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A spatial exploratory model for rural land prices

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Abstract

Several developments have raised questions about the functioning of the land market in the Netherlands. Agricultural land prices have increased strongly, especially near built-up areas. For a better understanding of the land market, this study aims at developing a GIS-based spatial exploratory model for rural land prices. Factors that affect land prices outside built-up areas are collected, analysed, categorised, and used to explain spatial differences in prices of parcels in rural areas using a linear regression model. The current model is based on data for the province of Noord-Brabant in the southern part of the Netherlands. For this province data at parcel level is available. This data is combined with a rich set of spatial data using a geographical information system (GIS).

1. Introduction

The land market in the Netherlands is getting much interest of policy makers and researchers in the past few years. Increasing land use pressure, caused by a high population density and an increasing economic growth and prosperity, has resulted in strongly competing land use claims from a range of sectors. Housing, business, recreation, and other activities require land which is usually taken from agricultural functions, as very little bare land is left in the Netherlands. Strict planning schemes segment the land market into submarkets and create an artificial scarcity of land for some activities, like housing and business, which face much higher land prices than other activities. The high land prices at certain submarkets, however, spill over into the agricultural land market and into other submarkets.

Land use planning decisions of the government aim at an optimal use of the available land with the least negative externalities. In some cases the planning decisions result in unwanted situations and speculation in the land market. This is one of the indications that the functioning of land market is still poorly understood. Actors and factors affecting land prices have been studied extensively, though a comprehensive framework is still not available, models are often area-specific or case-specific and based on limited data. Consequently, outcomes of studies on the determinants of land values give partial answers and differ considerably.

In order to get a better understanding of the land market, this study aims at developing a GIS-based spatial exploratory model for rural land prices. Factors that affect land prices outside built-up areas are collected, analysed, categorised, and used to explain spatial differences in prices of parcels in rural areas. The model does not aim at explaining land price changes through time but land price differences in space, while not neglecting the non-spatial factors. Focussing on rural areas may give an answer to the question how rural land markets are affected by land use claims from other activities and may give insight into the land conversion process at the edges of built-up areas.

A large set of data has been analysed by using a geographical information system (GIS). The current model is based on data for the province of Noord-Brabant in the southern part of the Netherlands. The results of the model will be used in the Land Use Scanner, a large, grid-based, high-resolution simulation model for future land use [1], and can be used to answer several questions that exist at policy-making departments for rural areas.

The outline of the paper is as follows: the next section reviews briefly some theory on land prices and discusses the actors and factors that play a part in the land market. In section three the model and the data will be discussed. Section four gives the results of a regression analysis. Finally, section five contains some concluding remarks, summarises the results, and indicates how the results can be used in the context of land use modelling.

2. Land markets and land prices: a review of the theory

Land has special characteristics being an economic good: the supply of land is (almost) fixed, every parcel of land has a fixed location, which is a unique property, and the use of a parcel of land affects the use and value of surrounding parcels. These externalities of land use give rise to government intervention. The special characteristics, the externalities and intervention make an analysis of the land market rather complicated.

The attention for land in economic theories has changed over time. The early and well-known theories of Ricardo and, in a more spatial context, Von Thünen have laid the foundation of land price and land use theories, and are to a certain extent still valid and used in current research. Ricardian land use models explain the existence of land rents from differences in fertility, or more general, differences in land qualities. The surpluses that exist for lands with a higher productivity can be absorbed by landlords as competition in the land markets is far from perfect. Von Thünen's model is concerned with location and transportation costs, which are also characteristics of a parcel of land. Ricardo's and Von Thünen's theories can be extended and improved in may ways (see for example Randall and Castle, 1985).

Another theory that focuses on land prices is the bid rent theory. The bid rent theory was mainly developed in the context of urban land uses and urban land values (see for example Alonso, 1964 or Mills and Hamilton, 1994). The bid rent theory is based on microeconomic theory, though the derivation of agricultural land values in the bid rent theory owes more to Von Thünen's theory (see Isard, 1956). The crop that produces the highest revenue at a certain location will be able to make the highest bid and thus will be cultivated on that parcel. The land is sold to households or firms if their bid is higher than the bid of agriculture; the situation which defines the limits of the city.

Though the bid rent theory is a good theoretical framework, land prices are still difficult to determine. The bid rent theory relies strongly on an analysis of the market, market prices and bids actors make, though in reality the land market is not transparent and information is often hard to get. Moreover, other values than the market price for land can exist, like the social land value or non-revealed values as a result of zoning restrictions. This is for example the case with land for nature areas (Ruijgrok, 1999). If other prices than market prices exist methods like the contingent valuation method, the hedonic pricing method or the travel cost method can be applied to estimate land prices. The hedonic pricing method is closely related to the bid rent theory. This method attempts to derive the value of goods with an unknown market price from goods that do have a market price and have some of the amenities of the good with the unknown market price internalised. This approach is used in the bid rent theory to determine the bids that actors make for a parcel of land. The bids are based on the amenities and properties of a parcel of land.

Besides the theoretical literature, an extensive body of empirical literature on land prices and land valuation exists. The empirical studies consider a wide range of topics and include for example the effect of zoning (Vaillancourt and Monty, 1985), urban encroachment (Broomhall, 1995; Shi et al., 1997), valuation of land when a market is absent (Hanink and Cromley, 1998), and the effect of (agricultural) income changes and macroeconomic variables on land prices (Daouli and Demoussis, 1992; Just and Miranowski, 1993; Veerman, 1983). Shi et al. (1997) have analysed approximately twenty studies on agricultural land prices. They divide the studies into two groups: the first group explains land prices as a function of different sources of agricultural income (e.g. higher crop prices are supposed to be associated with higher land prices) and the second group utilises primarily non-farm factors such as distance from urban areas. The second group mainly consists of studies carried out in the urban-rural fringe. Benirschka and Binkley (1994) make a difference between studies concerned with behaviour of land markets through time and behaviour across space. Most studies look at changing land prices through time. However, when examining land use studies, we can see that most regressions to estimate land prices include spatial variables as well as time dependent variables.

In this study we will be mostly concerned with spatial differences in land prices. The aim is to analyse and explain spatial patterns in land prices at a given point in time. Changes over time, like innovations and macroeconomic developments, will be considered as given. It is, however, not possible to ignore the time dimension. An important reason for this is that time-dependent variables can have different spatial impacts. For example, the conclusion of Benirschka and Binkley (1994) is that land price variation, resulting from macroeconomic developments that occur over time, increases with distance to markets. Depending on the spatial level under consideration the time dependent factors can occur at different places. Though on a regional level macroeconomic variables will likely show less variation than on country level.

Reviewing the time dependent factors in general terms, land can be seen as a production factor, a consumption good (for example in the case of land for recreational purposes) or a storage of wealth. In these cases the effect of inflation, interest rates, opportunity costs of capital, etc. differ for different types of actors and in different situations. The capitalisation model, in which all future earnings are discounted in the value of land, is mostly used to analyse land price changes over time.

Focussing on the studies with a spatial dimension, we soon find out that it is often difficult to make a clear distinction between the impact of time-related, spatial-related, and other factors. A clear example of this is a study on railroad development and land values (Coffman and Gregson, 1998). Improved access to markets due to railroad construction led to an increase in land values. This can be explained by Von Thünen's theory as a decrease in transportation costs will lead to an increase in land values. But another argument is that improved access to markets raised expectations of increasing revenues, which resulted in increased land prices. This last argument has a strong time dimension.

The spatial dimension can basically be described by the factor 'location'. Location can be expressed in many different ways: it can be related to accessibility, 'distance to', or other spatial variables. Closely linked to the location are the site characteristics of a parcel of land. Site characteristics are often related to the current or future land use. Examples of site characteristics for the determination of the suitability for wildlife reserves are factors such as vegetation, slope, elevation and proximity to water and human activities. In the case of agriculture, one can think of site characteristics such as type of soil, irrigation, and drainage. If the site characteristics are considered more favourable, the land price will be higher.

Many other factors have a spatial dimension. Two factors that should be mentioned are zoning and taxation. Several studies show that zoning has a clear effect on land prices (Vaillancourt and Monty, 1985; Kruijt et al., 1990; Needham, 1992).

Taxation can have direct and indirect effects on land prices. Especially local (municipal) taxes can result in spatial differences in land prices. For instance, tax reductions to attract investors can result in higher land prices in a municipality.

Summarising, many spatial as well as non-spatial factors can influence land prices. Figure 1 below gives an overview of all factors that have been found in the literature and publications, and which have been mentioned in interviews with some land price experts.

The actors are a special category in figure 1. Following the bid rent theory, actors bid for a parcel at the land market. Their bid is based on how they value a parcel, which is affected by the factors. Each type of actor (or on the micro level each actor) gives different weights to different factors and some factors are even not relevant for certain actors. Thus the land price is strongly affected by the actors involved in the bidding process.

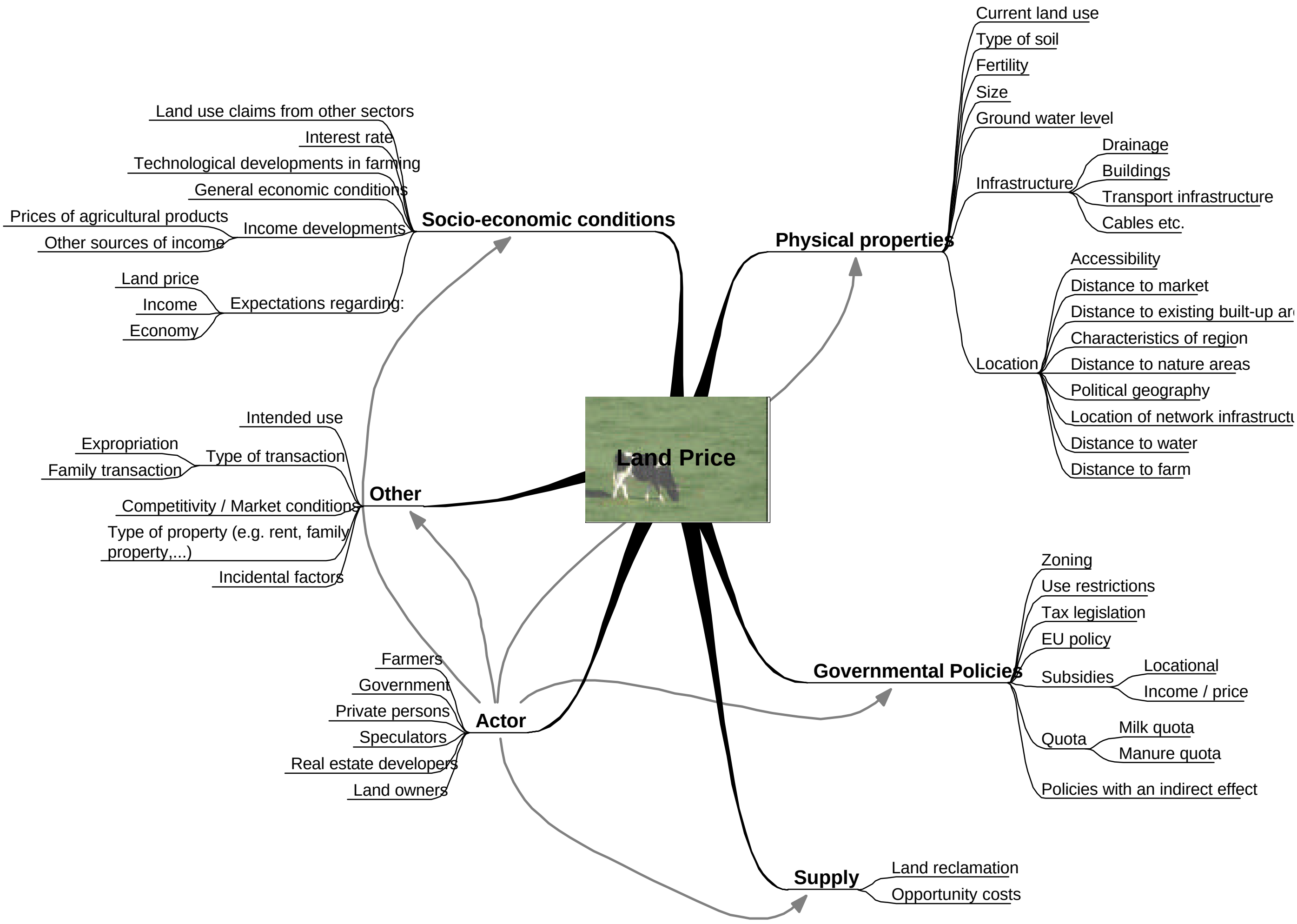

Figure 1: Overview of the factors affecting the land price.

The space is too limited to discuss al the factors in this paper. In the next section, which discusses the data and the model used in this study, we will see that only a limited number of factors can be used in a model, as data and knowledge of factors is often limited. Only the factors from figure 1 that will be used in the model will be explained in the next section.

4. The model and the data

Based on the analysis of the actors and the factors affecting the land market a linear regression model has been formulated and estimated. For the estimation of the model we could make use of a database with all the land transactions outside urban areas in the province of Noord-Brabant (see figure 2 below) in 1998 and 1999. In this section the model and the data will be discussed.

Figure 2: Location of Noord-Brabant

As mentioned in the previous section, land prices are the result of a bidding process which is affected by many different factors. A seller offers his/her land and has a certain price in mind, based on his/her information about other, similar land transactions and on his/her valuation of the properties (factors) of the parcel. An interested buyer will offer a price for the parcel (or parcels in case of multi-parcel transactions). The price the buyer will offer is determined by the properties of the parcel and the type of actor (which is related to the intended use of the parcel). The properties of the parcel and additional factors will for a large part be determined by the location of the parcel.

Based on this, we would like to analyse the effect of different factors on the land price. Therefore, a linear regression model has been formulated. The factors that have been included in the model are restricted to the spatial factors and to the actors. In future research more factors will be added and analysed.

The available data consists of two parts: data on land transactions, supplied by the Government Service for Land and Water Management of the Netherlands (‘Dienst

Landelijk Gebied' (DLG), a department of the Netherlands Ministry for Agriculture, Nature Management and Fisheries) and a rich set of spatial data on all kinds of factors, supplied by the National Institute of Public Health and the Environment of the Netherlands (RIVM). This spatial data consists of digital GIS maps of infrastructure (roads, railroads), land use (a 100 by 100 metre grid of main land use in 25 categories), nature areas and planned nature areas, plans regarding roads and built-up areas for the next 5 years (called The New Map of the Netherlands) and maps that indicate suitability of agricultural land for different types of crops.

The data on land transactions consists of two tables: one for information on transactions and one for information on parcels. The information on parcels is quite limited and includes a geographical co-ordinate, a cadastral registration code, the surface, and a short description of the state of the parcel. The information on transactions includes the transaction price, buyer and seller characteristics and the transaction date. The information covers about 12000 parcels, of which about 11100 are outside built-up areas. The 12000 parcels have changed owner in about 5500 transactions. The quality of the data is rather good, except for the buyer and seller characteristics, which has many blanks fields, and for some parcels the co-ordinates are missing. After cleaning the data set 11395 parcels in 4598 transactions are available for the calculations.

A difficulty with the land transaction data is that the price is known only for a transaction, which can consist of more than one parcel. About 1500 transactions consist of more than one parcel and they do not necessarily lie adjacent. It is thus not possible to directly estimate parcel prices as prices are only known for transactions and locations (and thus spatial parcels characteristics) are only known for parcels. In order to work around this problem, parcel characteristics have been weighted by surface and added up in case a transaction consists of more than one parcel. This can be seen in equation 1 below. Applying the surface as a weight has the additional advantage that the regression coefficients of the spatial variables can be interpreted as changes per square metre.

A disadvantage of this operation is that the correlation between the explaining variables increases and the possibility of heteroscedasticity increases. When carrying out the regression, attention should be paid to these problems. An alternative formulation of the model is to use transaction price per square metre as dependent variable. This causes, however, problems with transactions that include immobile property. At the current stage of the study equation 1 seems the most appropriate formulation of the model.

$$\begin{aligned} TRPRICE = {} & C + a_1 DATE + a_2 \sum_{j=1}^{k} SURFACE_j + a_3 IMPROPERTY + \\ & a_4 (ACTFAM * \sum_{j=1}^{k} SURFACE_j) + a_5 (ACTGOV * \sum_{j=1}^{k} SURFACE_j) + \\ & a_6 (BUYERAGR * \sum_{j=1}^{k} SURFACE_j) + a_7 \sum_{j=1}^{k} (SURFACE_j * AGRVALUE_j) + \\ & a_8 \sum_{j=1}^{k} (SURFACE_j * DISTBUA_j) + a_9 \sum_{j=1}^{k} (SURFACE_j * DISTROAD_j) + \\ & a_{10} \sum_{j=1}^{k} (SURFACE_j * DISTMAINROAD_j) + a_{11} \sum_{j=1}^{k} (SURFACE_j * INNEWMAP_j) + e \end{aligned}$$

Equation 1

The transaction price (*TRPRICE*) is a function of several characteristics of the parcels in the transaction and of some buyer characteristics. *DATE* is a linear trend variable to compensate for the fact that the data spans two years. This variable has not been multiplied by the surface to avoid too strong correlation. The dummy variables *ACTFAM*, *ACTGOV*, and *BUYERAGR* have been multiplied by the transaction surface to obtain a price per square metre. *AGRVALUE*, *DISTBUA*, *DISTROAD*, *DISTMAINROAD*, and *INNEWMAP* have been weighted by the parcel surface and, as a result, also give a price per square metre. *IMPROPERTY* is a dummy that indicates if the transaction includes immobile property.

The following list gives an overview of the variables in the model.

TRPRICE	Transaction price in euros.
C	A constant.
DATE	A linear trend variable, increasing in time.
$SURFACE_j$	The surface of parcel *j* (*k* = number of parcels in the transaction).
IMPROPERTY	A dummy variable which is 1 if one or more parcels in the transaction contain immobile property, like a house, an office or a road.
ACTFAM	A dummy variable which takes the value 1 if the buyer is a relative of the seller.

ACTGOV	A dummy variable which takes the value 1 if the buyer is a public authority.
BUYERAGR	A dummy variable which takes the value 1 if the buyer has its main activity in agriculture.
$AGRVALUE_j$	An index of the agricultural value of parcel *j* for the main crops (potatoes, corn, beets, wheat, and grass (fields for cattle)), based on type of soil and ground water level, on a scale of 0 to 100, where 100 means the best land and 0 the worst.
$DISTBUA_j$	Distance from the centre of gravity of parcel *j* to the nearest built-up area.
$DISTROAD_j$	Distance from the centre of gravity of parcel *j* to the nearest road (excluding main roads).
$DISTMAINROAD_j$	Distance from the centre of gravity of parcel *j* to the nearest main road.
$INNEWMAP_j$	A dummy variable which indicates if a parcel is within 100 metres of an area designated as housing or for business on the New Map of the Netherlands.

Note: distances are calculated as the crow flies.

The transaction price will be dependent on the amount of land. The variable *SURFACE* will indicate a kind of base price or average price per square metre of land. The other variables are corrections to this average price.

A difficulty with estimating land prices is that often immobile property is present on a parcel and the value of the immobile property and the land are interwoven. The *IMPROPERTY* dummy variable is supposed to take up the value of immobile property. To analyse the effect of immobile property, also a regression of all transactions without immobile property will be carried out.

ACTFAM, *ACTGOV*, and *BUYERAGR* are an indication of the actors involved in the transaction. If family or government is involved, it is supposed that the land price will deviate from the average land price. Speculators and real estate developers (see figure 1) will also have a significant impact on land prices. Unfortunately no information is available on these categories and besides that they will buy relatively few parcels. *BUYERAGR* is a separate category as an actor can be family as well as a farmer. In fact, many transactions of farmland are transactions from father to son.

The distance variables (*DISTBUA*, *DISTROAD*, *DISTMAINROAD*) indicate favourable properties of a parcel for several actors. If the distance to a built-up area is smaller, the chance that a parcel will be sold for housing or business purposes will be higher (due to planning and advantages like agglomeration economies). It is likely that speculation, which has a strong effect on land prices, will also be more present near built-up areas. The variables *DISTROAD* and *DISTMAINROAD* are an indication of the accessibility of the parcels. Farmers will have advantages if their parcels are easily accessible by road. Main roads can have an attracting effect on business or housing.

If a parcel is located in an area indicated in the New Map of the Netherlands as housing or business, plans exist to use the land for these purposes. As the land value for housing and business is much higher than for agriculture, due to land use planning among other reasons, *INNEWMAP* should indicate a higher land price.

5. Results of the regression analysis

With the variables and data as described in the previous section, several regressions have been carried out. The results of three regressions are given in table 2. Regression number 1 includes all observations. The second regression, labelled number 2, was carried out with transactions that did not involve immobile property and in the third regression the three highest outliers from the first regression with all observations were excluded. The regressions have been carried out using White's heteroscedasticity-consistent standard errors procedure to correct for heteroscedasticity and correct the t-statistics. If this procedure should not have been used, all variables except the constants should have been significant.

The results of the first regression with all 4598 observations shows good results; the signs and the magnitudes of the coefficients are as should be expected from the theory. The R^2 which indicates the fit of the model is a moderate 34%. The constant is not significant; the interpretation of the constant is somewhat difficult as one should expect zero or a small positive figure. The *DATE* variable means that transactions become more expensive in time with an average of €58,93 per day, which is a price increase of €21.535,- per year. If one compares this figure with the average price of about €200.000,- of all transactions over two years, one can see that the price increase has been rather large, which corresponds with what was observed in reality: in 1999 for example the average land price in the Netherlands rose with 14%.

The base price of a parcel, indicated by the *SURFACE* variable, is €1,38 per square metre which is a realistic price considering the average price of €2,00 per square metre for farmland and €0,00-€0,90 per square metre for nature land mentioned by Centraal Planbureau (1999). The average value of immobile property over all transactions is €270.011,-. This is an average for all kinds of immobile property, such as houses, offices, roads, barns, etc. The value of immobile property is also affected by many different factors, like the state of the structure and from the data it is rather difficult to know the type and value of immobile property. Because the difficulties with separating the land price from the price of the immobile property we have also carried out a regression of all transactions in which no immobile property was involved. This regression, which is regression number 2, is discussed later in this section.

Variable	**1**	**2**	**3**
C	-24215	-22343	-10991
	(-1.39)	(-0.84)	(-0.88)
DATE	58.93*	64.01*	41.67*
	(2.30)	(2.76)	(2.24)
SURFACE	1.38	3.12	0.69
	(0.94)	(1.67)	(0.51)
IMPROPERTY	270011*		265733*
	(15.00)		(22.36)
ACTFAM	-3.22*	-2.34*	-3.01*
	(-4.92)	(-4.68)	(-4.69)
ACTGOV	0.88	-1.29	1.33
	(0.76)	(-1.07)	(1.18)
BUYERAGR	-1.58	-2.49	-0.67
	(-1.47)	(-1.41)	(-0.89)
AGRVALUE	0.07*	0.07*	0.06*
	(3.32)	(2.76)	(3.03)
DISTBUA	-3.40*	-2.70	-2.44*
	(-3.04)	(-1.89)	(-3.46)
DISTROAD	-0.59	-1.15	-0.58
	(-1.52)	(-1.80)	(-1.56)
DISTMAINROAD	-0.10	-0.27	-0.06
	(-0.89)	(-1.49)	(-0.58)
INNEWMAP	14.32*	15.41*	15.29*
	(3.93)	(4.07)	(4.24)
R^2	0.34	0.35	0.47
F-statistic	216.42	175.87	375.97
No. of obs.	4598	3286	4595

*Table 1: Results of the regression analysis. * significant at the 5% level.*

Note: the figures between brackets are the t-statistics.

Considering now the other regression results, it can be seen that family transactions take place at a significant lower land price, about €3,22 per square metre lower than the reference category, which consists of 'other private bodies'. Often land transactions between family members include already part of the inheritance. Public authorities on the other hand pay €0,88 more than the reference category. As the category of public authorities is rather large, it is quite difficult to give an explanation for this. It might be that often public authorities need to buy certain parcels in order to built a road or develop new housing. As the sellers may know that, they can ask a higher price. Looking at *ACTGOV* in regression without immobile property, which has a negative coefficient, another explanation is that the government buys land with relatively expensive immobile property on it.

If the buyer's main activity is related to agriculture the land price is €1,58 lower than if that is not the case. This indicates again that farmland has a lower price than land that is used or will be used by housing, business or other 'high value' purposes. Of course a buyer who has his/her main activity related to agriculture may also buy the land for non-agricultural purposes, though the majority will buy it for farming. The agricultural value of land has an increasing effect on the land price, which was already explained by Ricardo. The value is 7 euro cents per index point per square metre. As most of the land falls in the categories between 70 and 100, see figure 3, this can have quite some effect on the land price.

From the distance variables the distance to built-up areas has the strongest effect. This is very interesting as it confirms the hypothesis that land in urban fringes is more expensive. Especially in the Netherlands, where the chance of land conversion from a low value use to a high value use will result in a strong land price increase, land in urban fringes will be more expensive.

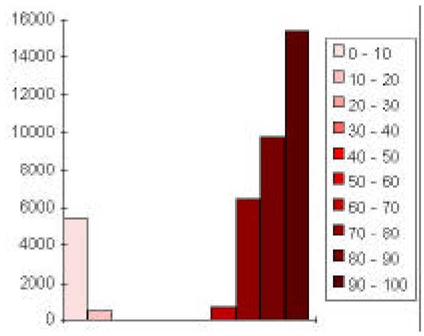

Figure 3: Histogram of agricultural value of land: the figure shows the amount of cells of 500 by 500 metres that fall in a category of the index.

The variable with the strongest effect per square metre is *INNEWMAP*. This means that if land is located in an area for which building plans exist, the land is significantly more expensive. Several reasons are mentioned in the literature to explain this. First the land price can increase because of speculation. If plans are known to only a few people or if some people expect developments at a location they can try to buy the land and sell it more expensive and thus increase the land price. Similarly, real estate developers can try to acquire land positions in order to have a strong position in negotiation on assigning building orders. Besides these reasons, existing owners of the land, usually farmers, can require compensation for moving their farm elsewhere, which can be included in a higher land price. Finally, land in these areas can have been improved already with roads, sewers, etc., after which is may be resold from the municipality to real estate developers (for a good explanation of process of acquiring land for development of housing or offices in the Netherlands see Needham, 1992)

We now turn our attention to the second regression. This regression has been carried out to analyse the effect of immobile property on land prices. In this regression only the observations without immobile property have been used. In general we do not see any important changes in the regression results, which shows that the dummy for immobile property is working well. The two most significant changes are an increase of the average land price and the changing sign and value of *ACTGOV*. The fact that the government buys much land for nature development may explain the changing sign. Land for nature development is usually cheaper as it is less valuable for agriculture and does not have any immobile property on it. The changing average land price may be a mere technical change. As the dummy for immobile property is not present anymore, high land values are now attributed to the *SURFACE* variable.

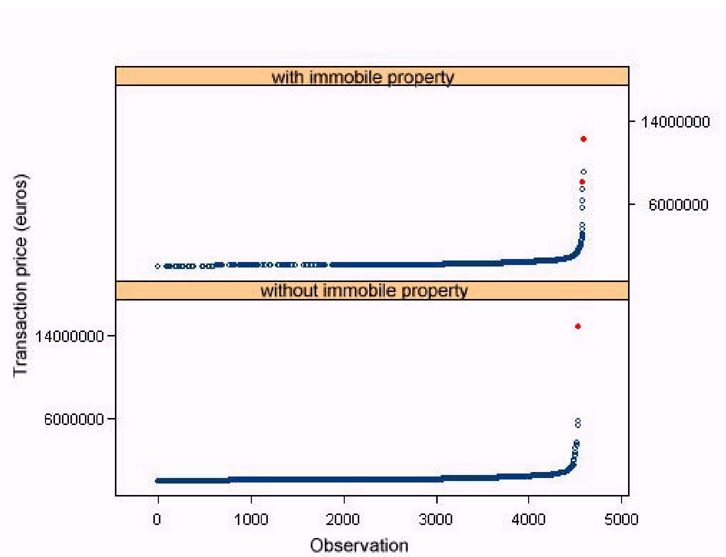

Figure 4: transaction prices of the observations ordered by size.

The third regression that has been carried out analyses the effect of extreme values of variables. Figure 4 shows the transaction prices ordered by size for parcels with and without immobile property. It can be seen clearly that there are quite a few extreme values. The most expensive transaction is even a transaction without immobile property. Also the graphs of the transaction price per square metre, which are not shown here, show the same shape of distribution of observations. Removing the three observations with the highest residue from regression 1, indicated by the red, closed dots in figure 4, gives the results of regression 3 which are shown in table 1. The R^2 increases from 34% to 47% and the coefficients of variables change somewhat, though there are no large changes. The signs of the coefficients stay the same. The most significant changes are the decrease of the *SURFACE* variable from 1.31 to 0.69 and the shifts of *ACTGOV* from 0.88 to 1.33, *BUYERAGR* from -1.58 to -0.67 and *DISTBUA* from -3.40 to -2.44. These changes can be explained by the characteristics and the weight of the observations that have been deleted.

Although the observations which have been removed from the data set in regressions 3 are outliers in a statistical sense, they are very interesting observations if one looks a little closer at the data. Figure 5 below shows for example the location of the observation with the highest transaction price. The 14 parcels in this transaction are unbuilt farmland and lie very close to the city of Eindhoven, at a probably very strategic location. Though the surface comprises 208.563 square metres, there are about 50 observations with a larger surface. The price per square metre is ranked only number 190. The explanation for the fact that this observation is such a strong outlier should be sought in unobserved variables other than currently in the model. Possibilities of unobserved variables are speculation or compensation orders (if the land is bought against a high price from the municipality, a real estate developer may be given the right to develop the area). Other outliers include the purchase of a large nature area by the public authorities and three parcels with houses and farmland next to a highway exit.

The ideal land price model should of course also capture these interesting cases. As this study is still work in progress, we aim at developing such a model. It is however difficult to get information about some unobserved variables. Land prices can be very location specific, depending on many factors of which only a few are observed. Land prices of adjacent parcels can differ strongly because of planning. An example is a case of urban expansion along with nature development: parcels used for housing were considerably more expensive than adjacent parcels used for nature development. Another example from agriculture shows that the size of grains of sand present at some parcels resulted in a strong price increase when the land was used for tulip growing. In depth study of individual cases may reveal some of the unobserved factors.

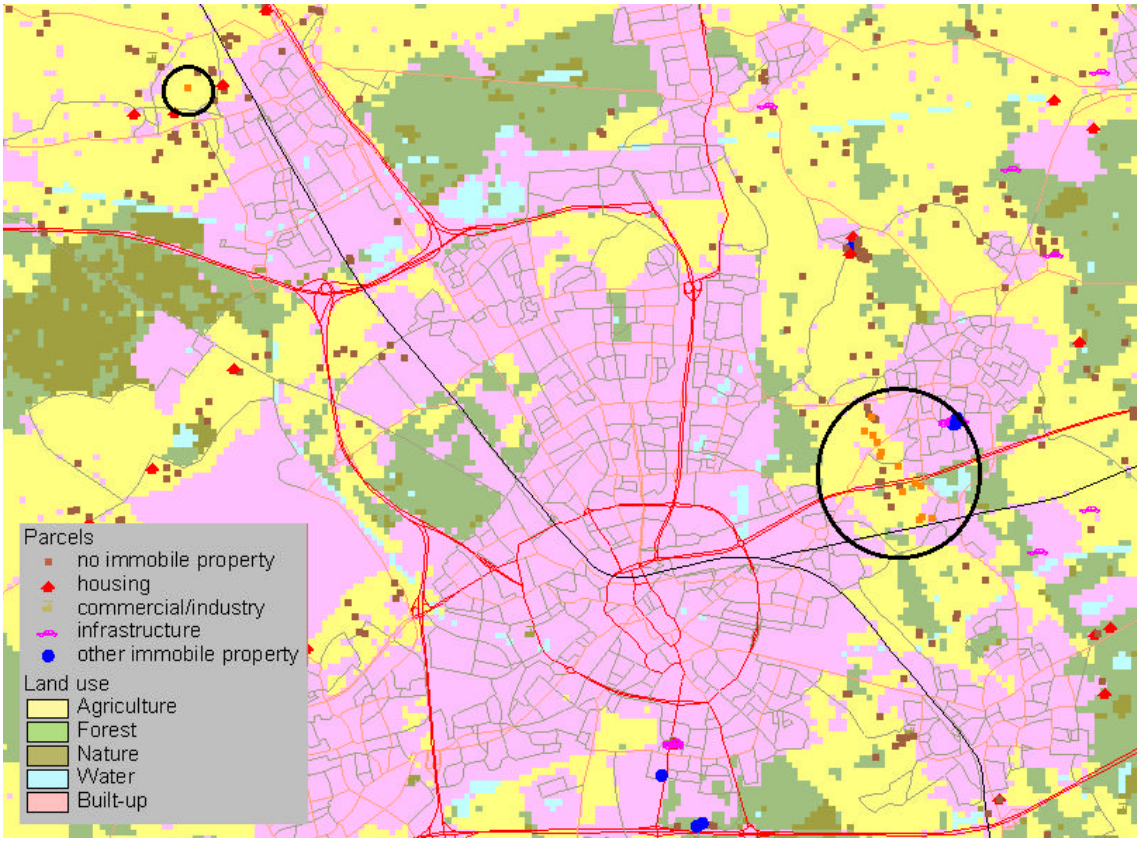

Figure 5: Location of the parcels of the most expensive transaction (the orange dots in the circles).

6. Conclusions and further study

Increasing land use pressure caused by the demand of several sectors in a situation where land supply is limited has resulted in land price increases and a discussion on the functioning of the land market. Although nature and agricultural land are protected from unlimited and unstructured expansion by land use plans, the resulting segmentation of the land market results in strong price differences between markets, and, in a spatial context, between areas and parcels. Agricultural land prices increase especially near built-up areas.

Theory on land markets shows that different actors bid for a parcel of land. The height of the bid is based on the valuation of different factors, which are the different properties of the parcel, and the actor's characteristics. In empirical studies many factors that affect the land price can be found. Besides many factors that can explain changing land prices through time, like macroeconomic developments, many factors exist that explain different land prices at different locations. This last category of factors forms the basis of the spatial exploratory land price model, of which a preliminary version is presented in this paper.

The data on which the model is based consists of 4598 land transactions comprising 11395 parcels in the province of Noord-Brabant in the Netherlands. The results of a regression analyses confirm the relations found in theory and observations found in practice. The sizes and signs of the variables are as should be expected. The strong price increase over two years is captured and lower land prices for family transactions and at locations further away from built-up areas are significant variables. However, the explanation power of the model still needs to be improved and outliers in statistical sense, but interesting observations from a theoretical point of view, are not well explained with the model.

The model is still very much a work in progress. Besides including the interesting observations, work needs to be carried out in validating the model and analysing specific cases. The final model will need to contribute to the comprehensive spatial model Land Use Scanner. Validation of land prices from the model and analysing and modelling the relation between land prices and land use can contribute to better land use modelling.

Note

[1] For more information on the Land Use Scanner see Stillwell and Scholten (2001) or http://www.econ.vu.nl/re/similor/. More information on this study can be found at http://www.econ.vu.nl/gis/research/landuse/default.asp

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