GIS Analysis of Rural Land Market in Slovenia

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Abstract: In this article, GIS methodology is developed for measuring the accessibility of land plots, where accessibility is determined for any plot in the analysed area to central place(s) at different level of spatial hierarchy. The developed method has been used to analyse the rural land market in Slovenia. Test of contingency between accessibility of land plots to the capital and rural land price (transaction value) shows very high significance ($\alpha < 0.001$).

Keywords: accessibility, GIS, land market, rural land market, Slovenia

1 INTRODUCTION

A key issue in the sustainable spatial development is the availability of timely and accurate data referring to the land, where land market data together with demographic, other economic indicators and data on land characteristics play a significant role in the market oriented economies. Land has a number of characteristics, which make it different from other assets that may be traded on the market. Besides economic aspects, such as immovability, limited supply, planning regulations and permitted land use etc., geographical location as the unique characteristic of each land parcel (or other elementary unit of land transaction) influences land value. As location is the basic characteristic of land, the use of spatial multi-attributes analysis methods has become a necessity in the land market analysis (Lisec and Drobne, 2007). Development of information technology in the last decades has brought new challenges in the land market analysis, especially in terms of analysing the influence of location on the land market based on location theoretical background. Today, IT solutions enable data manipulation on a large scale. In addition, the GIS technology provides support for spatial analyses and analyses of spatially related data.

Unlike labour and capital one unit of land is not directly substitutable for another because each unit is unique at least in terms of its geographical location (Schiller, 2001). Location can be measured either absolutely or relatively. Absolute spatial location requires geographic coordinates. Relative spatial location requires a single distance measurement, such as distance from the city centre (Thrall, 2002). The influence of location on the rural land market can be appreciated in terms of transportation facilities – accessibility. Accessibility can be measured in several different ways, such as composite measures, comparative measures, and the time-space approach based on determination of travel time (Jong and Eck, 1997).

For the purpose of Slovenian rural land market analysis, accessibility in terms of travel time (by car) to the capital has been modelled using the GIS approach. This paper expands the work in modelling accessibility fields taken by Donnay and Ledent (1995) for the urban region of Liège (Belgium) and Julião (1999) for Tagus Valley Region (Portugal). The main emphasize is on the analysis of the rural land market price in the statistical regions in Slovenia (12 statistical regions) which are treated equal to the NUTS 3 regions (the 3rd level according to the Nomenclature of Territorial Units for Statistics, Eurostat).

2 FROM VON THÜNEN TO HOTELLING AND MODERN THEORY OF SPATIAL GAMES

Being rural essentially has to do with location of particular areas in space. Therefore the work of Johann Heinrich von Thünen (1783-1850) becomes the main source of the paradigm for rural development theory and rural land appraisal. We are starting with his the most basic analytical model of the interplay between markets, production, and accessibility. In his theory, developed in *The Isolated State* (1826), he gave the first serious treatment of spatial economics, connecting it with the theory of rent. The importance lies in its analytical approach to bid curve. Von Thünen developed the basics of mathematically rigorous theory of marginal productivity summarizing it in the expression

$$R = Y(p - c) - YFd,$$

where R is land rent, Y is yield per unit of land, c are production expenses per unit of commodity, p is market price per unit of commodity, F is freight rate and d is distance to market, where he supposed Euclidian distance to the market.

The model develops the structure of four concentric rings of agricultural activity. The concentric rings are the results of the hypothesis that accessibility can be described using Euclidean distance functions in homogeneous space, which is not the case in real world and can be better studied today using GIS tools. The application of Von Thünen theory has given the following results:

a) Dairying lies closest to the monocentric central place, since dairy products must get to market quickly.
b) Timber and firewood, produced for fuel and building materials, was suggested to be planted in the second ring. It is very heavy and expensive to transport so it is located as close to the city.
c) Transportation costs of crops are less high therefore the third zone consists of extensive fields crops such as grain. Since grains last longer than dairy products and are much lighter than fuel, reducing total transport costs, they can be located further from the city as a central place of the total area.
d) Ranching is located in the final ring because animals can be self-transporting (walk to the central city for butchering).
e) The wilderness with no activities lies beyond the fourth ring, because it is too distant from the central city for any production.

Here, the value of land is understood as the net present value of rentals NPV and it is reduced for the net present value of all accessibility costs $NPV(YFd)$.

There exist many analytical limitations of the Von Thünen model for furthering a body of knowledge that has practical usefulness in rural land appraisal and rural development policy:

a) the model was developed in an isolated state and did not take into consideration differences in sites (local physical conditions) and spatial hierarchy of central places;
b) topography with its variations has not been considered;
c) variations in fertility of land and climate differences have not been introduced in his model, but has been well developed later;
d) different transportation costs, because of different transportation modes and given transportation networks (road characteristics), do not allow to use the hypothesis of homogeneity at any practical study of land rent;
e) government policies define what is rural and what urban land is and also how it is turned from rural to urban use.

In Europe, the technological change in the second half of the last century has drastically reduced the needs for labour in primary industries and forced rural residents, being without a source of livelihood, in the rural-to-urban migration and daily commuting. When rural rent has become less important topics for study isolated from the urban land use, the theory of urban land rent was developed on the bases of Von Thünen theory by William Alonso (1964) and others.

To understand rural land market not only the theory of Alonso and Von Thünen has to be taken in consideration, but also industrial location and production orientation of Weber (1909), Smith (1776) and Isard (1969) or Moses (1958) theory has to be consider in details. Mono-centric approach has to be replaced by Christaller (1933) and Lösch (1954) theory which play important role in the regionalization of modern Europe and also the regionalization aspects of each particular state in Europe, also Slovenia. In this case scalar approach has to be replaced by vectors describing remoteness or accessibility and it's changing in time where demand and supply at each location is changing in spatial dynamics. Finally the explanation of variances in rural land rent and transaction prices gives the theory of spatial competition described by Hotelling (1929) many years before Alonso and Isard (1969) and later developed by some other researchers towards spatial game theory, also introduced by Bogataj M. and Bogataj L. (1996, 1999, 2001) considering the case of remoteness and accessibility of activity cells in modern supply chains. All these theories are of limited use for applications and land policies in case when GIS is not based on the well developed database about:

(a) spatial and physical characteristics of land,
(b) activities in the space and planning restrictions present or anticipated as well as
(c) networks which enable better accessibility between sites.

In this paper, the attention is especially given to the question how to develop the procedures in GIS to offer the parameters needed in application of the above mentioned theories. Using GIS approach the variances in rural land rent and rural land transaction prices can be better explained also in Slovenia in the time of transition to market economy.

3 MODELLING ACCESSIBILITY

3.1 Model formulation

The raster-based GIS methodology for accessibility evaluation, proposed in this paper, required a two-stage modelling. For the purpose of modelling accessibility in GIS, layers describing the public road network and location of central place were used. The image resolution obviously influences the accuracy of accessibility evaluation. In our application, the vector layers were rasterized with the resolution of 100 m, which is accurate enough when working at the regional level.

The key issue in modelling accessibility fields is the determination of cost surfaces. Cost surfaces are defined by data on distances from origin (features) in terms of costs measures (e.g. cost distances). Evaluation of cost surfaces requires a friction surface that indicates the relative cost of moving through each cell. In our application, costs of movement across the region were expressed as travel time when travelling by car. These represent the time necessary to move through areas with certain attributes.

The friction surface was calculated using a simple model that fixes the value of the cell crossing time as it has been already introduced by Drobne (2003, 2005) and Drobne et al. (2005):

$$CCT = \frac{PS \cdot 60}{TS \cdot 1000},$$

where *CCT* is Cell Crossing Time (in minutes), *PS* is Pixel Size (in meters), *TS* is Travel Speed (in kilometres per hour).

Cartographic modelling of accessibility fields in raster-based GIS-approach at higher levels (administrative, regional, interregional, state or interstate level) makes it necessary to work out specific methodologies. In this case, two different cost surfaces are needed: one indicating the travel time considering the whole road network, and another one excluding the motorways. Two-stage modelling of accessibility fields as a spatial continuous geographic variable is necessary because one can not get in and out of a motorway at any point – which is the case for all other road categories.

Two-stage modelling of accessibility fields, applied in our cartographic model, follows the steps:

1. Calculation of travel time to the centre outside (without) the motorways and major roads.
2. Calculation of travel time from the centre using motorway or major road to motorway or major road connections.
3. Calculation of travel time from hinterland (from each location, defined by pixel size) to the motorway or major road connections. And, territorial allocation for each connection according to the travel time to the connections.
4. Adding up travel time from hinterland to connections (step 3) with the travel time from the centre to the connections (step 2).
5. Determining the minimum travel time from the centre (capital of Slovenia) (comparing travel times from the centre without motorways or major roads (step 1) with travel times using motorways and major roads (step 4)).

3.2 Data acquisition and integration

In Slovenia, the public roads have been classified as state roads owned by the Republic of Slovenia, and local roads owned by municipalities, respectively. The total length of Slovenian public road network is more than 37000 km. The raster-based accessibility evaluation methodology proposed here requires layers describing the public road network for the national road network and for local and other road networks. The image resolution obviously influences the accuracy of accessibility. In our application, the vector layers were rasterized with the resolution of 100 m – this being precise enough when working at the national on regional level. In this way, each image consists of 4141500 pixels (matrixes with 1650 rows and 2510 columns).

3.3 Model application

The calculations of travel time (by car) to the capital of Slovenia, as a central place at the highest spatial level, were performed for the year 2005. To calculate the friction surface, the average speed for every road category of the road network as well as for the hinterland was defined. The overall data and results are presented in Table 1.

Table 1: Average travel speed and cell crossing time according to the road category.

Road category	**Average speed [km/h]**	*CCT* **(Cell Crossing Time) [min]**
Motorway (MW)	110	0.0545
Major road (MR)	90	0.0667
Main road 1 (MR_1)	70	0.0857
Main road 2 (MR_2)	65	0.0923
Regional road 1 (RR_1)	65	0.0923
Regional road 2 (RR_2)	50	0.1200

Regional road 3 (RR_3)	40	0.1500
Regional road 3 - tourist road (RT)	35	0.1714
Local road (LR)	40	0.1500
Other road (OR)	30	0.2000
Outside the road network (OUT)	*15*	*0.4000*

In our application, we analyzed the accessibility of every location (plot) in Slovenia to the central place of Slovenia; that is the capital (Ljubljana). Therefore, the cost value (time distance) was calculated as the less cumulative costs starting from the origin (Ljubljana) and moving through a friction surface. The time-spending distance was calculated for the ideal circumstances without consideration of traffic flows by day time schedules, traffic restrictions on road segments, relief, etc. Figure 1 shows public road network (without local and other roads, which have been analysed in the accessibility analysis as well) and time-spending distances in Slovenia in 2005, determined on the base of the introduced GIS methodology.

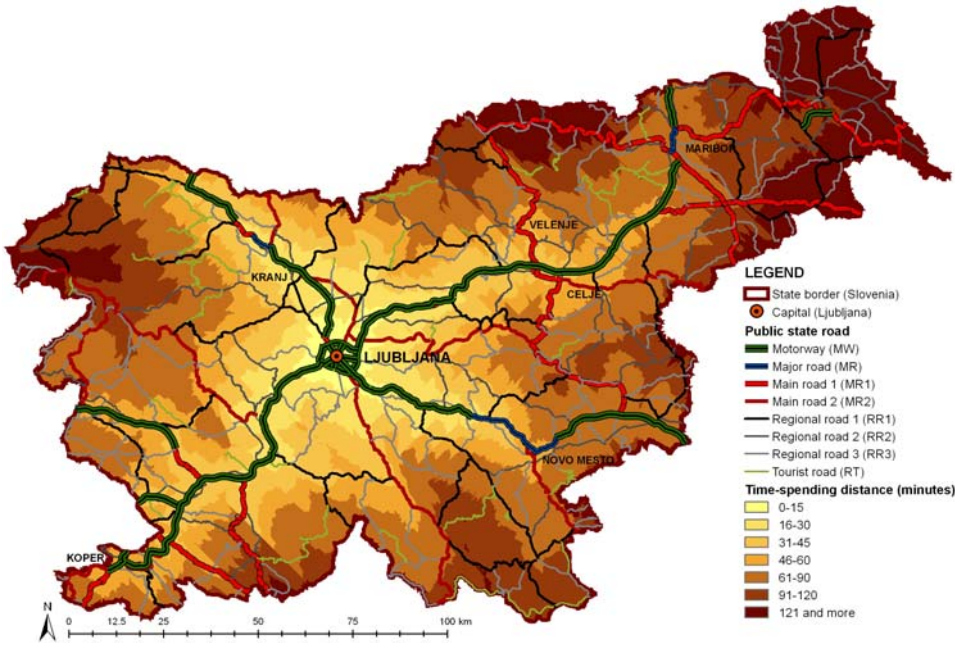

Figure 1: Time-spending distance to the capitol, public road network, and statistical regions in Slovenia in 2005.

GIS tools enable to calculate the mean time-spending distance in analysed areas. For the purpose of the rural land market analysis in Slovenia, the mean time-spending distance to the capital of Slovenia was calculated for every statistical region in Slovenia. The results are in the Table 2.

Table 2: Mean time-spending distance to the state capital by statistical regions in 2005.

Region ID	Statistical region/State	Mean time-spending distance [min]	Rank of time-spending distance
	Slovenia	***73***	
8	Osrednjeslovenska	28	1
5	Zasavska	49	2
9	Gorenjska	53	3
12	Obalno-Kraška	57	4
10	Notranjsko-Kraška	62	5
4	Savinjska	64	6
7	Jugovzhodna Slovenija	76	7
11	Goriška	84	8
6	Spodnjeposavska	85	9
2	Podravska	97	10
3	Koroška	108	11
1	Pomurska	134	12

5 APPLICATION TO THE RURAL LAND MARKET IN SLOVENIA

5.1 Characteristics of the Slovenian rural land market

Slovenia, which lies at the crossroads between Western and Eastern Europe, is a small country with two million inhabitants living in a land area of 20273 km^2, representing an average population density of 98.7 inhabitants per km^2. Slovenian particularity is that a large proportion of citizens live in the countryside or in the municipalities, which are in the EU context defined as rural municipalities. However, relatively few are active in agriculture due to the small size of holdings, so that farms are mostly of a mixed type. The share of agriculture in the gross domestic product (GDP) is slightly lower than the European average and totals just fewer than 2%. Despite the small share in GDP, the economic activities in the rural areas hold multipurpose roles, where the human pressure on rural land has to be handled in appropriate way.

As typical for countries with former planning economy, Slovenia has no tradition in the rural land market and no tradition in the land market analysis consequently. With the transition to the market-oriented economy in the beginning of the nineties the rural land market has been awaking in Slovenia. Today, the sale of rural land is mainly regulated by The Agricultural Land Act (2003), which has its origin in 1996 (Lisec, 2007). The act has been substantially changed in 2002. One of the most important issues was relating to the reducing of rural land market restrictions, when the article that the purchaser of rural land had to be a farmer or is qualified for agricultural/forest production was invalidated. The second important change was the abolishment of special payment for agricultural land use change, which was introduced in the eighties in order to protect the rural land against the process of urbanisation. As the consequence, the number of transactions with the average higher price per m^2 has been increasing (the transactions with the land price over 2 €/m^2), while the number of transactions with the lower price per m^2 has been decreasing (the transactions with the land price under 0.2 €/m^2), especially since 2002. This phenomenon is evident in Figure 2, where the

frequencies of the rural land transactions for 6 classes regarding to the land price per m^2 are presented for the period of 2001-2005.

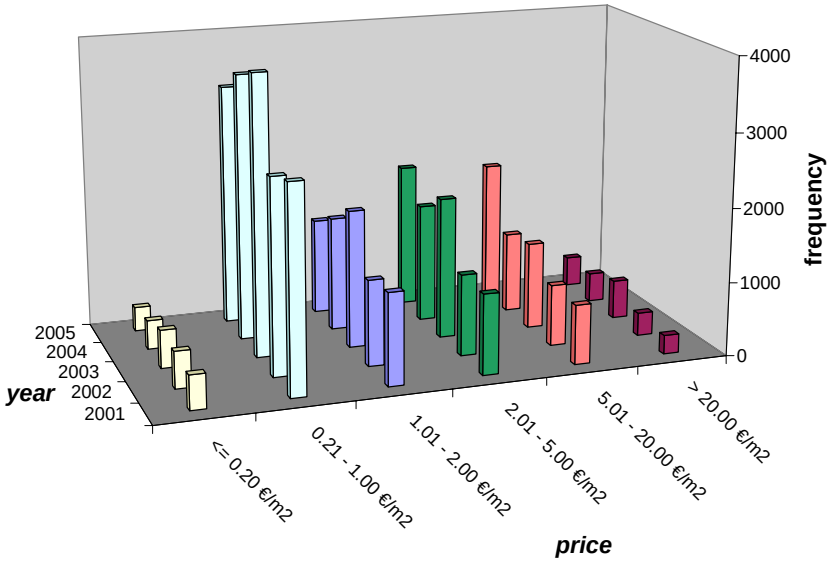

Figure 2: Distribution of prices in realized transactions of rural land in Slovenia (2001-2005).

5.2 Land market data

The elementary unit of land transaction is land plot (parcel). Data relating to the land plot have characteristics of personal data and because of personal data protection it is impossible to acquire market data with the spatial accuracy to the land plot. The new database of real property transactions is being established since 2004, where the public accessibility allows the acquisition of land market data for the spatial unit on the level of cadastral community. The cadastral community is administrative unit in the Land Cadastre, where Land Cadastre presents the elementary land information system in Slovenia. Figure 3 shows the activity of rural land market in Slovenia in 2005 on the level of this spatial unit – the market activity is determined as the frequency of transactions per square meter of a cadastral community. In addition, the statistical regions are presented (as explained in Table 2).

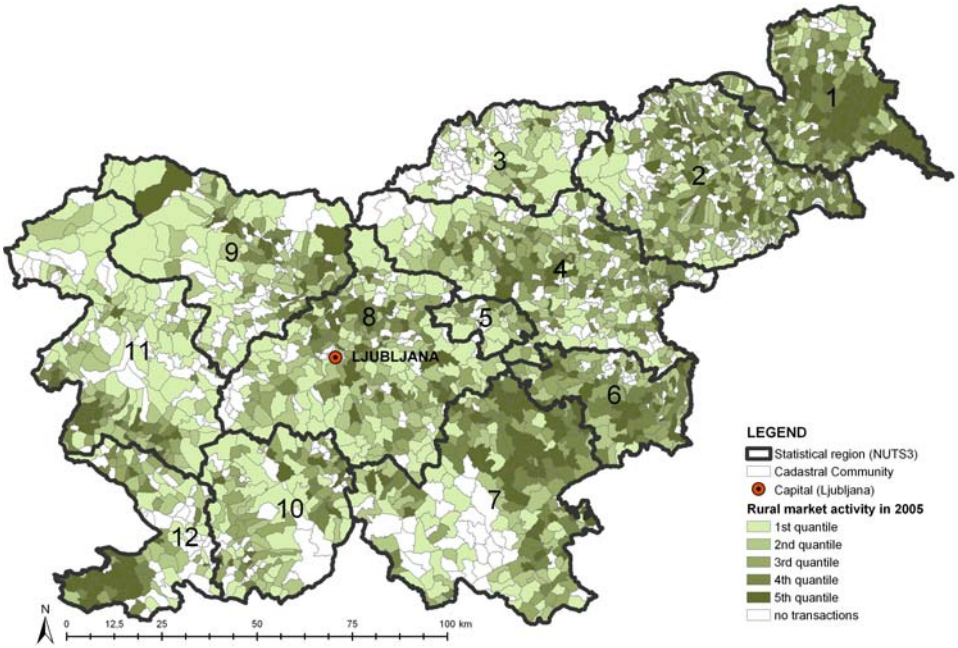

Figure 3: The rural land market activity in the cadastral communities in Slovenia in 2005 according to the new database of real property transactions, and statistical regions.

The study of contingency between accessibility to the central market space of Slovenia and rural land market price has been implemented for the time interval 2001-2005. The analysis of rural land market is based on the transaction data acquired from the Tax Authority of the Republic of Slovenia, which is the only source of the market data for this period. The spatial unit of the database is the municipality, which is Slovenian local administrative unit (the country is represented by 220 municipalities). In our research, the spatial component of rural land transaction data was determined through the spatial unit of municipality, consequently. For the purpose of the rural land market analysis on NUTS 3 level such spatial determination of the land transaction is adequate.

The attributes of the database at the Tax Authority on real property transactions are structured for the real property transfer taxes assessment and control. For the purpose of real estate market analysis some records have missing attributes which are crucial for the real estate market analysis, such as spatial component (municipality), market price (transaction value) etc. There were approx. 10% of inappropriate records for the market analysis per year.

5.3 Contingency between accessibility to the central market space and rural land price

The market price of rural land has two components: the value of land rent deriving from agriculture, forestry, recreational use etc., and the anticipated future rent, increased due to urbanisation process and dependent mostly on location. The analysis of the rural land market prices in Slovenia for the period of 2001-2005 shows that rural land transactions with high market price are frequent in the municipalities with better accessibility to the capital (Figure 2) and vice versa.

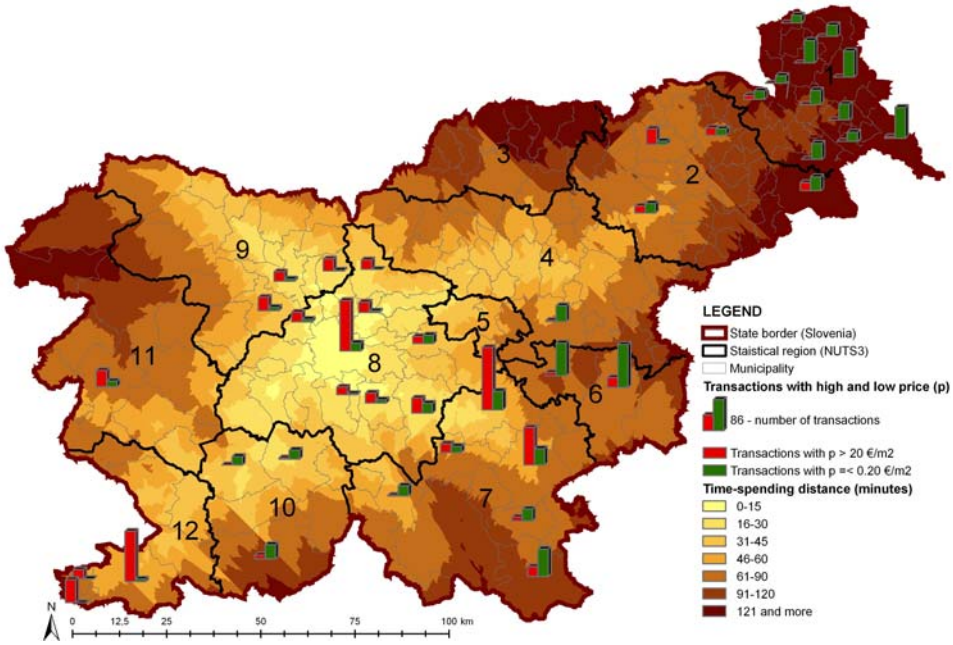

Figure 4: Time-spending distance, statistical regions and the number of rural land transactions with the price over 20 €/m^2 (red column) and under 0.2 €/m^2 (green column) in the municipalities for the period 2001-2005.

Figure 4 shows transactions with high price of land (over 20 €/m^2) and law price of land (under 0.20 €/m^2) only for the municipalities, where more than 20 such transactions have appeared in the period 2001-2005. It is evident, that location in terms of accessibility plays a significant role in the rural land market. It can be assumed, that still rural land in the regions closer to the capital (of higher accessibility to the capital city), has higher market price in average.

The contingency has been studied between mean accessibility to the capital and mean transaction price in the statistical regions. For the test of contingency, the transactions of the rural land were merged into three groups referring to the land price *p*:

- A: $p \leq 1$ €/m^2
- B: 1 €/m^2 $< p \leq 5$ €/m^2
- C: $p > 5$ €/m^2.

The statistical regions were ranked according to the accessibility (time-spending distance by car) to the capital and grouped into three classes, as it is evident from the contingency table (Table 3).

Table 3: Contingency between the mean accessibility in the region to the central market space of Slovenia and the rural land price.

Accessibility (group of ranks)	Rural land prices			TOTAL
	A $p \leq 1€/m^2$	**B** $1€/m^2 < p \leq 5€/m^2$	**C** $p > 5€/m^2$	
1-4	2 584	3 887	2 939	**9 410**
5-8	5 847	6 181	2 401	**14 429**
9-12	9 909	4 769	2 351	**17 029**
TOTAL	**18 340**	**14 837**	**7 691**	**40 868**

From the contingency table it follows, that the percentage of transactions of the cheapest rural land is increasing with distance (column A) and that the percentage of the plots where the price is higher than 5 €/m^2 is decreasing by distance to the central market space of Slovenia (Ljubljana). The χ^2 value of contingency table is $2.9 \cdot 10^3$. Therefore, we can conclude, that the accessibility to the capital of Slovenia significantly influence rural land prices ($\alpha < 0.001$). Monitoring the land transactions on the bases of their location, characterised by accessibility developed here, give us better understanding of rural land market in Slovenia.

6 CONCLUSIONS AND FURTHER DIRECTIONS

The results of our research indicate that location in terms of accessibility to the capital city plays a significant role in the rural land market value in Slovenia. Rural land in the statistical region closer to the capital in terms of accessibility to the capital, has in average higher market price, also in case when changes of land use are not anticipated in very near future. This fact can be linked with the attractiveness of rural landscape for living place and development of economic activities in the regions with favourable economic and demographic indicators, and is associated with the urbanisation process. Therefore, rural land market shows also the tendencies of land use in longer time horizon. The spatial analysis of the land market will have to play an important role in monitoring spatial development and assuring sustainable spatial development in the future.

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