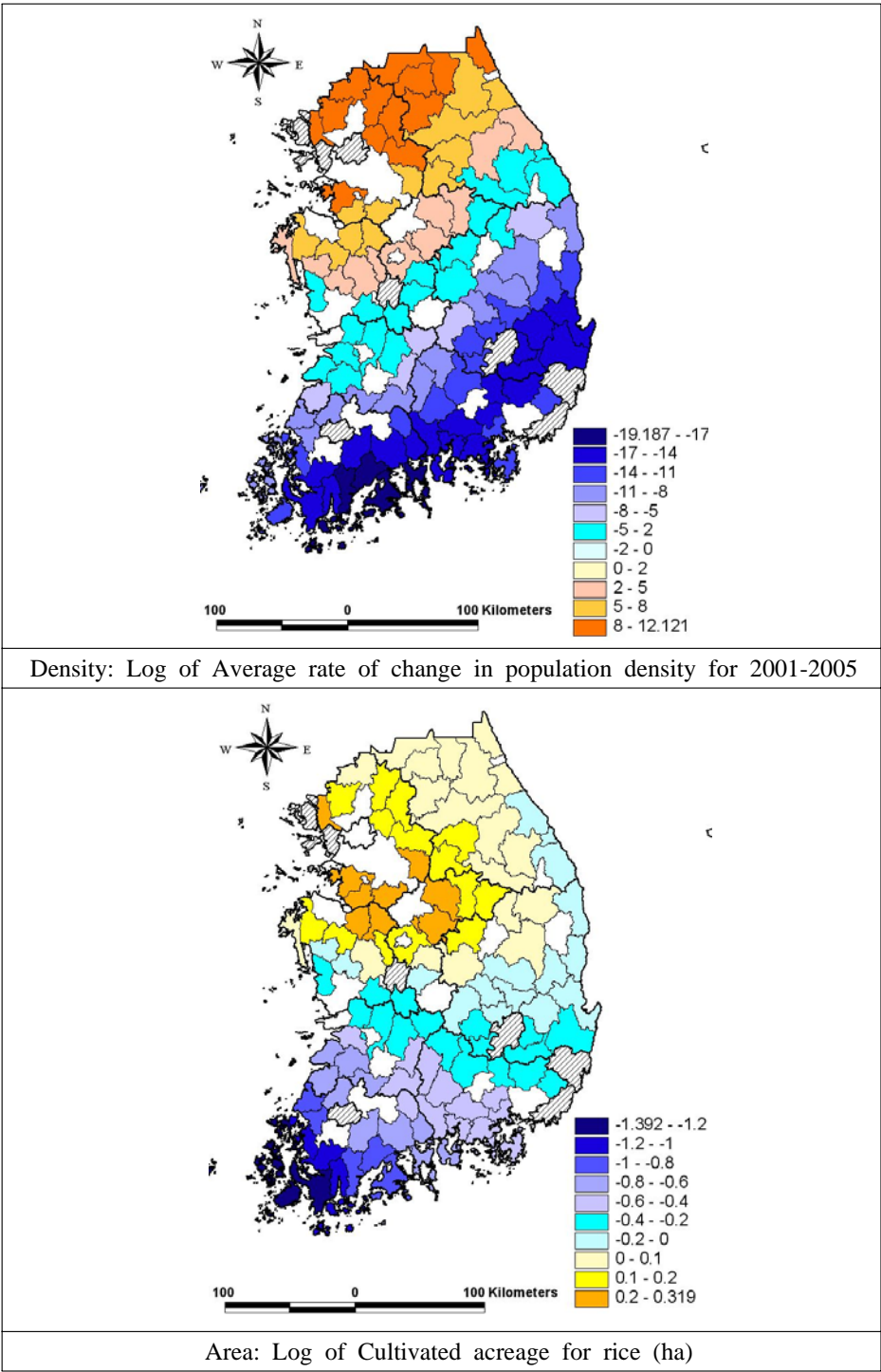
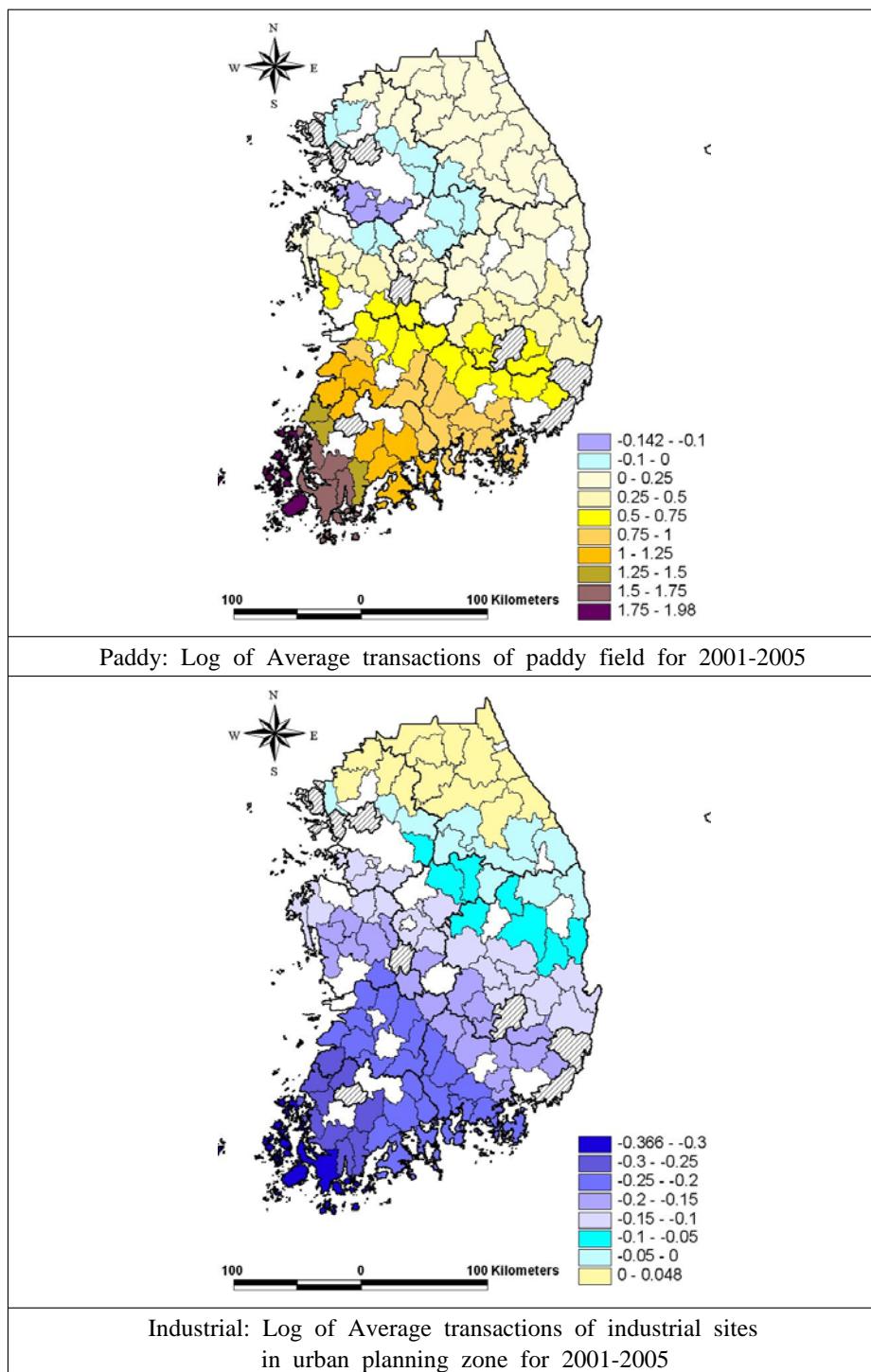


FIGURE 2. Estimated local parameters for each region : Paddy and industrial



area(Gangwon, Chungcheong and Daejeon). The farther from SMA it is located, the more the region's agricultural land price is negatively affected by population density change.

Since larger cultivated acreage for rice(Area) may represent larger agricultural produce, a positive sign of coefficient is expected in general. However, similar to population density change, effect of the variable declines as location of regions is getting away from SMA and even its marginal effect turns to be negative. The magnitude of negative effect was larger in the southwest area which has been a major rice production region.

Average transaction of paddy field(Paddy) is negatively related in most of the regions, except a few counties in SMA. The number of counties occupies approximately 10% of total number of counties used in the analysis. As seen in Figure 1, the tendency of negative effect of average transaction of paddy field is intensified in southwest area.

The sign of average transactions of industrial sites(Industrial) was estimated to be negative in general, except for north Gyeonggi and Gangwon province, which is located in the northeast in central area. Considering that industrial activities tend to concentrate geographically in order to achieve agglomeration economies, transactions of industrial sites are expected to be negative to rural land conversion. Carrion-Flores and Irwin(2004) reported a similar result. In Figure 2, a steady trend of intensifying negative effect from the northeast side to the southwest side is observed.

A GWR model specifies a separate regression model at every observation point, thus enabling a unique coefficient to be estimated at each location (Brunsdon, Fotheringham, and Charlton. 1996). Since Eq (3) reflects the spatial dependency by the distance decay principle, estimated coefficients at each point can get various scales and even opposite signs of coefficient. However, even though some points get positive and other points have negative coefficients, direct interpretation of coefficients' magnitude and sign might cause some misunderstandings about the model. In GWR modeling, researchers can choose various kernels such as Eq (3), thus it is possible for them to have a different magnitude for a same coefficient with respect to different kernels. Therefore, it is a more accurate interpretation of magnitude and sign of coefficient to comprehend that marginal effect of independent variables might not always have constant influence on every point.

But some independent variables would have constant or similar influ-

ence on each point and others might have different impacts. A mixed GWR, adopted in this study, allows us to identify global and local parameters statistically. Identified local parameters are also estimated by the original GWR method, and its coefficients should be understood in the GWR context. Therefore, identified local parameters' magnitude and sign do not have absolute effect on dependent variable, but have relative effect on observation points when researchers consider the spatial dependency and heterogeneity.

In this point, the empirical results of this study show that Korean agricultural land price might not be explained by only constant impacts of its determinants. But rather, there exist global and local determinants. Estimated results imply that agricultural factors are likely to have constant marginal effect on agricultural land price and also that urban development factors are prone to affect agricultural land price differently even though there are some exceptions. These empirical findings would support an argument that appraisers should not apply a sole evaluation basis when they assess agricultural land located in different spatial conditions.

VI. Conclusion

The present study examined determinants of agricultural land price in Korea focused particularly on the effect of urban development pressure. Based on county-level data of Korea, explanatory variables that approximate both agricultural productivity and urban development pressure were introduced in to a hedonic model. In estimation, we adopt the strategy of mixed GWR modelling to deal with spatial heterogeneity which occurs in the analysis over space.

Not surprisingly, the results indicate that both agricultural productivity and nonfarm use potential affect agricultural land price of Korea. Not surprisingly, our results indicated that agricultural land price increases with average agriculture sales, ratio of water supply, expenditure of economic development and transactions of forest field. A larger cultivated acreage for rice was found to affect negatively agricultural land price, implying the decline of the traditional agricultural region of Korea. Only the negative sign of length of paved road was different from the expectation.

We were also able to estimate the non-stationary of coefficients of de-

terminants and its variation across the regions, discerning local and global effect of each variable through the mixed GWR approach. Our mixed GWR model showed superiority over other models such as OLS, standard spatial econometric models, and basic GWR model on its explanation power and stability. Among eleven explanatory variables of our analysis, four variables were identified as local parameters whose coefficient varies over space. Three of four local parameters were proxies for urban development pressure. This result indicates that the influence of factors that affect agricultural land price varies across regions and we cannot simplify the role of urban development pressure in agricultural land price as constant throughout Korea. Urban growth may influence agricultural land prices both positively and negatively according to regions, and the differences should be considered when policy decisions are made.

Further research needs to be done to uncover the exact nature of spatial heterogeneity in agricultural land prices. The counterintuitive mixed GWR estimates found at some locations deserve further attention as well. Plus, this study was conducted based on aggregate data at the county-level, but more detailed information on geographical characteristics of land in parcel-level would allow us to detect clearer effects of such variables on agricultural land prices. While this study provided general tendency of Korean rural land prices influenced by urban development pressure, more intricate and deeper study is needed in the future.

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