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AGRICULTURAL LAND PRICES AND SPATIAL QUANTILE REGRESSION

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ABSTRACT

The aim of this paper is to determine the spatial relationship of agricultural land prices with the selected features. The article presents data for land prices low, medium, and good in the period 2004 to 2011. The paper presents a comparison of different regression models: SAR, quantile regression. The results justifying by using quantile regression.

JEL classifications: C13, C21, C51, R19
Key words: agricultural land prices, spatial analysis, quantile regression

INTRODUCTION

Polish accession to the European Union resulted in changes in all fields of the economy. When it comes to agricultural real estate market it is the field where one will find the biggest price increase relating to other financial assets. It should be noted that since 2004, the price of agricultural land is growing steadily, however there is some slowdown in the growth. Investing in agricultural land is still interesting for people who do not want to incur the risks associated with investments in the stock market or the housing market. It is necessary to mention that weak soil situated within large cities is of a special interest. Increase in the price of agricultural land is also connected with state policy, preferential loans and opening the land market to foreigners in 2016. All the factors make the land market to be still very popular among investors. The crucial problem is therefore an estimate of the price of land and the factors leading to its diversity. The specificity of the agricultural land market as in the case of the housing market causes difficulty in the selection of appropriate models which describe the market. In the case of the housing market client's preferences should be measured by the method of hedonic pricing [Zietz 2008]. It is therefore necessary to consider why an investor is willing to pay a higher price for the property than it is worth. As stated by many authors, the primary factor that affects the price of land is its location and neighbourhood. The spatial method is used to analyse land's price because of the specificity of land. To estimate the function of supply and demand for agricultural land prices the method of estimator OLS is generally used. The same method is wieldy used and estimates functions regression parameter by minimizing residual sum of squares. In many cases, a problem that occurs when conducting analyses is the failure of assumptions. One of the assumption is a normal distribution of agricultural land prices. Failure to comply with the assumption of normal distribution of the dependent variable does not biased OLS estimators. These estimates are still consistent, but they are not efficient estimators among unbiased. The solution to this situation is the use of quantile regression [Kostov 2009], which are robust econometric methods.

The aim of this study was to determine the spatial relationship of agricultural land prices with the selected features using quantile regression.

METHODOLOGY

The spatial research determine**s** the interrelationship between the investigated objects which has a fundamental role [Anseli 2001]. The study use**s** a standard matrix of weights in standarized rows. Moran's correlation coefficient was calculated according to the formula:

$$I_g = \frac{n}{N_w}\frac{\boldsymbol{z}'\boldsymbol{W}\boldsymbol{z}}{\boldsymbol{z}'\boldsymbol{z}} \tag{1}$$

where:
W – matrix weight of standardized rows
z – vector of elements
N_w – is the sum of all elements of the matrix **W**

The following hypothesis was verified by Moran coefficient.

H_0: the observed values of the stochastic variable are distributed at random between the different spatial units (no spatial autocorrelation)

H_1: the observed values of the stochastic variable are not distributed at random between the different spatial units (spatial autocorrelation be positive or negative value)

Spatial autocorrelations may be presented at the Moran scatterplot which relates to the global Moran coefficient (Ig). This chart is used to visualize spatial relationships and determine the direction of spatial autocorrelation. The graph is divided into four parts to zero values. Each part is plotted on the axes of standardized consumption value of certified seed and the spatial lag variable [Anselin and in. 2004].

Classical linear regression model is:

$$\boldsymbol{Y} = \boldsymbol{X\beta} + \epsilon, \epsilon \sim iid, \epsilon \sim N(0, \delta^2 \boldsymbol{I}) \tag{2}$$

The following spatial regression models are:

spatial lag model - SAR

$$\boldsymbol{Y} = \rho \boldsymbol{WY} + \boldsymbol{X\beta} + \epsilon \tag{3}$$

spatial error model - SEM

$$\boldsymbol{Y} = \boldsymbol{X\beta} + \epsilon, \epsilon = \lambda \boldsymbol{W}\epsilon + \varsigma \tag{4}$$

mix model - SAC, SGM, SARAR[1,1]

$$\boldsymbol{Y} = \rho \boldsymbol{W}_1 \boldsymbol{Y} + \boldsymbol{X\beta} + \epsilon, \epsilon = \lambda \boldsymbol{W}_2 \epsilon + \varsigma \tag{5}$$

The paper is based on the classic model of spatial regression and spatial quantile regression. Having the form of cumulative distribution of quantile order (tau) we obtain the following formula:

$$Y_\tau = F_y^{-1}(\tau) \tag{6}$$

where:
(Ypsylon_tau) quantile order (tau) (in the paper tau = 0,5 is median)
F - cumulative distribution of variable y

Quantile regression can define conditional quantile of the form:

$$\Upsilon_\tau(\mathrm{x}) = F_{y|\mathrm{x}}^{-1}(\tau) \tag{7}$$

Estimation parameters of the order of quantile regression function is to minimize the residuals sum of the absolute values:

$$\min_{\beta\in\mathbb{R}^k} \sum_{i=1}^{n} |y_i - \Upsilon_{\tau=0.5}(x_i, \beta)| \tag{8}$$

Form quantile regression model spatial SAR:

$$\boldsymbol{Y} = \Upsilon_\tau \boldsymbol{WY} + \boldsymbol{X\beta}_\tau + \epsilon \tag{9}$$

In contrast to the classical model of spatial regression SAR (3) spatial lag parameter and vector regression parameters are dependent on the corresponding quantile tau order. The standard errors of the coefficient estimates are estimated using bootstrapping as suggested by Gould [Gould 1997]. All calculations were performed in the R-CRAN 2.15.1.

RESULT

The data used in the work came from the base of the CSO and ANR in the years 2004-2011. In this paper, the spatial relationship has been studied for the price of agricultural land. The following variables are as follow: prices of agricultural land (y), uniform direct payments (x1), complementary direct payments (x2), payments for LFAs (x3). All variables were observed at the level of provinces (NUT 2).

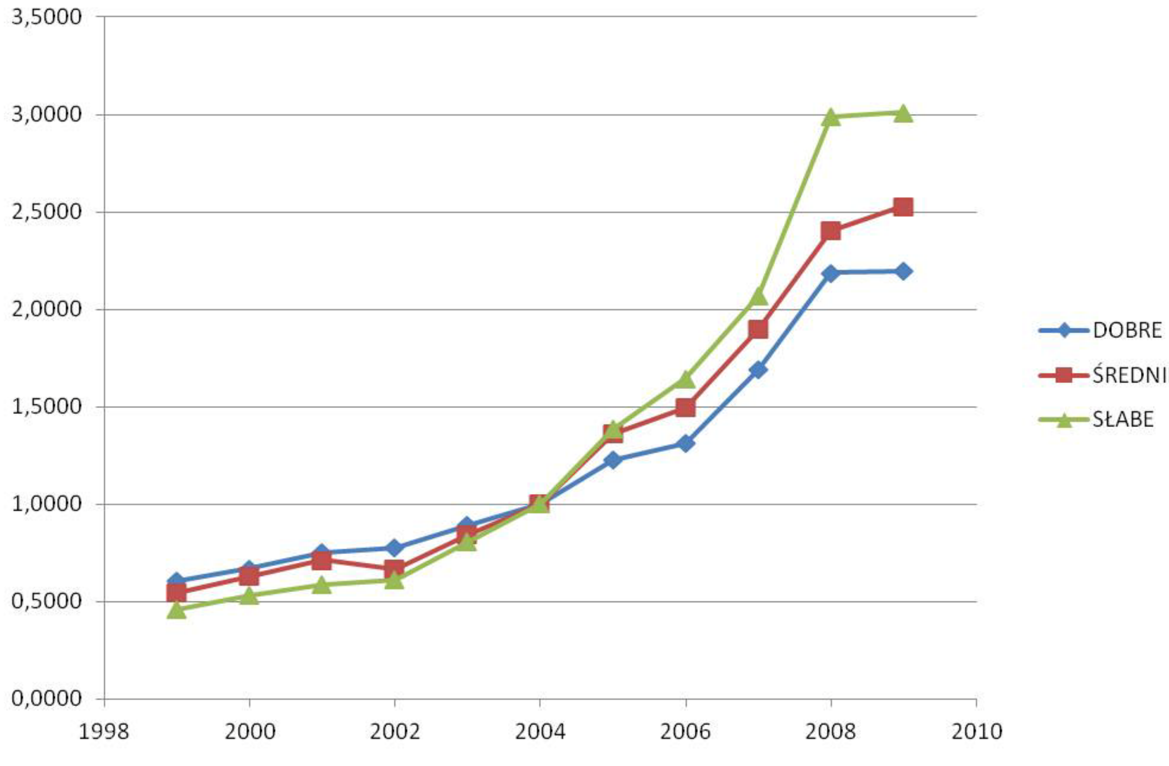

Figure 1 Changes in agricultural land prices (low, medium, and good) in the years 1999 to 2011

Agricultural land prices have been growing for over 12 years (Figure 1). Polish accession to the European Union in 2004 was a lever that caused a marked increase in prices and a change in demand due to the quality of the soil. Until

2004 the greatest demand for agricultural land was observed in case of good and medium soil quality. However, the weak agricultural land was not attractive to anyone. After 2004 there was a change in the relative prices of the quality of soil. The largest change was observed for the price of weak agricultural land. Figure 2 shows, a systematic increase in land prices compared to 2004. As you can see after 2004 the highest price change was achieved for weak quality of land (increase by nearly 300% compared to 2004). Medium quality of land was increased comparing to 2004 by approximately 200% and good by about 275%. Comparing the changes in the rate of price after 2004 they are as follow: good, medium and weak land: 15.50%, 17.38% and 20.87%. Although the prices of all quality land were growing from year to year, the highest average growth rate of 20.87% was observed for prices of weak quality land.

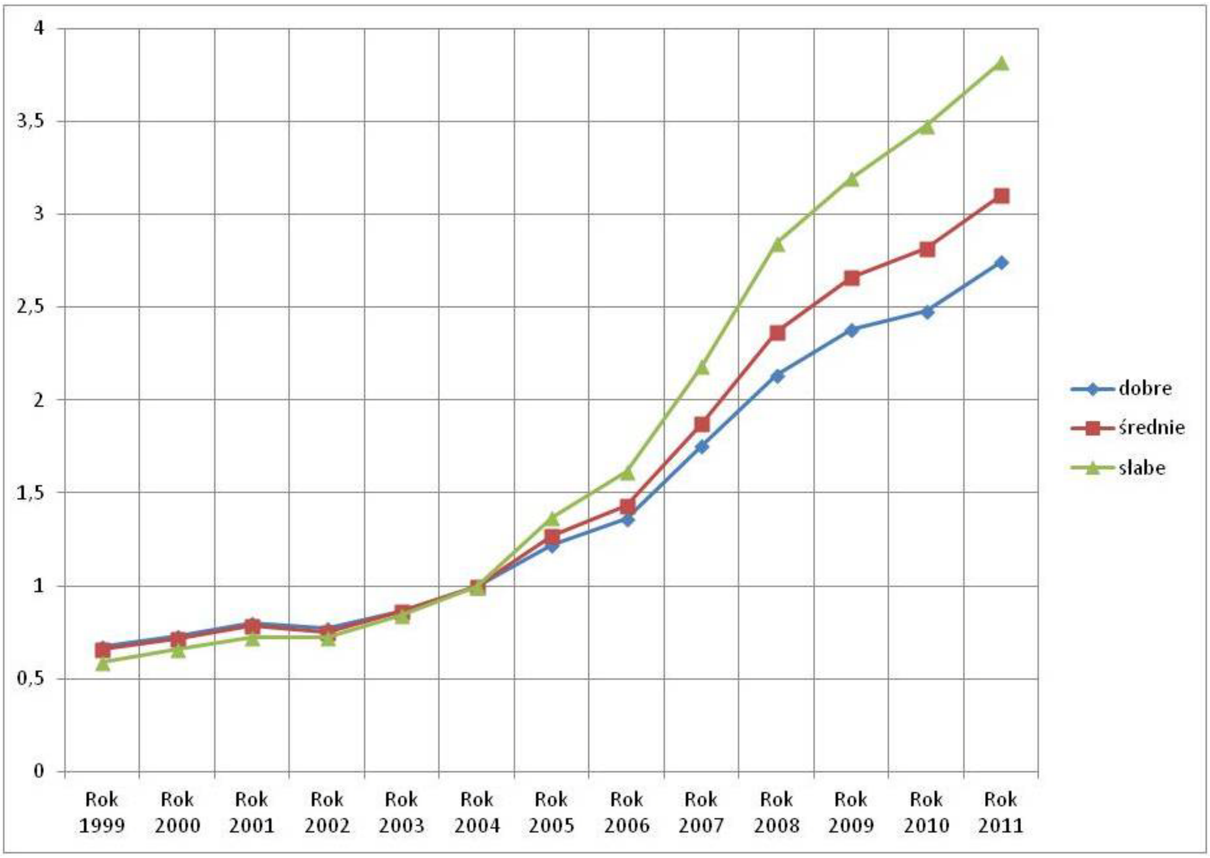

Figure 2 Dynamics of changes in agricultural land prices (weak, medium, and good) in the years 1999 to 2011

The increase in prices can be explained by various factors such as: the introduction of direct payments after joining the EU, the interest of investors in low quality land intended for construction purposes, the state policy offering preferential loans to young farmers, the investment is not risky. Figures 3, 4, and 5 present the prices of agricultural lands of a different quality in provinces between 2005 – 2010. Changes in the prices of agricultural land are the same in the structure of provinces. The highest prices of agricultural land over the period are observed in the provinces: wielkopolskie, kujawsko-pomorskie and pomorskie. Variation in the prices of land of different quality have been observed only since 2008.

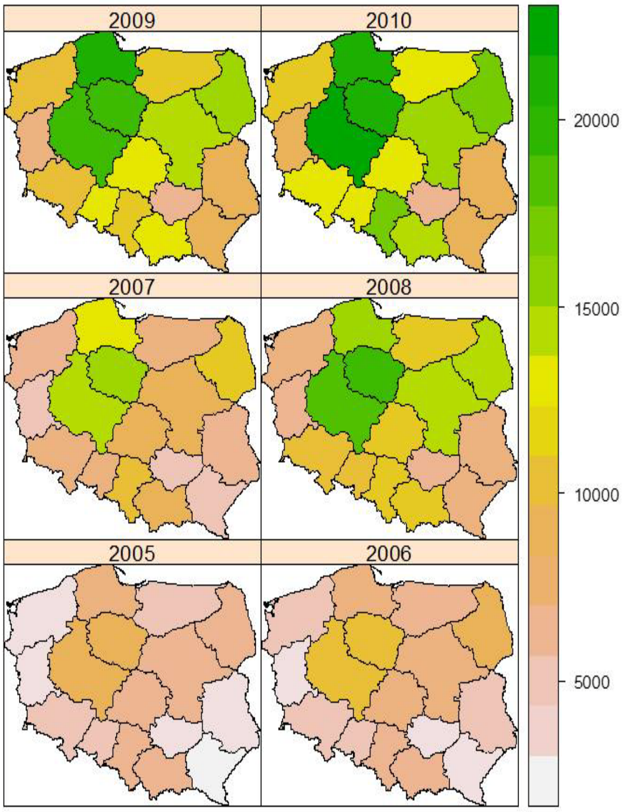

Figure 3 Average prices of weak of agricultural land in provinces.

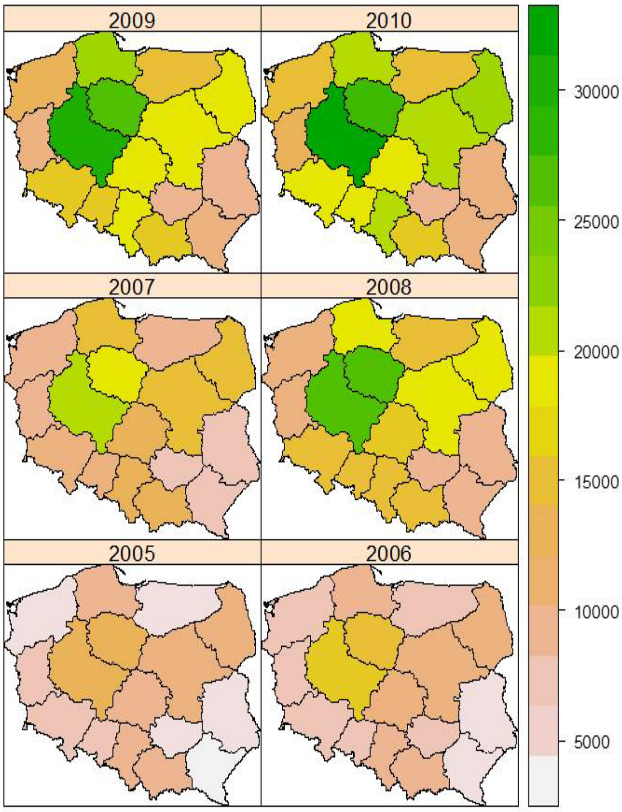

Figure 4. Average prices of medium of agricultural land in provinces.

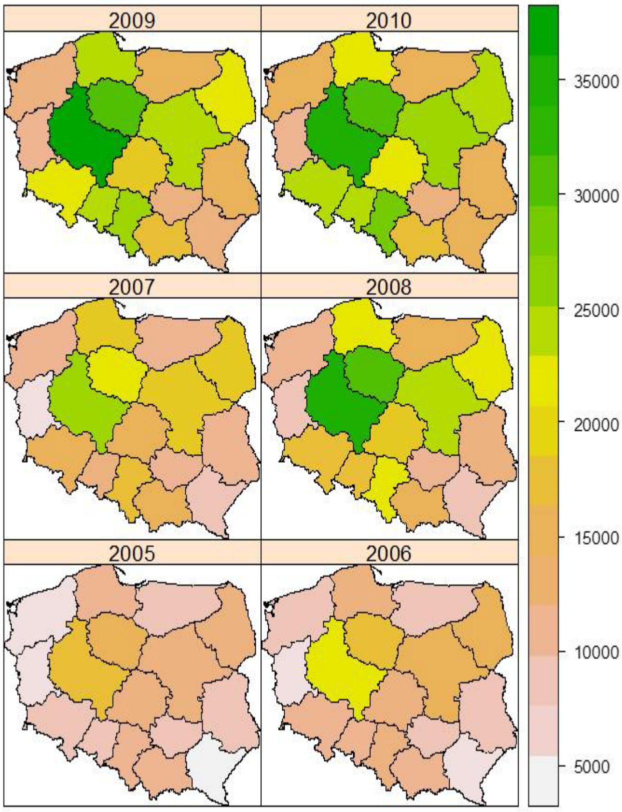

Figure 5. Average prices of good of agricultural land in provinces

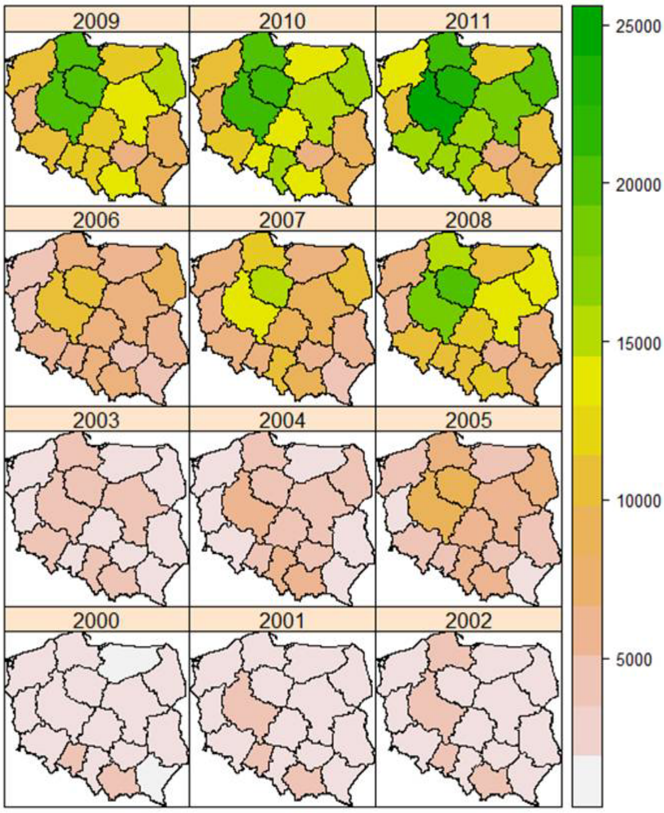

Figure 6 Average prices of weak of agricultural land in provinces (long period from 1999 to 2011).

Due to the previous considerations for weak quality of agricultural land a detailed analysis of price changes in the period from 2000 to 2011 was made (Figure 6). Until 2004 price of agricultural land was similar in particular provinces. After 2005, the price increase is noticeable only in provinces: wielkopolskie and kujawsko-pomorskie. In subsequent years, this trend persists. The provinces lubuskie and świętokrzyskie have the lowest prices of weak quality.

In the further part of the paper a detailed analysis of the weak land prices will be presented. This variable is calculated for the correlation coefficient to determine Moran spatial correlation. The analysis used a standard matrix of weights in standarized rows. The study found land prices or spatial correlation so it can be concluded that the observed value of agricultural land prices are not arranged at random between provinces and create a spatial regimes due to the studied trait. The graph shows the distribution of Moran provinces in the four quadrants (Figure 7).

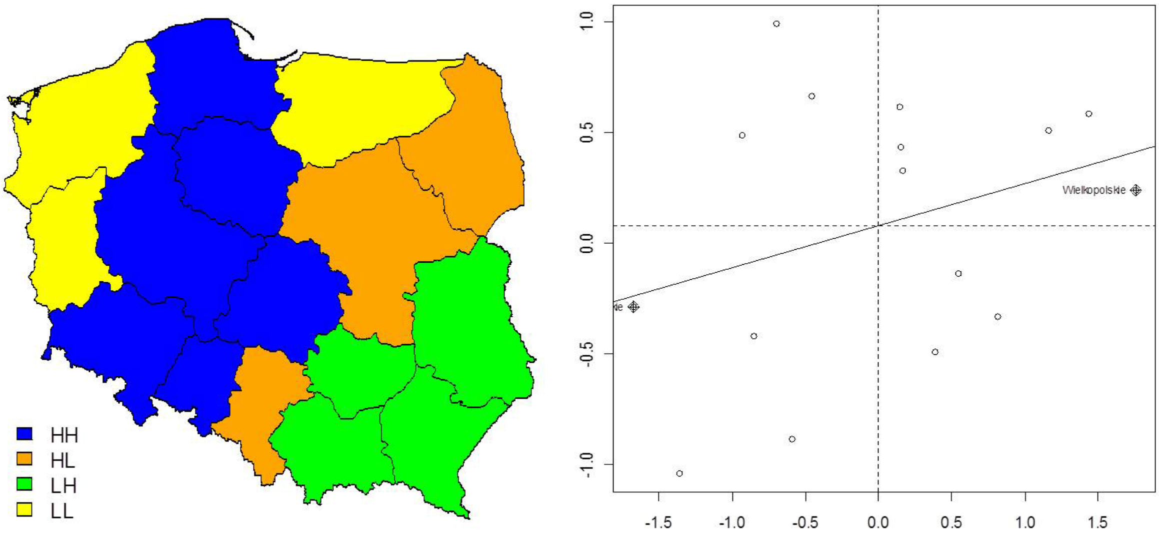

Figure 7 Moran scatterplot and its visualization on the spatial map of Poland

The Moran scatterplot (Figure 7) confirmed changes of agricultural land prices in provinces (Figure 6). The highest land prices are in quadrant marked HH (province marked in blue). In addition to the high price of land in the province higher prices in neighboring provinces are also seen. In further analysis estimates parameters for spatial quantile regression (formula 11) and standard regression (formula 10).

$$f1 = 13800.1920 - 0.0872x1 + 0.1165x2 + 0.1431x3 \quad (10)$$

$$f3 = 14360.0000 - 0.1141x1 + 0.1462x2 + 0.1847x3 \quad (11)$$

The models had been compared by AIC criterion selected to afford respectively 307.4523 and 298.6156. Quantile regression model is better model due to this criterion. The graph 8 shows the results of estimated regression coefficients for each quantile. All variables (uniform direct payments (x1), complementary direct payments (x2), payments for LFAs (x3)) used in the study proved to be statistically significant. In regression analysis, positive values were obtained for the two regression coefficients (complementary direct payments (x2), payments to LFA) and a negative regression coefficient for a single direct payments (x1). The negative regression coefficient for the variable x1 can be related to system occurring in Polish provinces. Uniform direct payments are paid regardless of the nature of the land and depend only on its surface. Therefore, the regions which have a large area of good and medium soil, weak lands are not relatively numerous. The result of quantile regression model differ inconsiderably from results for classical regression model.

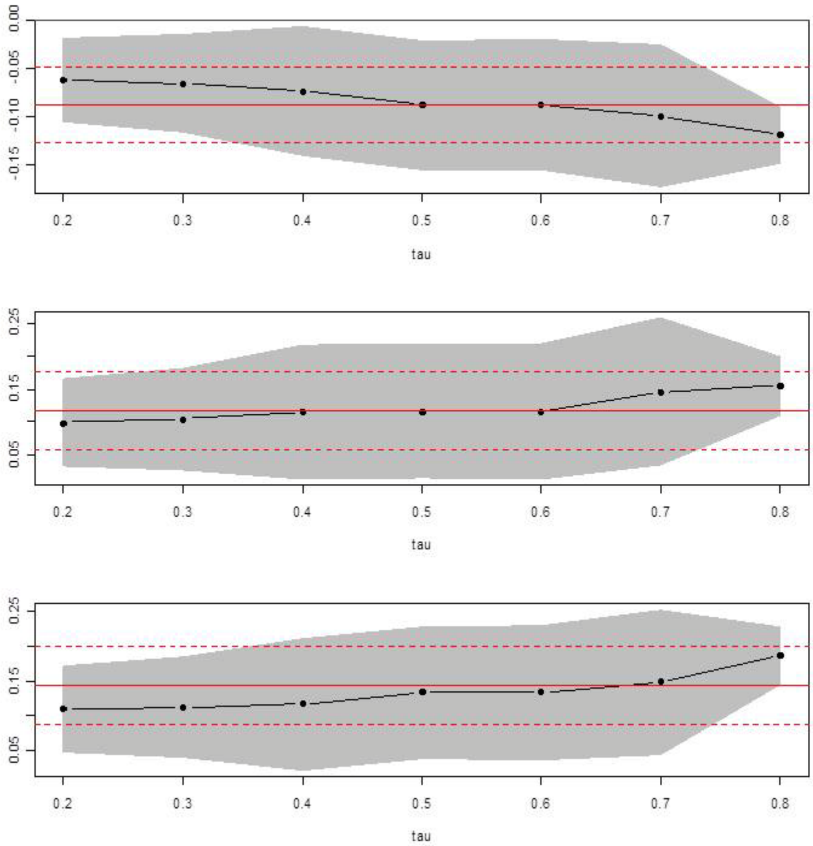

Figure 8 The ranges for each quantile regression parameters estimated in the spatial quantile regression model (from the top to particular variables: single direct payments (x1), complementary direct payments (x2), payments for less-favored areas (x3))

CONCLUSIONS

The price of weak of agricultural land is dependent from uniform and complementary direct payments and payments for LFAs. It can be assumed that the payment system determines the changes (increase) in agricultural land prices.

The use of quantile regression (tau = 0:5) is justified in absence of the assumptions: lack of normal distribution for dependent variable, occurrence of heteroscedasticity or outliers. Otherwise the achieved results are similar to those obtained with the use of conventional methods.

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