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IMPACT OF SPATIAL CHARACTERISTICS OF LAND ON THE PRICE OF ARABLE LAND

Siim Maasikamäe [1], Ph.D.[+]; **Kersti Luik** [1], bach. stud.; and **Kristjan Aasmäe** [1], M.Sc.
[1] Estonia University of Life Sciences

Abstract. The price of agricultural land and arable land is particularly low in Estonia when compared to Western European countries. The demand for agricultural land was low during the first decade after the collapse of the Soviet agriculture system. The situation is changing and the demand for agricultural land is increasing at the present time. Yet, simultaneously, the formation of arable land prices is not studied much. There are several factors affecting land prices and spatial characteristics are among them. The aim of the study is to estimate the impact of spatial characteristics of land parcels on the price of arable land in Estonia. Correlation and regression analyses were used in order to find the possible impact of spatial characteristics (e.g. soil productivity, access conditions and distance from cities) on arable land prices. Data about the 86 rural municipalities were used for the study. The results of the study show that the impact of spatial characteristics of land explain about 20 percent of the arable land price variation. Quality of land and the access conditions to land plots had a statistically significant impact on arable land prices. The impact of the distance from cities and the shape of arable land plots on arable land prices were not detected in the study.

Key words: soil productivity, access conditions, distance to cities.

JEL code: R39, Q24

Introduction

The price of agricultural land in Estonia is low when compared to Western European countries. The average price of arable land in 2009 was 981 EUR ha^{-1} (Eesti kinnisvaraturg 2009, 2010). At the same year the price of arable land in Finland was 6,885 EUR ha^{-1} and in Denmark respectively 25,919 EUR ha^{-1} (Eurostat …, 2014). However, the price of arable land in Estonia is rising and in 2013 it was 1934 EUR ha^{-1} (Eesti kinnisvaraturg 2013, 2014), which is almost two times higher than four years before. The number of transactions with arable land is also increasing. Land market processes are not properly investigated at the same time. Land prices play an important role in the management of land resources. Land prices can be

[+] Corresponding author. Tel.: +372 731 31 20; fax: + 372 731 31 56.
E-mail address: Siim.Maasikamae@emu.ee.

indicators of urban pressure and urban sprawl or warning indicators for environmental degradation (Land in Europe …, 2010). For example the urban pressure will increase the land price because of the increasing need for land.

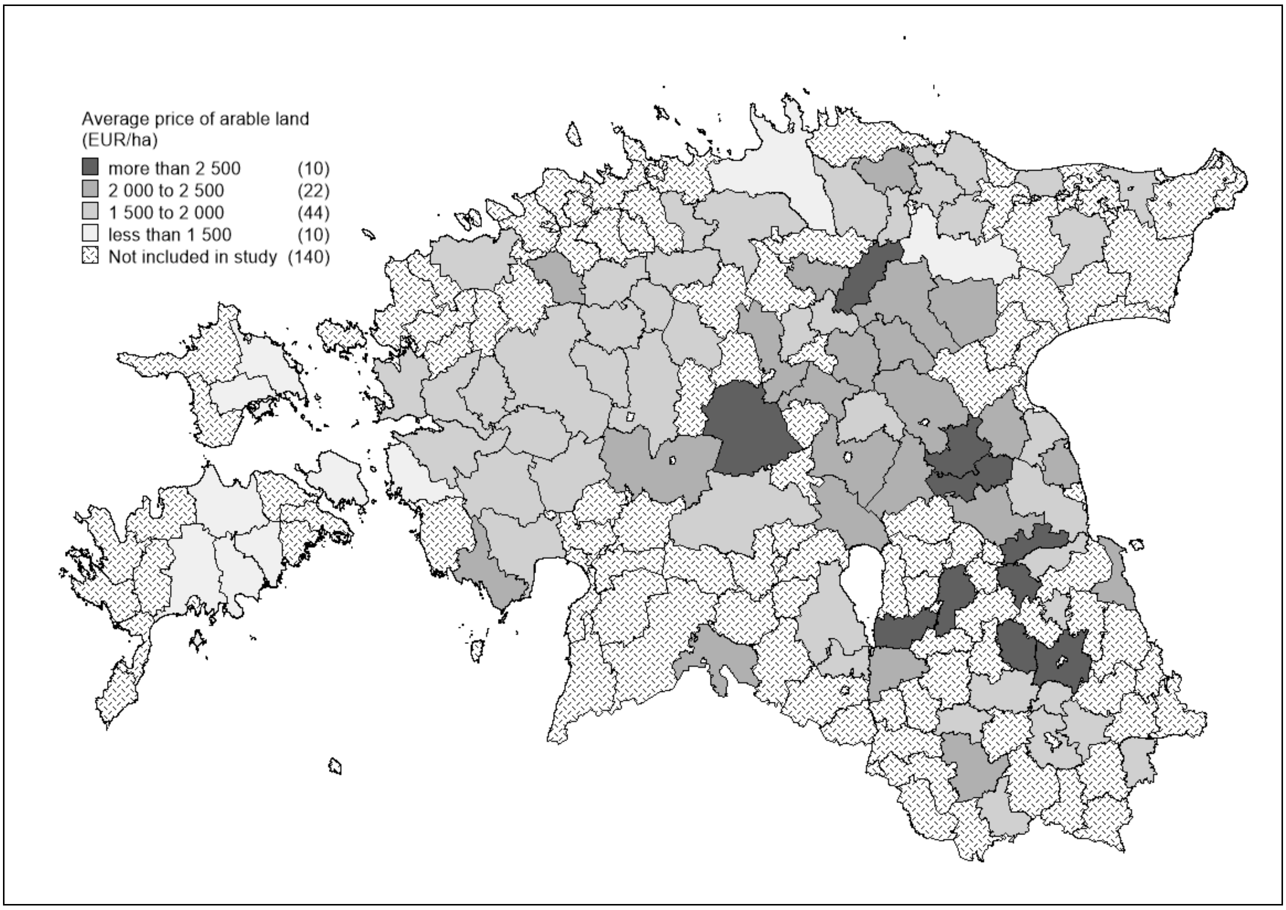
The factors affecting agricultural land prices are the subject of study for many researchers. The nature of those factors is manifold. P. Feichtinger and K. Salhofer (2011), for example, distinguished six groups of variables that can be used to explain land value. Some of those factors have a macroeconomic character, for example, the inflation rate, while others are related directly to land characteristics like soil quality. The importance of socioeconomic factors on agricultural land prices can be the focus of the study (Awasthi M.K., 2014). The suitability of land parcels for production export-oriented crops can be an important determinant for land value (Donoso G. et al., 2013).

The spatial characteristics of land can be treated as a separate group of factors affecting land prices. The common feature of the spatial characteristics of land is the fact that they are related to the particular plot of land. Among such characteristics are definitely plot location, plot size and plot shape. Plot location can be measured from different objects or points like big cities, local centres or from the closest road. Plot locations can also be determined as the parameter that characterises the surrounding of the plot, e.g. the ratio of arable land in a particular locality. The importance of spatial characteristics of land as a factor influencing land prices was mentioned by several researchers. P. Pyykkönen (2005) "… showed that ignoring the spatial dependence may lead to incorrect results". The role of location determinants on agricultural land prices was pointed out by P. Nilsson and S. Johansson (2013).

The problems of agricultural land prices have not been in the focus of research in Estonia for the last two decades. The EU wide study (Land, Labour …, 2013) focuses only on the general issues of land market and did not analyse the impact of spatial properties of land on the land price. There was little interest in agricultural land in the 1990s due to the collapse of the old Soviet-type of agriculture. However, the situation is changing and there is increasing demand for agricultural land at present. The changed situation is a clear indicator of the need to research factors that have an impact on agricultural land prices. The aim of the study is to estimate the impact of spatial characteristics of land parcels on the price of arable land in Estonia. The study was performed in two steps. Correlation analysis was the first task of the study. Secondly, multiple regression analysis was carried out in order to find the joint impact of several spatial characteristics on arable land prices. The study is limited only to the spatial characteristics of land. Land market data have been analysed only for that purpose.

Materials and methods

There are three data sources for the study. Data about transactions of arable land parcels by municipalities in 2013 are the first data source. The data are provided by the Estonian Land Board for public use (Eesti kinnisvaraturg 2013, 2014). The average prices of arable land (EUR per ha) for municipalities were published only when there were at least five transactions in the year. This rule is established due to confidentiality reasons. Arable land parcels are parcels where the ratio of arable land is at least 90 percent. There were available data about arable land price for 86 municipalities in Estonia for the 2013 and all of them were included in the study. The locations of those municipalities are shown in Figure 1. This figure is constructed as a thematic map that also shows arable land price groups for the investigated municipalities.



Source: author's construction based on Estonian Land Board data

Fig. 1. **Location of study areas and the groups of average arable land in investigated municipalities**

The second data source for the study was the Estonian National Topographic Database and the Estonian Soil Map. Both data sets are in digital form. ArcGIS software was implemented for calculation of average spatial characteristics for all municipalities. The following characteristics were calculated:

- soil productivity grade (hereinafter SPG), which characterises the average productivity of all arable land for each municipality;
- average arable land plot area (hereinafter AvPA). An arable land plot is a contiguous area that is not split into parts by roads, ditches or other linear landscape elements. This is an area that can be cultivated as a whole. This indicator characterises the average land tillage conditions in a particular municipality;

arable land ratio (hereinafter ArLR), which is calculated by dividing the arable land area in a municipality by the total area of the municipality. The indicator characterises the average density of arable land in a particular municipality;

average compactness of arable land plots (hereinafter CC) was calculated to characterise the shape of arable land plots. The compactness of plots is the ratio of perimeter of parcel to circumference of square whose area is equal to area of parcel. The shapes of arable land plots have an impact on land tillage conditions. Preferred are more compact shapes of the plots;

average distance of arable land plots from the state road network (hereinafter DiRd) was calculated in order to characterise the conditions of access to arable land plots. The distance of a particular plot from the road was calculated in the GIS as the shortest line between that plot and the closest road;

the density of road network (hereinafter DeRN) describes a general access condition in a particular region. The density of the road network was calculated by dividing the total length of state roads in a particular municipality by the total area of that municipality.

Finally, the third data source was Statistics Estonia (www.stat.ee), which provided data about the location of municipalities in respect to Tallinn and the county centres. The following indicators were used in the study:

the distances of municipalities' government buildings from Tallinn (hereinafter DiTln);

the distances of municipalities' government buildings from county centres (hereinafter DiCnt).

The correlation analysis of all variables was the first step of the data processing. The next step was the implementation of multiple regression analysis in order to find out the possible impact of spatial characteristics of land on arable land prices. The average price of arable land was a dependent variable and the spatial characteristics of arable land were independent variables. The Statistica software (version 12) was used for all calculations and the statistical significance level was set on α=0.05.

Research results and discussion

The results of the correlation analysis are presented in Table 1. Arable land prices were not high but there were statistically significant correlations with five spatial characteristics. The arable land ratio (ArLR) and soil productivity grade (SPG) have the highest correlation with arable land prices. The average area of arable land plot (AvPA) is also correlated with arable land prices. However, the correlation coefficient between the three mentioned characteristics shows that they are also correlated (multicollinearity). The possible explanation of the phenomenon is that more land is used for agriculture in regions with productive soil and it leads to a higher ratio of arable land. The arable land fields are bigger if the soil productivity in the region is higher. The average area of arable land plots tends to include the impact of soil productivity.

The average distance of arable land plots from the state road network (DiRd) and the density of road network (DeRN) have a low but statistically significant correlation with the arable land price. It should be noticed that the correlation between the two mentioned characteristics is not statistically significant and they do not include the impact of each other. The shape of arable land plots (CC) and distance to the cities (DiCnt and DiTln) do not have a correlation with arable land prices.

Table 1

Correlations between investigated variables

Variables	Prc	SPG	AvPA	ArLR	CC	DiRd	DiCnt	DiTln	DeRN
Prc	1	0.342*	0.245*	0.433*	-0.144	-0.233*	-0.127	0.126	0.287*
SPG	0.342*	1	0.748*	0.356*	-0.102	0.003	-0.201	-0.339*	-0.142
AvPA	0.245*	0.748*	1	0.500*	-0.130	0.007	-0.150	-0.371	-0.072
ArLR	0.433*	0.356*	0.500*	1	-0.161	-0.090	-0.304	0.132	0.446*
CC	-0.144	-0.102	-0.130	-0.161	1	-0.073	0.019	-0.005	-0.245*
DiRd	-0.233*	0.003	0.007	-0.090	-0.073	1	0.064	-0.302*	-0.116
DiCnt	-0.127	-0.201	-0.150	-0.304*	0.019	0.064	1	-0.037	-0.121
DiTln	0.126	-0.339*	-0.371*	0.132	-0.005	-0.302*	-0.037*	1	0.422*
DeRN	0.287*	-0.142	-0.072	0.446*	-0.245*	-0.116	-0.121	0.422*	1

Note: * correlation coefficients statistically significant at α=0.05
Source: author's calculations based on Estonian Land Board data

A multiple regression analysis was performed on the basis of correlation analysis. Three different linear multiple regression models were found to be relevant to the aim of the study. The main parameters of those models are presented in Table 2. The forward stepwise methodology was implemented to build the models. The soil productivity grade (SPG) average area of arable land plot (AvPA) and arable land ratio (ArLR) were not included simultaneously in the list of independent variables because of multicollinearity problems. All variables in Table 2 are statistically significant at $\alpha=0.05$ ($p<0.05$) except the intercept of Model 1.

The highest determination coefficient is for Model 1 ($R^2 =0.244$) but because of the high p-value of the intercept (p-value = 0.52) it is not the best model. The soil productivity grade was used in this model to characterise land fertility. The β-coefficients show that the impact of the soil productivity grade on arable land prices is about twice as high as the impact of the location of arable land plots in relation to the state road network.

The average arable land plot area was used in Model 2 to characterise land quality. In this model the determination coefficient R^2 and F-value were the lowest when compared with other models. The impact of different variables (see β-coefficients for Model 2) on arable land prices is more equal when compared with Models 1 and 3. It is necessary to note that density of road network (DeRN) and average distance of arable land plots from the state road network (DiRd) were included both in Models 1 and 2. It indicates that access to arable land is an important issue for the formation of arable land prices. The access question is obviously a complex and complicated phenomenon.

Table 2

Main parameters of the regression models

Variable name	b	Std.Err. of b	β	Std.Err. of β	t	p-value	Adjusted R^2	F
Model 1								
Intercept	277.86	432.66	x	x	0.6422	0.5225	0.244	10.132
SPG	33.17	8.1456	0.3881	0.0953	4.0724	0.0001		
DeRN	998.24	300.04	0.3192	0.0959	3.3270	0.0013		
DiRd	-0.56	0.2722	-0.1972	0.0949	-2.0770	0.0409		
Model 2								
Intercept	1628.64	211.63	x	x	7.6955	0.0000	0.164	6.557
DeRN	883.83	313.03	0.2826	0.1001	2.8233	0.0059		
AvPA	17.080	6.3750	0.2664	0.0994	2.6792	0.0089		
DiRd	-0.580	0.2862	-0.2024	0.0998	-2.0273	0.0458		
Model 3								
Intercept	1710.58	176.99	x	x	9.6646	0.0000	0.207	12.081
ArLR	16.66	3.891	0.4152	0.0969	4.2815	0.0000		
DiRd	-0.561	0.278	-0.1959	0.0969	-2.0195	0.0466		

Source: author's calculations

In Model 3 were included only two independent variables. The arable land ratio (ArLR) was used to characterise the land quality. The F-value for that model is higher than for the two other models. R^2 is less than for Model 1 and more than for Model 3. The impact of the arable land ratio to the arable land price is about two times higher than the impact of average distance of arable land plots from the state road network.

The study carried out shows that the spatial characteristics of land have an impact on arable land prices. According to the present study about 20 percent of arable land price variations can be explained with the impact of spatial characteristics. Two types of spatial characteristics resulted from the study: 1) the quality of land; and 2) the conditions of access to land. The quality of land is mentioned by some authors (Land in Europe …, 2010; Lebedinska J. et al., 2005; Sklenicka P., 2011) as the key factor for arable land prices. Some studies show the opposite results and the author's explanation is that land privatisation processes can influence land prices (Pletichova D., Gebeltova Z., 2013).

However, the impact of spatial characteristics on arable land prices is a complicated phenomenon. The discrimination between true and spurious spatial dependences (Kostov, P., 2009) is an important issue when studying the impact of the spatial characteristics of land on arable land prices. Nickerson C. et al. (2012) came to the conclusion that land productivity was well correlated with agricultural land prices in regions where there was no impact of cities. The impact of urban pressure can misrepresent agricultural land prices (Abelairas-Etxebarria P., Astorkiza I., 2012). Travel time to the centres is not a significant determinant of farmland prices (Sklenicka P., 2011). Similar results came out in this study. The distance to Tallinn or county centres did not have a correlation with arable land prices.

Data quality is also an important aspect for studies of land price formation. The average price and average spatial characteristics for a region, for example a municipality, will hide many important details of particular transactions and the specific features of the plots. In 2013 the average arable land price in the Tarvastu rural municipality was 4161 EUR ha^{-1}, the minimum price was 615 EUR ha^{-1} and the maximum price 4776 EUR ha^{-1}. This was an extreme example but it is no exception at all that the difference between the maximum price and minimum price of arable land per hectare is about 2000 EUR in the limits of one municipality.

There is a similar situation with spatial characteristics. The exact spatial characteristics (e.g. soil productivity, location with respect to roads) were substituted by the average figures of municipalities whereas the exact location of transactions was not known. The more precise initial data would obviously provide better and more reliable results in further studies of the impact of spatial characteristics on arable land prices. The use of aggregated (average) data instead of initial data is the biggest limitation of this study. This is the reason to continue the investigation of the impact of land spatial properties on arable land prices.

Conclusions

1. It came out from this study that land quality indicators and the possibilities to access land plots were the spatial characteristics that had a correlation with arable land prices. The correlation was not strong but statistically significant.
2. Land quality and the possibilities to access land plots explained about 20 percent of the arable land price variation.
3. There was a medium correlation between soil productivity grade, average area of arable land plot and arable land ratio in a particular region. It is not to the purpose to include all mentioned indicators as independent variables into the regression models simultaneously because of multicollinearity problem.
4. It is recommended to use initial data instead of aggregated (average) data for the study of land spatial characteristics' impact on arable land prices in future.

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