VALUATION OF LAND USE
IN THE NETHERLANDS AND BRITISH COLUMBIA;
A SPATIAL HEDONIC GIS-BASED APPROACH

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VALUATION OF LAND USE IN THE NETHERLANDS AND BRITISH COLUMBIA; A SPATIAL HEDONIC GIS-BASED APPROACH

GEERTE COTTELEER

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ABSTRACT

The main reason for government intervention in land markets is market failure. Open space is a non-market output or externality of farmland and, although it might be important to people, there is no actual market for the good as such. The Netherlands and the Province of British Columbia in Canada both experience similar problems of expanding cities and pressure on open space, and they both use zoning to regulate land use and its externalities. The objective of this research is to evaluate the effect of zoning on the preservation of open space in the urban-rural fringe and to quantify the externalities that different types of land use impose on residential properties.

A combination of Geographical Information Systems (GIS), hedonic pricing models, spatial and Bayesian econometric techniques is used to reach this objective. Because each specific dataset requires specific data-handling and methods, this thesis uses different econometric techniques.

Results show that zoning schemes to protect farmland on the Saanich Peninsula, British Columbia and in the Netherlands are only partly credible. On the Saanich Peninsula we find that zoned farmland sells for lower prices than other farmland. However, indicators for speculation show that farmland located closer to the city of Victoria is priced higher and hobby farmers pay higher prices than conventional farmers. For the Netherlands we find that agricultural zoning is more credible in rural areas than urban ones. Moreover, farmland in the Netherlands has to compete with urban development in urban areas and with nature preservation in more rural areas.

Both in Midden-Delfland (the Netherlands) and on the Saanich Peninsula premiums are paid for residential properties close to small urban parks. Although, larger nature areas and farmland also provide positive externalities such as open space, their presence does not result in higher property prices. Therefore, we conclude that negative externalities associated with these types of open space also play a role.

Keywords: Hedonic pricing models, spatial econometrics, Geographical Information Systems (GIS), farmland, zoning, residential properties, open space, non-market valuation, Bayesian econometrics, hobby farmers.

PREFACE/VOORWOORD

Het begon allemaal in de aanloop naar een WE-day (sportdag van Wageningen Universiteit en Researchcentrum). Daan Ooms, destijds Onderzoeker In Opleiding (OIO) bij de leerstoelgroep Agrarische Economie en Plattelandsbeleid (AEP) was op zoek naar een vrouw voor zijn beachvolleybalteam. Of ik nog iemand wist bij het LEI, liefst niet al te oud en het zou fijn zijn als ze ook nog een beetje kon volleyballen. Nou dat kwam goed uit, want tot mijn 18e had ik veel gevolleybald en zo oud was ik ook nog niet. Op de dag zelf raakten we aan de praat over het doen van onderzoek aan de universiteit en dat resulteerde in een open sollicitatie bij de leerstoelgroep AEP. Een jaar later was er binnen de groep een vacature en kreeg ik bericht of ik nog geïnteresseerd was. En dat was ik, dus zo kwam ik terecht in Wageningen. Dit proefschrift is het resultaat van de vier jaar onderzoek die daarop volgde.

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Wageningen, juli 2008

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CHAPTER 1

INTRODUCTION

1.1 Background

The main reason for government intervention in land markets is market failure. Policies to protect farmland and other types of open space are justified because externalities exist that are not efficiently addressed under free market conditions. Open space is a non-market output or externality and, although it might be important to people, there is no actual market for the good as such. According to Freeman (2003) "Externalities arise when a real variable (not a price) chosen by one economic agent enters the utility or production function of other economic agents and there is no requirement to or incentive for the first agent to take the effect on others into account when making choices". Therefore, externalities either result in overproduction of negative externalities or underproduction of positive externalities (OECD, 2003). Externalities can be both positive and negative. In this research, externalities are viewed as the non-market outputs of different types of land use.

The primary purpose of farmland is the production of marketable goods, but there are many positive externalities related to farmland (see OECD (2003), Abler (2004), Hall et al. (2004), Randall (2002), Bredhal (2003), Romstad, et al. (2000), Hellerstein, et al. (2002)). These include open space, cultural heritage, wildlife habitat, recreational opportunities, amenity values of the landscape, watershed and flood protection. According to Kline and Wichelns (1996) externalities can be categorized into 1) agrarian values that are concerned with food production and protecting the agricultural heritage and traditions of the area; 2) environmental values that are concerned with protecting wildlife habitat, flood protection and other environmental services; 3) aesthetic values related to the preservation of open space; and 4) anti-growth values that see land protection as an obstacle to urban sprawl.

Farmland also produces negative externalities such as noise, dust, odors and congestion on roads from slow moving farm equipment that affect surrounding residential properties (Daniels, 2000). Further, the use of pesticides in agriculture has negative impacts on biodiversity (OECD, 2003) and the use of nutrients has caused water pollution (Abler, 2004). Sometimes positive and negative externalities can conflict over specific land uses. For instance, agricultural production needs (agrarian values), can be achieved by using fertilizers and pesticides, but at the cost of environmental values.

Externalities flow in both directions, with agriculture affecting urbanities, but also urban development impacting farmland. If we look at open space amenities provided by farmland near urban areas we observe that, as the urban fringe is pushed out, fragmentation of surrounding farmland increases (with the spatial fragmentation also adding to farming costs) (Hardie et al. 2004), as do incidences of trespass and vandalism. Furthermore, there are nuisance complaints from neighboring urban residents who object to the sounds and smells of farming operations.

Although, the interaction between agricultural and residential land use is the main focus of this thesis, other open space providers such as nature and golf courses are also incorporated in the current study. Positive externalities associated with nature are scenic views, recreational opportunities (Irwin and Bockstael, 2001), wildlife refuge and historic sites (Cho et al. 2006). On the other hand, Geoghean et al. (2003) mention deer as a negative externality resulting from forests, because of landscape damage and car accidents. The spread of Lyme disease is another negative externality associated with forests. Paterson and Boyle (2002) indicate that people might simply not enjoy the views provided by trees. Golf courses provide positive impacts due to the popularity of golf as a recreational activity (Nicholls and Crompton, 2007) and the open space it provides, but golf courses can also be associated with negative externalities as recognized by Asabere and Huffman (1996).

1.2 Policy

Countries and states have employed various policy schemes to restrict certain types of land uses in certain areas. For example, many countries in Europe and states/provinces in North America are concerned about the conversion of agricultural land to urban uses and about the changes in the character of rural landscapes due to the loss of agricultural land (Abler, 2004). Therefore, agricultural land protection is a policy goal in many jurisdictions.

Many US jurisdictions rely on a combination of zoning and market-based approaches, such as tradable development rights (TDR) and purchase of development rights (PDR) or Purchase of conservation easements (PCE), to address income redistributional aspects of zoning. TDRs leave discretion as to which agricultural lands get protected and which get developed. In other circumstances, a government will simply purchase the rights to develop the land from the owner or landowners might receive a reduction in taxes, using PDRs or PCEs. This means placing a covenant on the property that prevents a future buyer from developing the land. While the purchase of development rights is effective and provides landowners with funds to invest in their farms, costs to the treasury can be prohibitive. A more detailed discussion of various instruments for protecting rural lands is found in Barichello et al. (1995).

Zoning schemes with restrictions on land use are used to prevent cities from expanding too rapidly into farmland areas, thereby preserving open space (Netusil, 2005). These schemes lead to segmentation of the land market, resulting in different price levels within submarkets. Prices in each submarket reflect the profitability of the related land use (CPB, 1999; Luijt and Van der Hamsvoort, 2002). For example, land prices in residential and industrial markets are much higher than land prices in farmland markets (CPB, 1999). Although zoning segments the land market, zoning regulations might change over time. Population growth, rising incomes and other factors increase the demand for land in residential, industrial, infrastructural, nature and recreation uses (CPB, 1999).

Therefore, the drawback of zoning is that it creates incentives for lobbying the zoning authority for exclusions and variances to the zoning regulations (Blewett and Lane, 1988). Speculation on land that developers believe has a high probability of being excluded, can increase farmland values well beyond the agricultural returns from the land, thus undermining one of the main reasons for zoning. Property prices in general reflect speculation and the externalities that surrounding uses of land impose on the parcel in question. Thus indicate changes that can be expected in the future, and the value different externalities impose on various land uses.

The Netherlands and the Province of British Columbia in Canada use zoning to restrict certain types of land use. They both experience similar problems of expanding cities and pressure on open space. In British Columbia, these problems might look less severe, because compared to the Dutch situation land is less intensively used in the province as a whole. However, in the urban-rural fringe, the area in which cities are expanding, land also has the highest agricultural capability (Hanna, 1997) and open space becomes more and more fragmented. In that sense, the situation in both research areas is similar.

Although the pressure on agricultural land is similar at the urban-rural fringe in British Columbia and the Netherlands, the policy focus in both jurisdictions is slightly different. In British Columbia, zoning is delegated to municipal governments under the Local Government Act (1996). Municipalities can restrict land in any way including type of use, presence and position of buildings, the configuration of parcels and how they might be subdivided. An exception is that municipalities may not prohibit or restrict agricultural activities in a farming area unless it receives approval from the minister responsible for administration of the Farm Practices Protection Act (Government of British Columbia, 1996). This act, also known as the 'Right-to-Farm' act was passed by provincial governments in Canada because residents near agricultural production frequently complained about farm practices that resulted in unpleasant smells and other negative external effects.

To further protect agricultural land, the province created an Agricultural Land Reserve (ALR) in 1973 that supersedes the local authority (Garrish, 2002/2003). The impetus for this was the rapid pace of urban development (an estimated 6,000 ha per year) encroaching on farmland (Runka, 2006), especially near the cities of Vancouver, Victoria and Kelowna. A parcel of land in the ALR may not be used for anything but agriculture without approval from the Agricultural Land Commission (ALC). It may contain one dwelling (a farmhouse) and other agricultural buildings and may not be subdivided. Besides zoning policies to preserve farmland, BC also utilizes beneficial property tax regulations to reduce farmers' financial burdens.

Zoning and land use policy in the Netherlands are based on the Spatial Planning Act (*Wet op de Ruimtelijke Ordening, WRO*) (Van Geest and Hödl, 2002). The implementation of spatial planning policy in the Netherlands is described by Faludi (2000), Louw, et al. (2003) and Van der Valk (2002). As a result of the Spatial Planning Act, all land in the Netherlands is zoned, implying that all land currently in agricultural production is zoned as agricultural land. Although farmland is protected in the Netherlands it is not the primary policy focus. A topic that receives more attention is the completion of the National Ecological Network (EHS) introduced in 1990 (LNV, 1990). The aim of the EHS is to connect nature areas in the Netherlands, so that these areas are not isolated and the survivability of animal and plant species is improved. Therefore, in many areas agricultural land is converted into nature.

In order to get better insights into issues like speculation and the value of externalities in the urban-rural fringe and open space premiums, the current research focuses on the Netherlands and the Southern part of Vancouver Island in British Columbia. In both areas similar research questions are investigated. By investigating similar research questions in different countries, better insights can be obtained about country-specific influences.

1.3 Hedonic pricing

The theory of non-market valuation, which has been covered by Freeman (2003), Hanley et al. (2007), Van Kooten and Bulte (2000) and Champ et al. (2003), describes how economic theory can be used to estimate values for non-market goods (such as externalities). Two main categories of valuation methods – both based on utility theory – are used: stated preference and revealed preference techniques. Stated preference techniques ask individuals about their preferences for particular (hypothetical) situations. They require the use of survey instruments that are beyond the scope of the current study. Revealed preference methods are based on observed behavior of individuals in markets that are related to the non-marketable amenities. For example, hedonic pricing methods use property prices to reveal shadow prices of particular environmental goods.

Hedonic pricing methods are used in this research to quantify the influence of property characteristics on property prices. The idea behind hedonic pricing techniques is that goods are valued because they provide utility. "Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them" (Rosen, 1974). The current research specifies these differentiated products either as residential properties or farmland properties.

A drawback of the hedonic pricing model as specified by (Rosen, 1974) is that it does not take the influence of market power into account. In fact, standard hedonic price theory assumes perfect competition in explaining transaction prices. However, for farmland this assumption may not hold. Most farmland parcels for sale only attract the interest of a limited number of local buyers. For example, a parcel of land might have perfect characteristics according to a certain buyer, but he will not buy it if it is located far away from his farm. In such a market there is not enough entry and exit to establish a competitive market. The effect of local land markets is further investigated in this research.

The characteristics of properties are not restricted to the current use of properties, but include surrounding land uses. Characteristics can also be associated with future uses. The capital asset pricing theory in combination with the option value theory (Dixit and Pindyck, 1994), predicts that the value of farmland reflects both its value in agricultural use and the option value from converting it at some point in the future to a non-farm use (Nickerson and Lynch, 2001). By measuring this option value, we can determine whether the future use of farmland is expected to be different from its current use. The chance that residential properties will be converted to other types of land use is almost zero. Therefore, this option value will not be taken into account if residential properties are investigated.[1]

Although, hedonic pricing models have often been applied to different settings and therefore, many examples for potential explanatory variables are set, there is no theoretical background for the inclusion of independent variables (Taylor, 2003). Therefore, there are only rules of thumb about which variables to include in hedonic pricing models. Potential solutions for this type of specification uncertainty are investigated in this research.

1.4 Sales versus assessed values

Hedonic pricing models require actual property transaction data as inputs, because these values reflect property characteristics which can then be decomposed into their constituent parts. However, sales values are not always readily available; therefore, some researchers have employed approximations of sales values in hedonic pricing models. For example, Chay and Greenstone (2005), and Isgin and Forster (2006), relied on a survey instrument to elicit estimates of property values. For practical reasons, it is very useful to know which approximations of property values will give valid and consistent results when transaction data are not available. Since properties in BC are assessed each year for tax purposes by BC assessment, this research investigates whether assessed values are good alternatives for actual sales values in hedonic pricing models.

1.5 Measurement of externalities

Because properties are unique, land markets essentially involve the trading of heterogeneous goods. Farmland parcels are unique with respect to characteristics such as soil type, ground water level, slope and so on. Similarly residential properties are unique with respect to the number of bedrooms, bathrooms, presence of a garage or a pool. However, the most important source of heterogeneity in property markets is location. Location is fixed for each property, so it cannot be relocated like most other goods and services. Because it is fixed, the location of the property in relation to the surrounding properties is also fixed. Therefore, properties located near each other impose externalities on each other, with such externalities affecting the value of surrounding land. This research attempts to measure these values and thereby the impacts of externalities that different types of land use impose on each other.

To measure the impact of externalities, explanatory variables for the hedonic pricing model have to be specified to quantify the 'reach' of externalities – the extent to which one type of land use

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[1] The concept of speculation is related to the option value of future conversions of the land. Speculation occurs when people try to benefit from price fluctuations as a result of future land use changes. The term speculation is often used in relation to the potential conversion of farmland to other uses. E.g. Hanna (1997) discusses speculation in relationship to the ALR, Cavailhes and Wavresky (2003) call land markets speculative and Livanis, et al. (2006) mention the speculative effect as represented by farmland conversion risks.

is able to affect other land uses as parcel sizes and distances vary. In GIS the location and size of different types of land uses are known. A variety of authors have investigated the impact of externalities imposed on each other by different types of land use. Different types of proxies that try to capture these externalities have been proposed. Irwin and Bockstael (2001), Kestens, et al. (2004), Gheoghegan (2002), and Cheshire and Shepard (1995) specify percentages of the land within specified buffer zones around each property which are used for the type of land use they are interested in. Halstead, et al. (1997), Wu (2001), Ihlandfeldt and Taylor (2004), and Wu, et al (2004), on the other hand, specify distance measures to the nearest lot with a specific type of land use. Another possibility is to specify dummy variables indicating the adjacency of a certain type of land use (Nicholls and Crompton, 2007; Spalatro and Provencher, 2001). The problem with distance measures is that large and small open space areas are treated equally and the problem with area percentages is that arbitrary buffer zones around each property have to be specified and open space outside those boundaries is not taken into account. In this research we investigate this issue further.

1.6 Spatial information

Externalities related to land uses have an important spatial dimension. To determine and quantify the influence of different types of land use on each other, the location of each of the land uses has to be known. The further apart, the smaller the impact of different types of land uses on each other. The locational setting of a property has to be identified to deal with questions such as: Which land uses surround the property? Which land uses are dominant in the area surrounding the property? What is the distance to other properties? Recently, economists increasingly incorporate spatial complexity in their models. Therefore, the use of Geographical Information Systems (GIS) in economics is growing rapidly (Bateman et al. 2006). Not only have spatial data and spatial software become more widely available, but spatial econometric techniques have also been developed. A more elaborate discussion of the recent use of spatial economic analyses can be found in Bell and Dalton (2007).

GIS can be used to collect, store, manipulate, analyze and visualize spatial data. We utilize all five of these functions of GIS. Both the Dutch and Canadian data consist of many different databases, which have to be linked before they can be used in the analysis. GIS is able to integrate different types of data using geographical coordinates as unique identifiers (Buurman, 2003). Furthermore, distances, area sizes, perimeter information and adjacency can be determined based on GIS-information.

Spatial econometrics is concerned with the measurement of spatial dependencies in economic data. Spatial effects can be divided into spatial heterogeneity and spatial dependence. In addition, spatial dependence can be subdivided into spatial lag dependence, spatial error dependence and spatial cross-regressive effects. Spatial heterogeneity refers to heterogeneity in the relationship between the dependent variable and the independent variables over space. Therefore, by allowing for spatial heterogeneity, the relationship between variables in the model can vary across regions. Spatial lag dependence refers to the spatial dependence between different observations of the dependent variable. An assumption of spatial econometric techniques dealing with this type of spatial dependence is that observations of the dependent variable that are closer to each other are more related than observations that are further apart. Spatial error dependence refers to the spatial dependence in error terms. Similar to the spatial lag dependence, it is assumed that error terms of observations that are closer to each other are more related than error terms of observations that are further apart. Finally, spatial cross-regressive effects occur when explanatory variables from neighboring observations influence the dependent variable directly.

If the number of observations is not too large, maximum likelihood techniques can be used to correct for the presence of spatial lag and error dependence. However, maximum likelihood requires the calculation of either the eigenvalues of the spatial weighting matrix or the determinant of a similar sized matrix. Both matrices are n x n, where n refers to the number of observations. This can only be done in a reliable way for datasets with limited numbers of observations (see Kelejian and Prucha (1999); Bell and Bockstael (2000); Pace and Barry (1997)). Another problem with testing and correcting for spatial lag or error dependence is that a spatial weighting matrix, reflecting the form of spatial dependence, has to be specified a priori. This leads to specification uncertainty. This research will address this issues, that arises in a spatial econometric context.

1.7 Existing literature the Netherlands and British Columbia

CPB (1999) and Segeren, et al. (2005) focus on the institutional environment as created by the government in studies about the Dutch land market. Buurman (2003) integrated many different data sources in research focused on land prices in rural land markets. However, he included observations of sales with different buyers, such as farmers, local and national governments, whereas Shonkwiler and Reynolds (1986) pointed out that shadow prices of land characteristics differ for different types of sellers and buyers. For example, a buyer who wants to use the land for residential purposes is interested in different characteristics than a user who wants to farm the land. Therefore, it would be better to allow for different estimates of shadow prices for different segments of the land market. Van Rij (2006; 2007) investigated collaborative planning processes that were aimed at the spatial quality of metropolitan landscapes in the Netherlands. Midden-Delfland was one of the areas of interest for this research, since it is a preserved open space area within a highly urbanized part of the Netherlands. However, this qualitative research focused on institutional arrangements. Others (e.g. Coeterier (1996) and Van den Berg, et al. (1998)) focused on the perception of different landscape elements. Similar to the current research, Koomen, et al. (2005) and Van der Straaten, et al. (2007) focused on the value residents attach to open space as reflected in the prices of residential properties. Although they calculated open space premiums for different areas in the Netherlands, the emphasis of Van der Straaten, et al. (2007) was more on open space within cities, while Koomen, et al. (2005) compared stated and revealed preference techniques to value open space. In contrast, the current study focuses on open space in all capacities, both within and outside urban areas. Furthermore, Luijt, et al. (2003) introduced the idea that farmland markets in the Netherlands are very local, because farmers want to buy land close to home given high internal transaction costs.

This raises the question whether the market form and personal characteristics of buyers and sellers influence market prices.

The literature about the preservation of farmland and open space in British Columbia is to a great extend qualitative. Green (2006) discusses case studies of exclusions of zoned farmland areas. Hanna (1997), Garrish (2002/2003), Campbell (2006) and Gordon (2006) more generally discuss the Province's zoning scheme – the Agricultural Land Reserve and the exclusions of farmland. To the best of our knowledge, Quayle and Hamilton (1999) were the only ones to quantify the value of open space in British Columbia, but they used very limited data and did not pay attention to spatial dimensions.

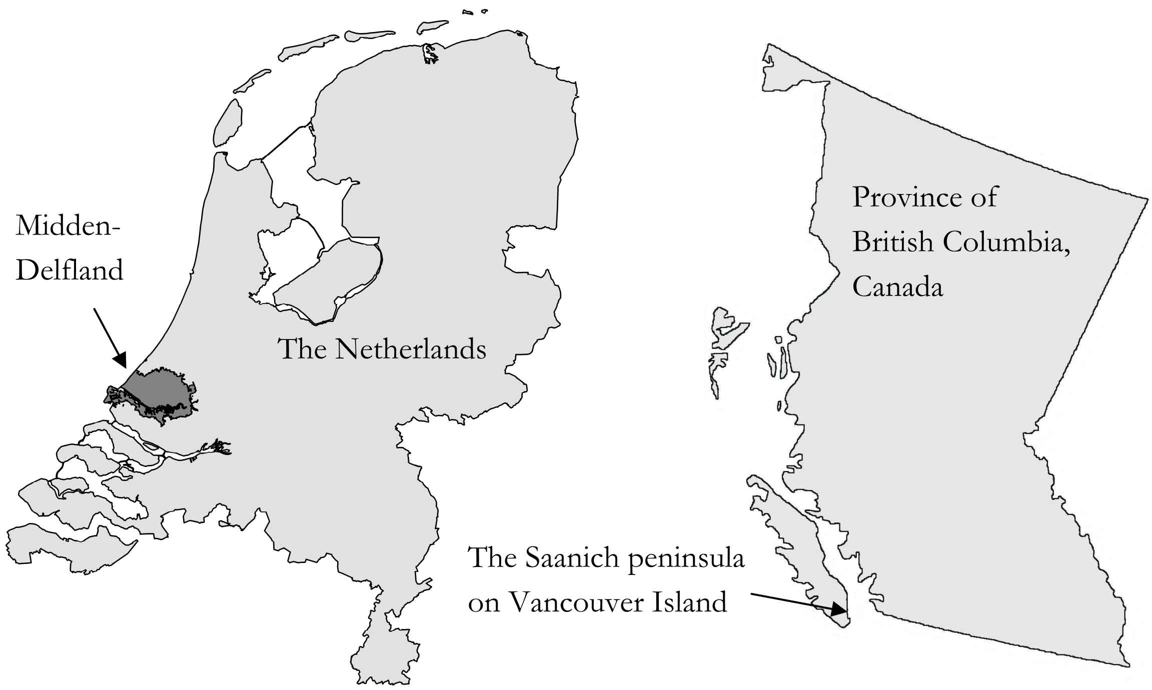

Figure 1.1 Research areas used in this thesis.
Note that the scaling of these areas differs.

1.8 Research objective

The general objective of this research is to quantify the externalities that different types of land use impose on farmland and residential properties, and to evaluate the effect of existing policies regarding the preservation of open space and farmland in particular. GIS-based hedonic pricing models are used to answer these questions. The estimated impact of externalities imposed by other land uses on residential properties and farmland are specified as net effects that result from the nearness of each of these different types of land use. The research areas are the Netherlands (for farmland), Midden-Delfland[2], an area in the Western part of the Netherlands (for residential properties), and the Saanich Peninsula on Vancouver Island near the capital city of British Columbia

[2] The area Midden-Delfland is defined in this thesis as the area that contains the municipalities Midden-Delfland, Bergschenhoek, Berkel & Rodenrijs, Delft, Maassluis, Pijnacker-Nootdorp, Rijswijk, Rotterdam, Rozenburg, Schiedam, Vlaardingen and Westland. This is a larger area than the area studied by Van Rij (2006; 2007).

(Victoria), Canada (for farmland and residential properties). Figure 1.1 shows the research areas used in this thesis. Given the broad research objective, we specify six research questions:

1. How are prices of farmland in the Netherlands influenced by the market form and personal characteristics of buyers and sellers? If markets are competitive, we expect hedonic prices not to be significantly different for local markets with a limited, but different, relative number of buyers and sellers. The research question will be answered using a combination of hedonic pricing techniques and GIS-data. The model is tested and, if necessary, corrected for heteroscedasticity, spatial lag and error dependence.
2. Has the ALR been effective in preserving farmland near Victoria? We wish to answer this question in a way that resolves uncertainty in hedonic pricing models that incorporate spatial autocorrelation. Therefore, we apply Bayesian Model Averaging (BMA) in combination with Markov Chain Monte Carlo Model Composition (MC^3) to deal with model uncertainty.
3. How do institutions and laws in the Netherlands and the Saanich Peninsula contribute to agricultural land preservation? We analyze farmland values using a GIS-based hedonic pricing framework, and thereby examine the direct impacts of laws and regulations.
4. Is the establishment of hobby farmers detrimental to the goals of agricultural land preservation? We investigate this issue by focusing on the role of hobby farming within and in close proximity of the Agricultural Land Reserve (ALR). We test whether hobby farmers affect prices inside and outside the ALR and identify what implications this has for the effectiveness of the ALR and other policy measures to protect agriculture in the urban shadow. The results of a hedonic pricing model are compared with the results of the propensity score method. This last method is used to control for potential endogeneity bias with respect to hobby farms in the hedonic pricing model.
5. Are assessed values good proxies for actual sales values in a hedonic pricing model that is used to estimate the value of open space on the Saanich Peninsula? The value of open space provided by farmland is compared to that provided by parkland and golf courses. We estimate a Seemingly Unrelated Regression (SUR) model with two equations, one with actual market values as the dependent variable and one with assessed property values, and compare the resulting estimates of shadow prices for open space amenities. Furthermore, we take account of spatial autocorrelation and combine Method of Moment estimates (Kelejian and Prucha, 1999) of the spatial parameters in both equations (Kelejian and Prucha, 2004).
6. What is the impact of land use surrounding residential properties, and its externalities, on residential property prices in Midden-Delfland? This research uses Instrumental Variable (IV) and Method of Moments (MM) to incorporate spatial lag and error dependence in the hedonic pricing model.

These questions will be answered in successive chapters of this dissertation and final conclusions and a discussion of our findings will ensue.

CHAPTER 2

MARKET POWER IN A GIS-BASED HEDONIC PRICING MODEL OF LOCAL FARMLAND MARKETS[1]

Abstract

Buyers of farmland are usually interested in parcels for sale that are close to their own farm. With a limited number of parcels for sale this may lead to market power in local farmland markets. The objective of this paper is to investigate whether market power affects farmland prices. Hedonic pricing models are adapted to allow for local market power of either sellers or buyers. A distinction is made between rural and urban farmland markets. The results provide evidence of market power effects in rural farmland markets. However, for farmland in urban areas, market prices are dominated by speculation effects.

2.1 Introduction

Hedonic pricing models have become popular tools in analyzing values of real estate and their specific attributes (see, e.g., Rosen (1974); Palmquist (2005); Taylor (2003)). A key assumption in hedonic pricing theory is that there are many potential buyers and sellers. With a limited number of buyers or sellers, individuals may be able to affect the price schedule, thus invalidating the results from standard hedonic pricing models (Feenstra, 1995). The economic consequences of such market power are that transaction prices deviate from efficient perfect competition outcomes, creating welfare losses for either buyers or sellers. In land markets there are many examples of market power that have an effect on transaction prices. For example, commercial real estate development agencies often act as the single supplier of land for construction purposes, leading to higher prices (Priemus and Louw, 2003). Another example of a market participant with market power is a government agency that buys land for nature and landscape preservation. In the Netherlands, the Government Service for Land and Water Management (*Dienst Landelijk Gebied, DLG*) buys land in order to extend

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[1] This chapter is a paper by Cotteleer, G., C. Gardebroek and J. Luijt, forthcoming in Land Economics, November 2008. This research was funded by the Netherlands Environmental Assessment Agency (*Milieu en Natuur Planbureau, MNP*). The authors would like to acknowledge the LEI for providing the data and give special thanks to Tom Kuhlman, Cees van Straaten and Marcel Betgen for their help with the data, and to Arie Oskam, Cornelis van Kooten and an anonymous referee, as well as to the participants at the Mansholt Graduate School PhD-day and the AAEA meeting in Long Beach, CA, for comments on earlier drafts of this manuscript.

the National Ecological Network (*Ecologische Hoofd Structuur, EHS*). This leads to additional demand for land, which drives up prices. This government agency can afford to pay higher prices since it commands a large government budget to meet its policy objectives.

At first glance, transactions of farmland between farmers seem to be least affected by market power. Even in an urbanized country like the Netherlands there are still many active farmers, suggesting that individual buyers and sellers cannot exert any influence on land prices. However, farmers are usually not interested in land for sale that is too far from their own business, simply because time losses and costs of operating land further away are too high. This results in transactions of land between farms located near each other. So, land markets are to a great extent local. In these local markets, there may be only a few buyers or sellers. If there are different numbers of buyers and sellers in such local markets, this potentially leads to market power effects on final transaction prices. If, for example, five neighboring farmers are all interested in a parcel sold by a single seller it is obvious that the seller has market power. On the other hand, in depressed rural regions many farmers might want to quit farming and sell their land, but not many other farmers are interested in buying these parcels. Therefore, the ones that are interested in buying can probably do so at lower prices.

A complicating factor in analyzing land markets is the influence of zoning regulations. In the Netherlands, the country on which this study focuses, all the land is zoned. The Spatial Planning Act (*Wet op de Ruimtelijke Ordening, WRO*) enables the central government, the provincial governments and the municipalities to develop zoning schemes. The provincial governments have an intermediate role in the process. They translate the spatial policy of the central government to the regional level and supervise and monitor the spatial policy implemented by the municipalities. For an overview of the Dutch spatial development policy see Louw, et al. (2003). At the level of central government, agriculture is considered as one zoning category. However, on the municipal level there are also various areas indicated which are zoned for specific types of agriculture. For example, in some regions horticulture is being promoted, in others intensive livestock farming is being restructured. In principle, residential development is not allowed on agricultural land.

Zoning schemes have led to a segmented land market, with different price levels within segments. Prices in each submarket are related to the profitability of the related land use (Luijt and Van der Hamsvoort, 2002). For example, land prices in residential and industrial markets are much higher than land prices in the farmland market. Although zoning segments the land market, zoning regulations might change over time and, as a result, land prices are subject to speculation. And farmers might be among the speculators in the land market. Because of speculation effects, farmland prices may be higher in urban areas than in more rural areas. As a result, the potential influence of market power in local markets as hypothesized above may also vary over regions. In predominantly rural regions, there will not be much speculation involved in farmland transactions, so local market power may have an important effect on prices. For farmland transactions in urban regions, local market power may be less an issue, as market prices are dominated by speculation effects and numerous potential sellers and buyers can participate in transactions.

The recent hedonic pricing literature on farmland mainly focuses on the effect of urban pressure on farmland and the resulting speculation on associated prices (e.g. Shi, et al. (1997);

Plantinga, et al. (2002); Cavailhes and Wavrevsky (2003); Huang, et al. (2006); Isgin and Forster (2006)). Although both parcel characteristics and urban influences have proven to be very important, King and Sinden (1994) pointed out that buyer, seller, and market characteristics are also important determinants of farmland prices, mainly because these variables are related to the bargaining position of market participants. Harding, et al (2003b) and Harding, et al. (2003a) also focused on the effect of bargaining positions on final transaction prices in hedonic pricing models, but their focus was on transactions of residential properties in the USA. In these papers it is argued that, because of limited numbers of market participants, the maximum willingness to pay of buyers is often higher than the minimum willingness to accept of sellers, resulting in an excess surplus that is subject to bargaining. Feenstra (1995) argued if markets are non-competitive and this is not explicitly taken into account, the coefficients in hedonic pricing models are biased and do not reflect the marginal values of the characteristics. Feenstra (1995) therefore suggests to include price-cost markups (differences between marginal values and marginal costs) in hedonic pricing models. Taylor and Smith (2000) explicitly calculated these market power price markups in the non-competitive market for beach rentals in North Carolina.

The objective of this paper is to investigate if market power has an effect on farmland prices in rural and urban areas in the Netherlands. If markets are competitive, we expect hedonic prices not to be significantly different for local markets with a limited, but different, relative number of buyers and sellers.

Since it can be expected that there are many local land markets in the Netherlands in which it is not a priori known which participants have market power, the approach of Feenstra (1995) is not applicable in our case. Instead, we extend the framework of Harding, et al. (2003b) by including proxy variables for market power in a hedonic pricing model, in addition to personal characteristics of sellers and buyers that account for bargaining positions. The advantage of our approach is that it allows for market power of both sellers and buyers, and that it solves the potential omitted variable bias suggested by Feenstra (1995) in a straightforward way. As well as market power and personal characteristics, the hedonic model also includes farmland characteristics and variables accounting for impacts of alternative land uses (e.g. commercial, residential).

In urban regions, local land prices may be affected not only by market power but also by speculation effects. In urban areas, zoning plans might change more easily, therefore zoning schemes become less credible, and speculation about the future ability to develop farmland increases. If speculation effects are strong, they may dominate the market power effects investigated in this study. To allow for varying impacts of market power in different regions, we estimate separate hedonic pricing models for urban, semi-urban and rural regions, and test whether differences exist between these regions. Because our focus is on market power in farmland markets, we only consider sales between farmers. Although the market for farmland interacts with other submarkets for land, it can still be analyzed as a separate market, since the Spatial Planning Act segments the total land market. By including characteristics of land related to other market segments in our model, we still allow farmland prices to be influenced by other segments.

2.2 Theoretical model

Hedonic pricing models are often used to explain prices in property markets. According to these models, implicit prices of property characteristics can be revealed from observed prices of heterogeneous properties. These models assume that the implicit price of a characteristic is determined at the point where the marginal willingness to pay (WTP) of buyers equals the marginal willingness to accept (WTA) of sellers. With free entry and exit there is no excess surplus, so WTP also equals WTA. This standard situation that is assumed in most hedonic pricing models is shown in Figure 2.1. For values *Xi** and *Xi*** of a particular characteristic *i*, the slopes of the maximum WTP-curve and the minimum WTA-curve are equal, and at these points the maximum WTP and the minimum WTA also are equal. Furthermore, *P* is the hedonic pricing function[2], reflecting the resulting shadow prices of characteristic *i* at different levels of the characteristic.

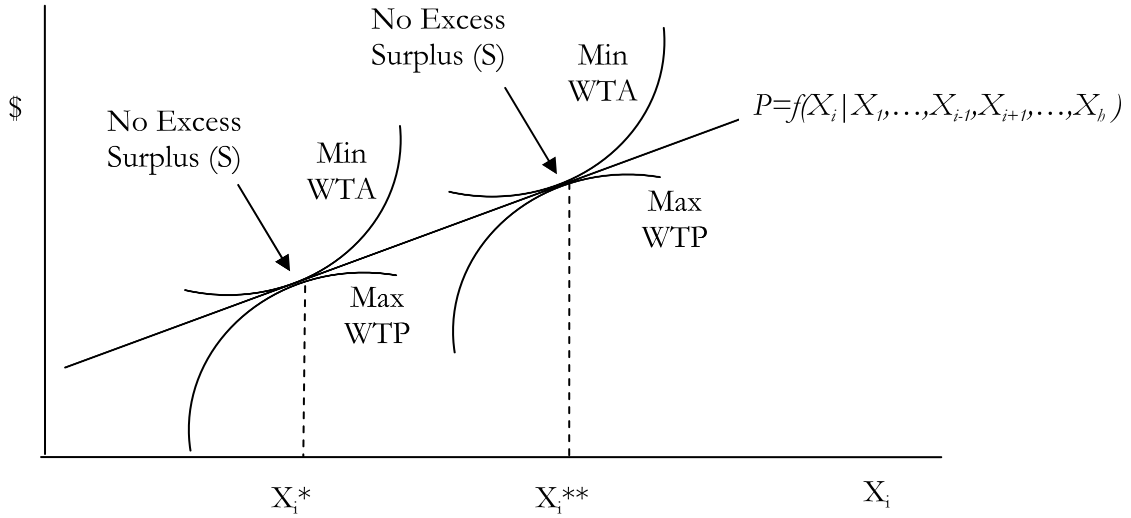

Figure 2.1 Hedonic Pricing Model without Excess Surplus.

A drawback of these original hedonic pricing models is that they do not take the influence of market power into account. In fact, standard hedonic pricing theory assumes perfect competition in explaining transaction prices. However, for farmland this assumption may not hold. Most farmland parcels for sale only attract the interest of a limited number of local buyers. For example, a parcel of land might have perfect characteristics according to a certain buyer, but he will not buy it if it is located 20 km from his farm[3]. In such a market there is not enough entry and exit for a competitive market equilibrium. In local land markets, the entry of prospective buyers with downward-shifted WTP functions and the entry of prospective sellers with upward-shifted WTA functions is limited, so there remains an excess surplus over which buyers and sellers can bargain.

King and Sinden (1994) introduced bargaining in hedonic pricing models. They determined the excess surplus over which buyers and sellers had to bargain through additional survey

[2] The hedonic pricing function does not have to take a linear form. So Figure 2.1 may be a simplification of the actual hedonic pricing function.

[3] The data used in this paper also indicates that a large majority of farmers buy land that is relatively close by. The data also show that in what we define as local markets in this paper there are on average, 20 sellers and 21 buyers.

information about the maximum WTP of buyers, and made some additional assumptions on the minimum WTA of sellers. Then, they determined the bargaining power by relating the actual price paid to the excess surplus. However, if only actual prices paid are available, but not WTA and WTP, this approach does not work. Harding, et al. (2003b) did not have survey information on WTP and WTA. However, they extended the hedonic pricing theory by explicitly allowing for bargaining power. In their empirical application on the housing market they estimated the bargaining power directly from the characteristics of the buyers and sellers. But they simply state that an excess surplus exists and do not put any effort into defining the size and the direction of the excess surplus.

The excess surplus as defined by Harding, et al. (2003b) is given in Figure 2.2. At the point *Xi** and *Xi***, the slopes of the minimum WTA and the maximum WTP-curves are equal. So, marginal benefits equal marginal costs, but yet there is a surplus. The positive surplus is divided between the buyer and the seller, depending on their bargaining power. Harding, et al. (2003b) assume that the deviation of the maximum WTP-curve from the hedonic pricing function is the same as the deviation of the minimum WTA-curve from the hedonic pricing function. In this paper we argue that these deviations in general depend on the number of buyers and sellers on the local market (market power), and that adjustments can be made to the general deviation based on the characteristics of the eventual buyer and seller on the market.

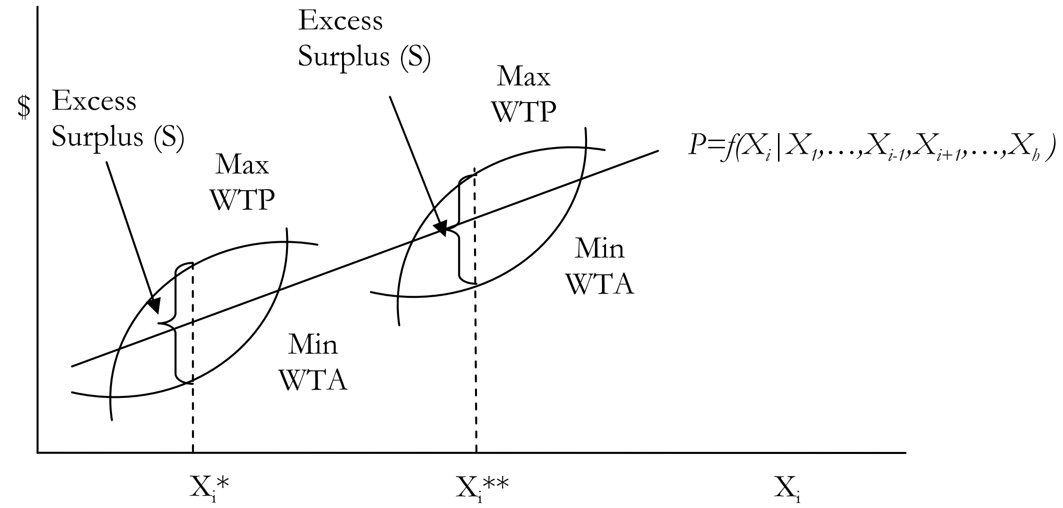

Figure 2.2 Hedonic Pricing Model with Excess Surplus.

More specifically, the excess surplus in this paper is determined by the market power. The more potential buyers there are, the less market power they have, and the bigger the chance that there are buyers who are willing to pay more (shifting WTP-curves up). The same argument holds for the sellers: more sellers results in less market power, and a greater chance that some sellers are willing to accept less (shifting WTA-curves down). Without knowing the maximum WTP and the minimum WTA of the eventual buyer and seller, it is not possible to determine the exact size and magnitude of the excess surplus. We estimate the deviation from the hedonic pricing function due to market power as the average of the WTP and the WTA at the point where the marginal WTP is equal to the marginal WTA. This deviation from the competitive market price is determined by the relative market power. This is illustrated in Figure 2.3.

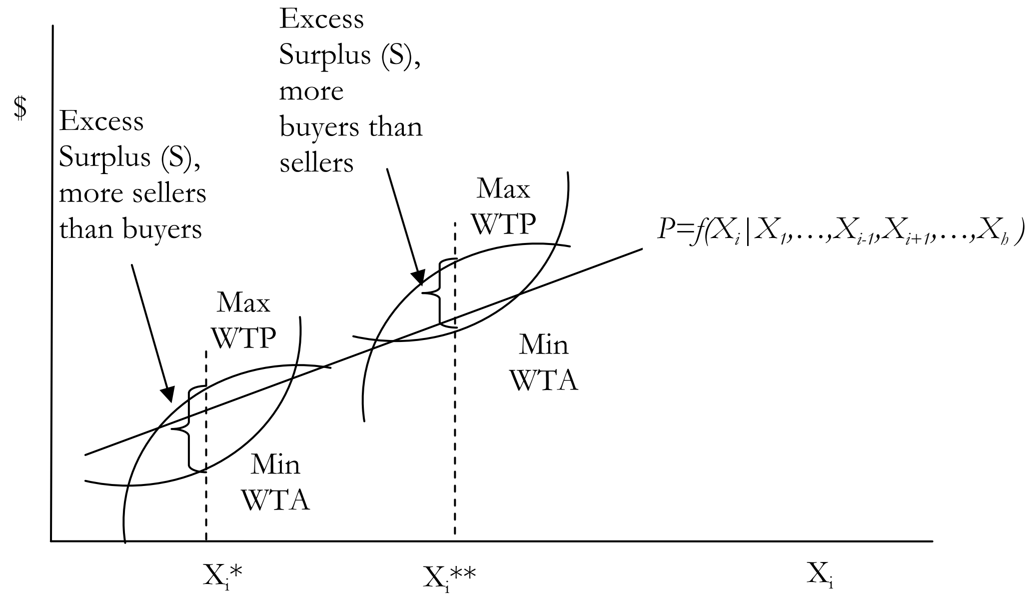

Figure 2.3 Hedonic Pricing Model with Excess Surplus and Market Power.

Our model is an extension of the Cournot model, which assumes that a decrease in the number of competing sellers increases the price. The competitive market price in the Cournot model is only attained if the number of sellers grows infinitely large. Stiglitz (1987) argues that the Cournot model does not necessarily hold if search costs are involved. A decrease in the number of competing sellers can also increase search costs, and with that prices could decrease. However, we assume these search costs play no role because markets are defined locally, and all potential buyers and sellers can find each other easily. As buyers are usually not interested in land for sale at locations far from their holdings, most buyers are from farms which neighbor the land for sale. And potential buyers are very likely to be the first ones to find out that their neighbor is intending to sell his land.

Similar to Harding, et al. (2003b), it is assumed that the personal characteristics of sellers and buyers cause parallel shifts in the hedonic pricing function. Whereas Harding, et al. (2003b) called these personal characteristics "bargaining power variables", we would rather use the term "personal characteristics" because some characteristics may indeed affect bargaining power, whereas others influence WTP and WTA directly. Furthermore, it is assumed that market power also causes a parallel shift in the hedonic pricing function. This means that attribute shadow prices are assumed not to interact with both the market form and the personal characteristics of buyers and sellers. Feenstra (1995) also assumed that price-cost markups in hedonic pricing models under imperfect competition do not interact with the other explanatory variables in the model.

Assume that the hedonic pricing function takes the following linear form:

$$P = Xs + M + C, \qquad [2.1]$$

where P is the price of the traded property on the local market; s denotes a vector of shadow prices of associated property characteristics X; M is the market power (determining the direction of the excess surplus); and C is the influence of the characteristics of the eventual buyer and seller. Replace

M in [2.1] by its proxy Nk ($k = 1,\ldots,K$, where K is the number of market power proxies), with an associated coefficient a_k and an error term e_a:

$$P = Xs + a_k N_k + e_a + C. \qquad [2.2]$$

C is described in the same way as in Harding, et al. (2003b) – as a function of the characteristics of the buyer and the seller:

$$C = C_{sell} b_{sell} + C_{buy} b_{buy} + e_b. \qquad [2.3]$$

This leads to:

$$P = Xs + a_k N_k + C_{sell} b_{sell} + C_{buy} b_{buy} + \varepsilon,$$
$$\text{where } \varepsilon = e_a + e_b. \qquad [2.4]$$

Furthermore, Harding, et al. (2003b) assumed symmetric effects of sellers' and buyers' characteristics on prices, so they could take care of possible biases caused by unobserved characteristics that are correlated with observed characteristics. Although unobserved characteristics might be a problem, we assume that some of the personal characteristics of sellers and buyers might influence not only the bargaining process but also the WTP of buyers and WTA of sellers directly. This implies that non-symmetric effects of the characteristics of sellers and buyers are expected. The second reason for allowing for non-symmetry is that the results are easier to interpret than the results from a model that corrects for potential omitted variable problems. So we estimate [2.4] and assume that the unobserved attributes are not correlated with the observed characteristics of buyers and sellers, rather than assuming symmetric effects of buyers' and sellers' characteristics.

2.3 Empirical specification

Several empirical issues arise in the estimation of the hedonic pricing function given by [2.4]. Since our focus is on market power in local land markets, it is first explained how local markets are defined, and how market power in them is measured. In the remainder of this section the choice of the functional form is discussed.

The size of local markets is determined by the distribution of the distances between the locations of the buyers and the locations of the parcels that were sold to them. From this distribution the distance that corresponds with the 90th percentile is chosen as the radius of the local market. Analyzing the data, we found that 90% of the agricultural buyers[4] are located within 6.7 km of the parcels they bought (see Table 2.1 for an overview of the distances between buyers and

[4] In this calculation only buyers whose physical location in rural areas could be assessed were taken into account. Some postal addresses refer to PO-boxes and not to the actual addresses of the farmers. Observations with addresses referring to PO-boxes could not be used.

the parcels they buy). Around each traded parcel, a buffer zone with a radius of 6.7 km is drawn to indicate a local market, resulting in a number of partly overlapping local markets equal to the number of transactions. For simplicity, we assumed this definition of a local market based on the 6.7 km radius to be uniform for all transactions. In other words, we did not vary the radius for different regions[5]. One can argue, of course, that the choice of 6.7 km is arbitrary, but we consider this distance to be manageable for farmers to operate their land on a daily basis. It should also be noted that there is a tradeoff in choosing the radius for local markets. If a large radius is chosen the local aspect might be lost, but if a small radius is used (potential) buyers and sellers may be left out. In Section 2.5 of the paper we therefore indicate how sensitive our results are to this definition of a local market.

Table 2.1 Distance Between Buyers and the Parcels They Buy.

Percentage of buyers located within the given distance	Distance in meters
50%	642
70%	1,442
80%	2,639
90%	6,697
95%	17,282
100%	205,841

Given the definition of local markets, a subsequent empirical issue is the construction of proxy variables N_k for market power. Market power is determined by the numbers of (potential) buyers and sellers in a local market. Based on this, three different proxies were considered, one of which is used in the empirical model:

$$N1 = (NAS - NAB) / (NAS + NAB)$$
$$N2 = (NAS - NPB) / (NAS + NPB)$$
$$N3 = (NAS / NPB) - 1) \text{ if } NAS >= NPB$$
$$\text{and } 1 - (NPB / NAS) \text{ if } NAS < NPB,$$

where *NAS* and *NAB* are respectively the number of actual sellers and buyers in 2003; and *NPB* denotes the number of potential buyers in 2003. The number of actual sellers (buyers) in each local market was determined by the sum of all farmers who sold (bought) land in 2003 and were located in the buffer zone of 6.7 km around each parcel. Because local markets can partly overlap, the number of actual sellers and actual buyers frequently differs within each local market.

Proxy N_1 defines market power as the difference between the numbers of actual sellers and buyers, relative to the sum of actual sellers and buyers. It is positive when there are more sellers than buyers, negative the other way around, and zero when the numbers of buyers and sellers are equal.

However, using the numbers of actual buyers and sellers in this proxy has one potential disadvantage. Both numbers do not take into account potential buyers and potential sellers who were active on the market but who did not succeed in either buying or selling. If this is the case for

[5] This assumption was supported by inspection of the data, showing that, on average, the numbers of sellers and buyers in urban, rural and semi-urban regions did not differ much.

both market parties, it still might not be that problematic since taking the difference between buyers and sellers may cancel out this effect. However, we expect that this problem arises especially for buyers. More farmers may have bid for a certain piece of land, but in the end only one is observed to have bought the parcel. For sellers it could theoretically be the case that they tried to sell some land but did not succeed because of lack of buyers, but we think that given the high demand for land in the Netherlands, most farmers who want to sell land are able to do so, so that the number of potential sellers equals the number of actual sellers.

To overcome this problem, we defined proxy N_2 that is similar to N_1 except that we now use the number of potential buyers (*NPB*) instead of the number of actual buyers (*NAB*). *NPB* is assessed in the following way. First, a probit model is estimated in order to assess what farm characteristics determine whether farmers bought parcels or not (see Appendix 2.1 for the specified probit model and estimation results). Farmers who are located within a circle drawn around each parcel that was sold are taken into account as potential buyers on that local market. After estimating this probit model, for each farmer in a local market the probability of buying land can be predicted. Summing these predicted probabilities for all farmers in a local market gives an indication of the total number of potential competing buyers in that local market.

Proxy variable N_3 is also based on actual sellers (*NAS*) and potential buyers (*NPB*), but here ratios of sellers to buyers and sellers to buyers are used. This also results in a variable that is zero if the numbers of buyers and sellers are equal, positive if there are more sellers than potential buyers, and negative if there are more potential buyers than sellers. So, all market power proxies are assumed to have a negative effect on the transaction price. The main difference with this proxy and proxies N_1 and N_2 is that in N_3 only ratios of sellers and buyers play a role, whereas in the first two the absolute difference in market parties, relative to the total sum of sellers and buyers, is used.

A second specification issue is the choice of the functional form. Economic theory gives little guidance in the choice of functional form for hedonic pricing studies (Taylor, 2003). Economic restrictions only apply to the price elasticities of supply and demand. However, these restrictions cannot be used as supply and demand curves are both unobserved (Cassel and Mendelsohn, 1985). The linear functional form has the disadvantage that it suggests parcel characteristics can be easily repackaged, so that arbitrage will prevent the existence of non-linearities (Rosen, 1974). However, in the land market, repackaging parcel characteristics is not possible, therefore non-linearities can occur. On the other hand, the introduction of empirically unnecessary non-linearities may 'over-parameterize' the problem, resulting in less precise estimates (Rasmussen and Zuehlke, 1990). Based on these findings and because we have many parameters to estimate (on account of the high number of explanatory variables), we use a linear functional form, with transformations on some explanatory variables. The dependent variable is not transformed because we need to be able to test for symmetry in buyers' and sellers' characteristics. Also, maintaining symmetry is important for the measurement of the impact of the market power proxies, so that on the local market the impact of a relatively high number of sellers as opposed to buyers has a similar impact as a relatively high number of buyers as opposed to sellers.

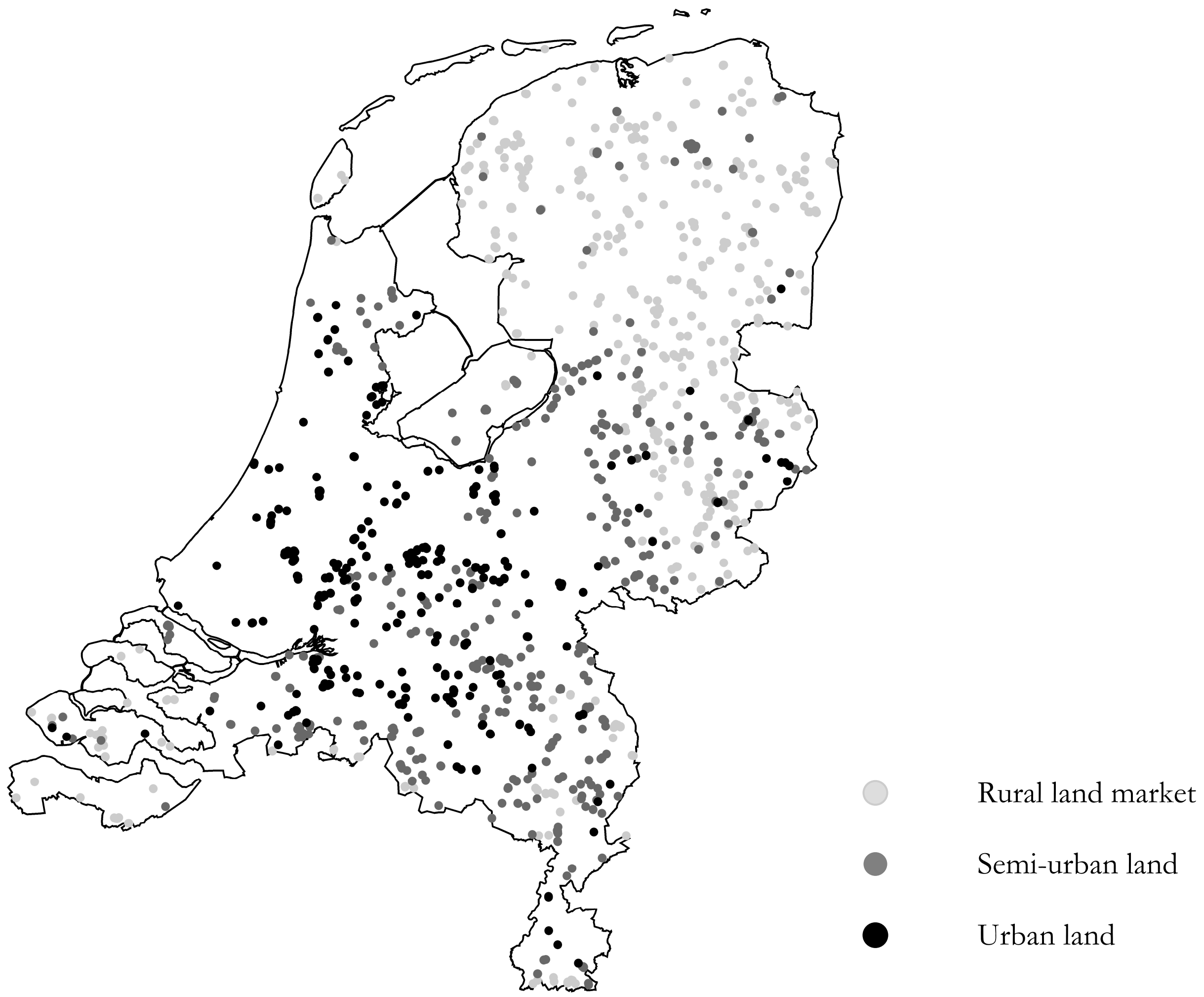

Figure 2.4 Location of Parcels Included in Hedonic Pricing Model.

2.4 Data and variables

The most important data source was the Cadastral Land Sales Database[6] that contains information on land transactions, transaction prices, and the location of each parcel sold in the Netherlands. From the Cadastral Land Sales Database we obtained the transaction prices per hectare, which we used as the dependent variable in the hedonic pricing model. An overview of all the parcels taken into account in the urban, semi-urban and rural land markets is given in Figure 2.4. This selection of transactions was based on the following criteria: (a) both sellers and buyers of land were farmers; (b) the transaction took place in 2003; (c) the indicated price was reliable[7]; (d) no buildings were present

[6] Cadastral data is contained in the Infogroma database, which contains all transactions of properties that are of importance to Government Services for Land and Water Management (*Dienst landelijk Gebied, DLG*) in the Netherlands. These are parcels with a green purpose either before or after the transaction took place. Green purposes are: agriculture, nature, and recreation. For example, farm land sold to the municipality for industrial purposes is included in this database, whereas housing transactions are not.

[7] In the database there is an indicator for the reliability of a transaction price. Reliability is based on official transaction documents and specific characteristics of the transaction.

on the parcel; and (e) it was possible to link information from all other databases to the transaction data either in a Geographical Information System (GIS) based on the spatial location or in other ways. In total 947 observations of farmland transactions were used[8]. An overview of all databases linked to the transaction data is given in Appendix 2.2. Table 2.2, with summary statistics for all variables included in the model, also refers to these databases.

An important variable included in the model was the market power proxy described in Section 2.3. In the original model we included proxy N_1. In alternative models we also considered proxies N_2 and N_3. Characteristics of sellers and buyers were included in the model to account for bargaining power (Harding et al. 2003b; King and Sinden, 1994), and direct effects on WTP and WTA. These variables were taken from a database containing census data of all farmers in the Netherlands[9]. Similar to Harding, et al. (2003b) we included age, gender, whether or not the farmer had children, and the number of times buyers and sellers had been involved in transactions in the period 1998 – 2002. Similar to King and Sinden (1994), we included the distance from the location of the seller and buyer to each parcel that was sold. We specified this variable as real distance, whereas King and Sinden (1994) used dummies for distance[10]. Another characteristic included to account for bargaining power is whether the farm was a personal enterprise or a partnership. This variable is related to farm size, because personal enterprises are mostly smaller than partnerships.

For the choice of other variables in the model, we mainly followed the literature on hedonic pricing models, in particular those studies that focus on farmland prices under urban pressure. We also included some variables specific to the Dutch situation.

To represent agricultural profitability of land, we included a standardized Dutch size unit (*Nederlandse Grootte Eenheid, NGE*) per ha, which corresponds to a size unit per ha specified in Cavailhes and Wavresky (2003). Furthermore, a specification of the farm type was included in the model as an indicator of the profitability of land. The farm type grazing farm animals was specified as a dummy variable for both sellers and buyers, and other farm types as a group were used as the reference level. We also included seven dummies for different soil types. The suitability of certain agricultural activities is often related to soil type. Parcel size was included since we expect farmers to have a preference for larger parcels since they can be utilized more effectively.

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[8] In total, 15321 transactions were recorded in the Infogroma database in 2003. However, these also include land bought for nature, residential, infrastructural, and commercial purposes. In total, 2537 transactions between farmers were recorded, with an average price of €161,727 per ha. After excluding transactions of parcels with buildings on them, 1965 transactions remained, with an average price of €95,271 per ha. Selecting only those transactions with sale prices indicated to be reliable resulted in 1439 remaining transactions with an average price of €49,249. Finally, transactions that were registered as farmland in the Parcel Registration database were selected. This resulted in the final 947 transactions with an average price per ha of €42,163.

[9] Only farms that are larger than 3 NGE are included in this census data. 1 NGE represents €1390 of gross value added.

[10] The definition of some variables is somewhat different from those used in other studies, depending on the availability of the data.

Table 2.2 Summary Statistics of Variables Included in the Hedonic Pricing Models (n = 947).

Variable	Database nr[a]	Mean	SD	Min	Max
Dependent variable					
Transaction price per ha (€10,000)	1	4.2163	7.5310	0.11	144.62
Transaction price per ha (€10,000), rural areas	1	3.0190	2.2542	0.34	30.54
Transaction price per ha (€10,000), semi-urban areas	1	4.7192	10.8386	0.11	144.62
Transaction price per ha (€10,000), urban areas	1	5.5683	7.3599	0.12	85.11
Market power indicators					
N_1 = proxy 1 for market power	1,2	-0.0500	0.1645	-0.64	1.00
N_2 = proxy 2 for market power	1,2	-0.0097	0.1861	-0.76	0.75
N_3 = proxy 3 for market power	1,2	-0.0622	0.6791	-6.50	5.88
Number of buyers on local markets	1,2	21.8057	12.8217	0.00	120
Number of sellers on local markets	1,2	19.9307	12.3140	1.00	94
Personal characteristics sellers and buyers					
Kidsbuy (=1 if buyer has children aged above 15, 0 otherwise)	2	0.0232	0.1507	0.00	1.00
Kidssell (=1 if seller has children aged above 15, 0 otherwise)	2	0.1331	0.3398	0.00	1.00
Genderbuy (=1 if farm operator at buyers farm is a male, 0 otherwise)	2	0.9335	0.2493	0.00	1.00
Gendersell (=1 if farm operator at seller farm is a male, 0 otherwise)	2	0.9293	0.2565	0.00	1.00
Agebuy (age of oldest farm operator at buyers farm)	2	50.9155	11.1107	24.00	84.00
Agesell (age of oldest farm operator at sellers farm)	2	53.9060	11.7594	23.00	95.00
Personalbuy (=1 if farm of buyer is a personal enterprise, 0 otherwise)	2	0.1267	0.3328	0.00	1.00
Personalsell (=1 if farm of seller is a personal enterprise, 0 otherwise)	2	0.0560	0.2300	0.00	1.00
TradedBeforebuy (number of times the buyer has been involved in transactions in the period 1998-2002)	1,2	0.8511	2.6341	0.00	64.00
TradedBeforesell (number of times the seller has been involved in transactions in the period 1998-2002)	1,2	0.4583	0.8993	0.00	8.00
Distancebuy (distance in km between buyer and parcel)	1,2	5.8001	18.5110	0.00	201.65
Distancesell (distance in km between seller and parcel)	1,2	4.5884	19.4612	0.00	224.04
Agricultural profitability					
NGEperHabuy (total NGEs per ha for buyer)	2	0.0114	0.0392	0.00	0.84
NGEperHasell (total NGEs per ha for seller)	2	0.0035	0.0072	0.00	0.10
GrazingFarmAnimalsbuy (=1 if the buyer's farm type is grazing farm animals, 0 otherwise)	2	0.6431	0.4793	0.00	1.00

(Table continued on next page)

(Table continued)

GrazingFarmAnimalssell (=1 if the seller's farm type is grazing farm animals, 0 otherwise)	2	0.5543	0.4973	0.00	1.00
Peat (=1 if soil type is peat, 0 otherwise)	9	0.1119	0.3154	0.00	1.00
Loam (=1 if soil type is loam, 0 otherwise)	9	0.0222	0.1473	0.00	1.00
Heavy clay (=1 if soil type is heavy clay, 0 otherwise)	9	0.0950	0.2934	0.00	1.00
Light clay (=1 if soil type is light clay, 0 otherwise)	9	0.0750	0.2635	0.00	1.00
Heavy sabulous clay (=1 if soil type is heavy sabulous clay, 0 otherwise)	9	0.1045	0.3061	0.00	1.00
Light sabulous clay (=1 if soil type is light sabulous clay, 0 otherwise)	9	0.0876	0.2829	0.00	1.00
Sand (=1 if soil type is sand, 0 otherwise)	9	0.5776	0.4942	0.00	1.00
Current land use indicators					
Distance to nearest residential area (km)	4	1.2865	0.8962	0.00	7.92
Distance to nearest industrial park (km)	4	1.9808	1.1929	0.03	8.83
Distance to nearest recreational zone (km)	4	1.1885	0.7030	0.04	6.05
Distance to nearest nature (km)	4	0.6752	0.7454	0.01	7.43
Distance to nearest wet nature (km)	4	3.6317	2.8358	0.07	20.21
Distance to nearest greenhouse horticulture (km)	4	7.3019	7.1101	0.02	43.06
Distance to nearest fresh water (km)	5	1.0728	0.7803	0.02	4.53
Distance to nearest highway (km)	10	6.6603	5.1030	0.06	28.85
Other variables					
Reilly index	4,6	0.0099	0.0762	0.00	2.35
National Ecological Network (EHS) (=1 if parcel is located within the EHS, 0 otherwise)	7	0.1088	0.3115	0.00	1.00
Parcel size (ha)	3	3.4413	3.0132	0.13	26.69
Land is rented (=1, 0 otherwise)	1	0.0433	0.2036	0.00	1.00
Buyer and seller are family (=1, 0 otherwise)	1	0.1183	0.3231	0.00	1.00
Land-use planning obligatory (=1 if farm is forced to participate in a land-use planning program, 0 otherwise)	8	0.1869	0.3900	0.00	1.00
Land-use planning voluntarily (=1 if farm can voluntarily participate in a land-use planning program, 0 otherwise)	8	0.2355	0.4245	0.00	1.00

[a] For the description of the database see Appendix 2.2. The number in this column refers to Appendix 2.2.

In urban areas, prices of farmland may be affected by speculation by farmers due to future changes in zoning. Therefore we included the Reilly index (Shi et al. 1997), which is a measure for the level of urbanization as a proxy variable to capture speculation effects on farmland prices. The Reilly index for parcel i is given by

$$R_i = \sum_{k=1}^{K} \frac{Pop_k}{d_{i,k}^2}, \qquad [2.5]$$

where Pop_k is the number of inhabitants of urban area k; and $d_{i,k}$ is the distance between parcel i and the k-th urban area. In this measure, urban areas within a distance of 100 km from each parcel that was sold were taken into account. The Reilly index is also used to distinguish between urban, semi-urban, and rural markets.

In addition, the influence of other types of land use was included. Therefore, distance measures were defined to the following land uses; residential, industrial, recreational, nature, wet nature, greenhouse horticulture, fresh water, and highways.

Furthermore, a dummy was specified to indicate whether or not a parcel was located within the National Ecological Network (*Ecologische Hoofd Structuur, EHS*). This is the land assigned to nature and wildlife uses. The federal government mainly tries to buy the assigned parcels. Another dummy was included to indicate long-term lease agreements on land. In the Netherlands, lessees are protected by law, which means that low lease prices are guaranteed and that leaseholds cannot be aborted prematurely without the lessees' consent. So leaseholds negatively affect land values. Also, two dummies were included to indicate whether a parcel was part of a land-use planning project. Some of these projects have forced farmers to exchange land or sell land, and in others farmers could voluntarily exchange parcels with neighbors to obtain parcels closer to their farm. Furthermore, about 70% of all governmental purchases of land for nature purposes are realized within these land-use planning projects.

Finally, a dummy was included to indicate whether or not buyers and sellers were family. If they were family, prices were expected to be lower. Furthermore, market power and personal characteristics are only allowed for if there is no family relationship between the buyer and seller.

Other than the dummies indicating that land was located within the National Ecological Network or within land-use planning projects, we did not include zoning variables, because all farmland transactions in this research were restricted to agricultural use according to the applicable zoning schemes.

2.5 Empirical results

Before discussing the estimation results for market power, personal characteristics, and other shadow prices of parcel characteristics, we now consider a number of specification issues and more general findings. First, since we expect different impacts of market power in different regions, the hedonic pricing model was estimated for three different levels of urbanization, based on the Reilly index. A high Reilly index indicates a high level of urbanization. We defined areas with a Reilly index over 0.010 as urban, areas with a Reilly index under 0.005 as rural, and areas with a Reilly index in-between as semi-urban. A Chow-test, with a test statistic value of 3.1585 exceeding the $F_{827;0.01}^{40}$ critical value of 1.61, indicated clear differences between these regions so that it is better to allow for parameter heterogeneity than to assume constant parameters. This indicates that the impacts of some explanatory variables on farmland prices differ between urban and rural areas. This also follows from the model estimates (Table 2.3). In rural areas, farm activities are still important, whereas speculation plays almost no role. However, in urban farmland markets prices are not driven by farm activities, but mainly by speculation. About 76% of the total variation could be explained in these markets and the Reilly index was the single largest contributor to the high percentage of variation explained. Furthermore, prices in semi-urban areas are hard to explain. Only 16% of the total variation in the prices in these areas could be explained in this model.

Table 2.3 Regression Results of the Hedonic Pricing Functions of Farm Land Markets.

Dependent variable: Price per ha (€10,000)	Rural model Reilly <0.005 (n = 393)	Semi-urban model 0.005<= Reilly <0.010 (n = 328)	Urban model Reilly >= 0.010 (n = 226)
Market power if seller and buyer are not family, 0 otherwise (N1), Radius local market: 6.7 km	-2.3751** (-2.46)	-6.9074 (-1.50)	2.2467 (1.12)
Kidsbuy if seller and buyer are not family, 0 otherwise	0.5368 (1.24)	-0.7630 (-0.45)	-0.2162 (-0.14)
Kidssell if seller and buyer are not family, 0 otherwise	0.7491** (2.36)	7.2144 (1.44)	0.6942 (1.02)
Genderbuy if seller and buyer are not family, 0 otherwise	-0.0722 (-0.26)	-0.2965 (-0.18)	-0.2640 (-0.27)
Gendersell if seller and buyer are not family, 0 otherwise	0.1071 (0.44)	4.6651 (1.26)	0.8900 (0.95)
Agebuy if seller and buyer are not family, 0 otherwise	-0.0206* (-1.90)	0.0347 (0.92)	-0.0773** (-2.33)
Agesell if seller and buyer are not family, 0 otherwise	-0.0108 (-1.35)	0.0302 (0.59)	-0.0921** (-2.31)
Personalbuy if seller and buyer are not family, 0 otherwise	2.0095*** (2.72)	2.6053 (1.35)	4.1582*** (3.33)
Personalsell if seller and buyer are not family, 0 otherwise	-0.2191 (-0.31)	-0.2622 (-0.07)	5.9702** (2.54)
TradedBeforebuy if seller and buyer are not family, 0 otherwise	-0.0598 (-1.29)	-0.4883 (-1.47)	-0.1586 (-1.14)
TradedBeforesell if seller and buyer are not family, 0 otherwise	-0.1008 (-1.02)	-1.1336 (-1.32)	-0.2898 (-1.55)
Distancebuy if seller and buyer are not family, 0 otherwise	0.0070 (0.50)	-0.0147 (-0.43)	0.0463* (1.67)
Distancesell if seller and buyer are not family, 0 otherwise	0.0090 (0.68)	0.0094 (0.46)	0.1844* (1.87)
NGEperHabuy if seller and buyer are not family, 0 otherwise	1.5435 (0.79)	-4.6715 (-0.19)	-28.7638*** (-2.67)
NGEperHasell if seller and buyer are not family, 0 otherwise	-10.5301 (-0.81)	186.0091 (0.86)	82.9490 (0.76)
GrazingFarmAnimalsbuy if seller and buyer are not family, 0 otherwise	-0.5053** (-2.34)	2.8206 (1.04)	-1.3748** (-1.99)
GrazingFarmAnimalssell if seller and buyer are not family, 0 otherwise	-0.3772* (-1.80)	-2.5611 (-1.38)	1.2922* (1.76

(Table continued on next page)

(Table continued)

Peat	-0.4886	-0.3666	-0.8280
	(-1.55)	(-0.26)	(-0.81)
Loam	-0.0780	2.8264	0.9999
	(-0.09)	(0.95)	(0.76)
Heavy clay	-0.0514	-0.7271	0.6077
	(-0.10)	(-0.45)	(0.57)
Light clay	0.1058	8.8305	-1.2267
	(0.30)	(1.21)	(-0.88)
Heavy sabulous clay	0.6956	-0.6198	-0.1625
	(1.56)	(-0.49)	(-0.15)
Light sabulous clay	-0.3906	0.4030	-1.4429
	(-1.26)	(0.27)	(-1.08)
Sand	0.4281	0.7046	-0.3037
	(1.26)	(0.32)	(-0.29)
1 / distance to nearest residential area (km)	-0.1506**	0.0280***	-0.0778
	(-2.31)	(5.61)	(-0.78)
1 / distance to nearest industrial park (km)	0.0226	-0.0927	0.1136
	(0.76)	(-0.27)	(0.62)
1 / distance to nearest recreational area (km)	0.4236*	-0.1928	0.2613*
	(1.81)	(-1.01)	(1.95)
1 / distance to nearest nature area (km)	-0.0085	0.0107	-0.0006
	(-1.23)	(0.26)	(-0.02)
1 / distance to nearest wet nature (km)	-0.2005**	-0.2289	0.1974
	(-2.36)	(-0.44)	(0.86)
1 / distance to nearest greenhouse horticulture (km)	0.2684**	0.0514	0.1353
	(2.32)	(0.88)	(1.62)
1 / distance to nearest fresh water (km)	0.0167	-0.1452	-0.0750
	(0.28)	(-1.17)	(-1.24)
1 / distance to nearest highway (km)	-0.3548***	-0.4215	0.0055
	(-2.62)	(-1.40)	(0.02)
Reilly index	75.8890	395.7133	27.4892***
	(0.78)	(0.56)	(10.57)
EHS (parcel within EHS = 1, 0 otherwise)	-0.8957**	-3.1494	-0.5083
	(-2.49)	(-1.47)	(-0.83)
Parcel size (ha)	-0.0113	-0.1264	0.0463
	(-0.36)	(-0.43)	(0.29)
Land is rented (=1, 0 otherwise)	-0.1828	-4.7392**	-1.5490*
	(-0.32)	(-2.00)	(-1.82)
Buyer and seller are family (=1, 0 otherwise)	-2.6712***	6.1314	-8.9309**
	(-2.89)	(0.89)	(-2.26)
Land-use planning obligatory (=1, 0 otherwise)	-0.4231*	-1.2727	-1.6134***
	(-1.78)	(-0.99)	(-2.96)
Land-use planning voluntarily (=1, 0 otherwise)	-0.0260	-1.1509	-0.6411
	(-0.14)	(-1.06)	(-1.11)
Constant	4.2956***	-5.5728	12.7091***
	(3.62)	(-0.69)	(3.00)
R^2	0.3527	0.1614	0.7571

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels. The numbers in parentheses are t-statistics.

Second, given the large number of explanatory variables in the model, we checked for multicollinearity using Variance Inflation Factors (VIFs) (Hill and Adkins, 2001). The highest VIF was found for the dummy for soil type 'sand' in the urban model, i.e. 6.78 which is still lower than the often suggested critical value of 10. In all three specifications (rural, semi-urban and urban), soil types had the highest VIFs, which can be explained by the spatial patterns in soil types and in other explanatory variables in the model. From these results, it can be concluded that multicollinearity is not a problem.

Third, given the spatial nature of the data, it is important to test for spatial dependence. Spatial dependence can be incorporated as spatial lag dependence and as spatial error dependence. Spatial lag dependence may exist when sellers and buyers use prices of parcels that were recently sold in the neighborhood as a reference point. Spatial lag dependence is tested for using the Lagrange Multiplier test (LM-lag) (Anselin, 1988a). Spatial error dependence arises if there is spatial interaction in the error term due to unobserved or omitted variables that have spatial patterns. Spatial autocorrelation is tested for using Moran's I statistic, derived from a statistic developed by Moran (1948) and using the Lagrange Multiplier test (LM-error) suggested by Burridge (1980)[11]. The test results show that there is not much evidence of any type of spatial dependence in our model (see Appendix 2.3). A large amount of spatial information is directly included in the explanatory variables. The more spatial information directly taken into account, the smaller the potential omitted variable bias and the smaller the spatial dependence among the errors. However, we did find evidence of heteroscedasticity, so we used White's correction to obtain robust standard errors (White, 1980).

2.5.1 Market power

On the basis of our model findings (Table 2.3), we can conclude that market power effects are present in rural farmland markets. This can be expected, because in these areas speculation does not dominate the land price. If speculation takes place in the land market, farmers are no longer the only buyers of land, so the theory of market power in the local land market no longer applies, as is observed in more urban land markets.

The parameter for the first proxy of market power, based on a radius of local land markets of 6.7 km, is included in Table 2.3. In rural farmland markets, this parameter is significant ($p<0.05$) and has the expected negative sign. This sign was expected because N1 increases when the relative number of sellers compared with the number of buyers increases. If there are more sellers than buyers, sellers have relatively less market power and sales prices decrease. If, for example, the number of sellers is set at 20 and the number of buyers decreases from 20 to 15, then the transaction price decreases by €3,393 per ha. Compared with the average price of farmland in rural

[11] In order to run these tests, spatial weighting matrices were specified a priori. We chose five different specifications. The first two matrices are based on inverse distance relationships (e.g. Bell and Bockstael (2000) and Patton and McErlean (2003)). The weights in the third and the fifth matrix have the value 1 if the distance between parcels is smaller than 1 km and 6.7 km respectively, and the value 0 otherwise. Bell and Bockstael (2000) use similar constructions in their model. Note that, for the construction of the fifth weighting matrix, a similar distance is used as for the specification of local markets. The fourth weighting matrix has a spatio-temporal structure (see Pace, et al. (1998)).

areas (€30,190 per ha), this is an 11% decrease. So, local market power is an important element in explaining rural farmland prices.

Table 2.4 Estimates of Different Market Power Proxies incorporated in Hedonic Pricing Functions.

	Rural model	Semi-urban model	Urban model
Market Power proxy N1, Radius of local market: 6.7 km	-2.3751** (-2.46)	-6.9074 (-1.50)	2.2467 (1.12)
Market Power proxy N2, Radius of local market: 6.7 km	-1.3127* (-1.73)	-4.2704 (-1.14)	-0.0022 (-0.00)
Market Power proxy N3, Radius of local market: 6.7 km	-0.4646* (-1.81)	-1.4642 (-1.42)	0.1141 (0.17)
Market Power proxy N1, Radius of local market: 2.6 km	-0.4141 (-1.41)	-0.8915 (-0.54)	-0.8923 (-0.76)
Market Power proxy N2, Radius of local market: 2.6 km	-1.3767*** (-2.64)	-3.5301 (-1.16)	-1.1479 (-0.87)
Market Power proxy N3, Radius of local market: 2.6 km	-0.1395* (-1.83)	-0.0954 (-0.25)	-0.1997 (-0.79)
Market Power proxy N1, Radius of local market: 1.4 km	0.1283 (0.37)	1.4231 (0.63)	-0.1966 (-0.20)
Market Power proxy N2, Radius of local market: 1.4 km	-0.4994* (-1.70)	-0.1755 (-0.19)	-0.5520 (-0.46)
Market Power proxy N3, Radius of local market: 1.4 km	0.0207 (0.24)	0.1496 (0.32)	-0.1201 (-0.58)

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels. The numbers in parentheses are t-statistics. The sizes of local markets correspond with the 90th percentile (6.7 km radius), 80th percentile (2.6 km) and 70th percentile (1.4 km) of the distribution of the distance between buyers and the parcels they buy (see also Table 2.1).

The same model was estimated with different proxies for market power and different size definitions of local markets. The results are included in Table 2.4. It appears that the results are somewhat sensitive to the choice of the proxy (N_1, N_2 *or* N_3) and to the definition of local markets. However, in most cases (6 out of 9), our market power proxy is significant in the rural model. The strongest evidence of market power was found for proxies that were based on the number of sellers and buyers in local markets with a radius of 6.7 km (90th percentile). Based on that choice, three out of three market power proxies were significant. For the radius of 2.6 km (80th percentile), two out of three proxies were significant in the rural model, and for the radius of 1.4 km (70th percentile), only one out of three proxies was significant. We also tried the 60th and 50th percentile but, in those cases, the market power proxies were not significant. Furthermore, in none of the semi-urban and urban models are market power proxies significant. From these results, it follows that our initial definition of a local market with a radius of 6.7 km was a reasonable one.

2.5.2 Personal characteristics

With respect to the personal characteristics of sellers and buyers in the rural land market, only 5 out of 16 parameters are significantly differently from zero ($p<0.10$). So there is some evidence for the effect of personal characteristics of sellers and buyers on farmland prices. We expect influences of personal characteristics, because farmers generally do not hire professional brokers. We found a significant ($p<0.05$) positive effect on land prices if the seller has children, which could mean that sellers bargain harder over the price if they have a potential successor. We also found a significant ($p<0.10$) negative effect of the age of the buyer on the price. Given that older people have more experience, it is expected that older farmers can bargain the price down more than younger farmers. Furthermore, we found a significant positive effect on land prices if the buyer is a personal enterprise. Because personal enterprises are mostly associated with smaller farms and smaller farms might have less bargaining power, it is expected that these farmers are less successful in bargaining the price down than larger farmers.

Personal characteristics also play a role in the explanation of farmland prices in urban areas. In this model, 9 out of 16 parameters were significant ($p<0.10$). However, we found no evidence for symmetry in the characteristics age and personal enterprise, as assumed by Harding, et al. (2003b). Personal characteristics might influence bargaining power, as reasoned by Harding, et al. (2003b), but, on the other hand, they may also directly influence the WTP or WTA. For example, when considering the age of the farm operator, we expect it to be positively correlated with bargaining power, implying a negative sign for buying farmers and a positive sign for selling farmers. However, for the latter we obtained a significant ($p<0.05$) negative sign, violating symmetry. The negative sign can be explained by the desire of some older sellers to sell their land quickly because of retirement. These sellers might be willing to accept a lower price for their land. Younger sellers can wait until they get a higher price for their land. For the bargaining power variables related to farm size we also rejected symmetry. For the farm size indicator, $Personal_p$, the parameters for both characteristics of the buyers and the sellers are significant and positive, clearly violating symmetry. If the buyer is a personal enterprise, then indeed a higher land price is paid. However, the parameter for the sellers is also positive. What may play a role here is the number of hectares and parcels sold. If the seller is not a personal enterprise, it can be expected to be a large farm that may sell more land and more parcels. This is negative for the bargaining power of the seller, resulting in the positive sign for personal enterprise. Similar to the rural model, we find that land prices for buying farms with the farm type grazing farm animals are generally lower. But, surprisingly, we find a significant ($p<0.10$) positive effect for selling farms. Also, we find other signs than expected for the impact of NGE per ha and for the distance between the parcel that was sold in the transaction and the location of the buyer and the seller. This again indicates that farmland prices in urban areas are driven to a lesser extent by characteristics of the land that are important for farming activities.

2.5.3 Shadow prices of parcel characteristics

In the urban model, the Reilly index explained by far the largest proportion of all the variation in the land prices. So, similar to Shi, et al. (1997), Cavailhes and Wavresky (2003), Shonkwiler and Reynolds (1986), Plantinga, et al. (2002) we found that there is a premium on farmland in more urbanized areas. However, in rural areas we do not find evidence of speculation closer to residential and commercial areas. On the contrary, the Reilly index in rural areas is not significant, and nearby residential areas and highways have a negative impact on farmland prices. For example, if the distance between a parcel in a rural area and its nearest residential area increases by 1 km, this leads to a price increase of €910 per ha on average. It indicates that negative externalities (e.g. mobility and environmental effects) take place in these areas. With respect to highways, one might have expected a positive impact due to speculation (many industrial parks are built along highways). However, our findings indicate that an increase of the distance to the nearest highway by 1 km on average increases the price by €80. This indicates that negative externalities are imposed by highways on farmland. Moreover, nearby highways make it harder for farms to extend their farming area in the future.

Furthermore, we find that indicators for the profitability of land such as NGE per ha, farm type, and soil type have only a minor impact on farmland prices, even in rural areas. Most likely this is caused by technical improvements in agriculture.

With respect to surrounding land use, we found that the nearness of recreational areas has a positive impact on land prices in both urban and rural areas. For farmers close to recreational areas, it is easier to start up additional non-agricultural activities on their land such as campsites. Furthermore, greenhouse horticulture has a significant ($p<0.05$) positive impact in rural areas, due to speculation on future zoning, because greenhouse horticulture is not allowed everywhere in the Netherlands. In rural areas, we also find a significant negative impact of wet nature located close to farmland. This has to do with the higher groundwater level close to wet nature.

Pressure on farmland in rural areas is related the development of nature and wildlife areas. If the farmland was located within the EHS, significantly ($p<0.05$) lower prices were offered. The reason for the lower prices is that land zoned within the EHS does not have potential future farm or urban use, which drives the speculative value of the land down.

For land that was included in land-use planning projects there is a significant ($p<0.05$) negative impact on land prices in both urban and rural areas if the redistribution of land was mandatory. This effect is as expected, because if others decide on the land-use planning in the area, the farmer's interests might not be best served. But, even if farmers participated voluntarily, the effect of the land-use planning project was insignificant.

Finally, selling land between family members in both rural and urban areas has a negative impact on farmland prices, as expected[12]. However, unlike the model for rural farmland, in urban areas we find a significant ($p<0.10$) negative impact of long-term leaseholds on land prices.

2.6 Conclusions

The hedonic pricing model was used to investigate the impact of market power in local farmland markets. In this research we found evidence of market power in local rural farmland markets. This means that there is not perfect competition in the rural farmland market, and prices deviate from competitive market prices leading to welfare losses for buyers and sellers. Although the results are

[12] We also estimated the model without family transactions. This resulted in parameter estimates quite similar to the ones presented here.

somewhat sensitive to the choice of the market power proxy and the choice of the size of local markets, the overall impression is that market power exists in local rural farmland markets. The strongest evidence of market power was found for proxies that were based on the number of sellers and buyers in local markets with a radius of 6.7 km. No evidence was found of market power in more urban farmland markets. Prices in urban farmland markets are mainly driven by speculation.

Besides market power, farmland prices are also largely dependent upon the degree of urbanization in the surrounding areas. Not only did we find an impact of the level of urbanization, we also found that different models apply to prices in areas with different levels of urbanization. Although all land considered in this paper was used for agricultural purposes, speculation seems to play an important role in determining prices of farmland in urban areas. This is similar to findings of other hedonic pricing studies that focused on farmland in the urban-rural fringe. In more rural areas we did not find speculation effects. In fact, we even found the opposite in the form of negative externalities imposed on farmland by residential areas and highways. From this we can conclude that in more urban areas it might be hard for farmers to compete with other buyers of land, although in more rural areas it is very unlikely that farmers will be priced out of the market.

Our findings with respect to market power and different impacts of surrounding land use in markets with different levels of urbanization have important consequences for subsequent work that uses hedonic pricing techniques to model farmland prices. Ignoring local market power in rural farmland markets may lead to omitted variable bias on estimated shadow prices in hedonic pricing models. Also, analyzing the market for farmland as a whole might bias the results, because our findings imply that, in areas with different levels of urbanization, parcel characteristics have different impacts on farmland prices.

With respect to personal characteristics of sellers and buyers, we found some evidence of their influence in the price determination process. Either they have a direct effect on the WTP of buyers or the WTA of sellers, or they influence the bargaining power of the sellers and buyers. Furthermore, we found that agricultural profitability variables like soil type, crops grown, and NGE per ha were not of great importance in determining farmland prices. Furthermore, we cannot conclude that urban pressure and speculation dominate the prices on farmland markets. They are dominating in urban areas, but in more rural areas the prices of farmland are influenced by a complex mix of factors, such as the externalities caused by non-agricultural functions, the influence of the small local submarkets, bargaining factors, and, finally, parcel characteristics, rights, restrictions and regulations.

Appendix 2.1

Table A2.1 Results of probit model with Buyer as a dependent variable (=1 if farmer bought land in 2003, 0 otherwise).

Explanatory variables	Coefficient	t-statistic
Farm is partnership (=1, 0 otherwise)	0.2884***	7.81
Farm is main activity of farm operator (=1, 0 otherwise)	0.0366	1.57
Additional activities are undertaken by farm operator (=1, 0 otherwise)	0.0339	1.49
Age of youngest farm operator (years)	-0.0082***	-11.71
Agricultural land (ha)	0.0028***	11.02
Land used for horticultural open air activities (ha)	0.0073***	6.11
Grassland (ha)	0.0023***	4.43
Fallow land (ha)	0.0490***	4.51
Number of Cattle Size Units (mainly cattle, sheep, goats and horses)	0.0023***	10.31
NGEs (Dutch Size Units), a normative size of the farm activities	0.0001**	2.40
Farmer sold land in the last five years (=1, 0 otherwise)	0.0842***	3.88
Farmer bought land in the last five years (=1, 0 otherwise)	0.2307***	12.26
Constant	-1.6135***	-36.14
Pseudo R^2	0.0497	
Likelihood Ratio Statistic $\chi^2(12)$	1,541	
Number of observations	85,189	

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels. The data source of all these variables is database 2 (see Appendix 2.2 for all data sources).

Appendix 2.2

Table A2.2 Databases Used in this Research.

No	Name database	Data source	Year data
1	Infogroma	Government Services for Land and Water Management (*Dienst Landelijk Gebied, DLG*)	2003
2	Agricultural census data (*Landbouwtelling*)	Government Services for Regulations (*Dienst Regelingen*)	2003
3	Parcel Registration (*Bestand Registratie Percelen, BRP*)	Government Services for Regulations (*Dienst Regelingen*)	2004
4	Land Use Statistics (*Bestand Bodemgebruik, BBG*)	Statistics Netherlands (*Centraal Bureau voor de Statistiek, CBS*)	2000
5	Spatial land use mapping (*Landelijke Grondgebruikskartering, LGN*)-4	Wageningen UR - Alterra	1999-2000
6	District and Neighborhood Information (*Wijk- en Buurtgegevens*)	Statistics Netherlands (*Centraal Bureau voor de Statistiek, CBS*)	2003
7	Note about Spatial Allocation (*Nota Ruimte*)	Ministry of Housing, Spatial Planning and the Environment (*Ministerie van VROM*)	2004
8	Land Use Planning Programs	Government Services for Land and Water Management (*Dienst Landelijk Gebied, DLG*)	2004
9	STIBOKA	Wageningen UR - Alterra	1965-1985
10	National Roadmap (*Nationaal Wegenbestand, NWB*)	Ministry of Transport, Public Works and Water Management (*Ministerie van V&W*)	2003

Appendix 2.3

Table A2.3 Test Statistics for Spatial Lag and Spatial Error Dependence.

		Test for spatial lag dependence		Test for spatial dependence in the residuals			
	Definition weighting matrix[a]	LM lag	Prob LM lag	Moran I	Prob Moran I	LM error	Prob LM error
Rural model	W1	0.0177	0.894	0.0163	0.376	0.5517	0.458
	W2	0.0071	0.933	0.0449	0.290	0.9627	0.327
	W3	2.1957	0.138	0.0367	0.378	0.7138	0.398
	W4	0.1660	0.684	0.0138	0.253	0.8136	0.367
	W5	0.7121	0.399	0.0517	0.249	1.2775	0.258
Semi-urban model	W1	0.0971	0.755	-0.0064	0.908	0.0616	0.804
	W2	0.1377	0.711	-0.0114	0.884	0.0525	0.819
	W3	0.0312	0.860	0.0009	0.988	0.0004	0.984
	W4	0.2378	0.626	-0.0041	0.972	0.0532	0.818
	W5	0.2973	0.586	-0.0235	0.659	0.2021	0.653
Urban model	W1	0.0155	0.901	-0.0047	0.957	0.0315	0.859
	W2	0.7692	0.381	0.0242	0.591	0.2455	0.620
	W3	0.1059	0.745	-0.0124	0.742	0.0987	0.753
	W4	0.2995	0.584	-0.0008	0.872	0.0016	0.968
	W5	0.1975	0.657	0.0089	0.910	0.0194	0.889

[a] Definition of weights in weighting matrices: W1: 1/distance between parcels, W2: 1/(distance between parcels)^2, W3: 1 if distance between parcels is < 1 km, 0 otherwise, W4: Spatio-temporal lower triangular matrix based on 1 / distance between parcels, W5: 1 if distance between parcels is < 6.7 km, 0 otherwise (similar to local market definition).

CHAPTER 3

BAYESIAN MODEL AVERAGING IN THE CONTEXT OF SPATIAL HEDONIC PRICING; AN APPLICATION TO FARMLAND VALUES[1]

Abstract

In 1973, British Columbia created the Agricultural Land Reserve (ALR) to protect farmland from development. In this study we investigate whether the ALR has been effective in preserving farmland near Victoria. Therefore, we employ a GIS-based hedonic pricing model to investigate characteristics that contribute to farmland prices near the urban fringe and quantify ALR specific measures. Bayesian model averaging techniques in combination with Markov Chain Monte Carlo Model Composition (MC^3) are used to address uncertainty with respect to the choice of the explanatory variables and the spatial weighting matrix. We explicitly incorporate the selection of different specifications of the weighting matrix (based on nearest neighbors, distances and spatiotemporal patterns) in MC^3 procedures for the spatial error dependence models. Our results indicate that the ALR is at least partly credible, on the one hand estimated signs of the effects related to the ALR all support the hypothesis that the ALR is credible. On the other hand, we find that there are also some indicators of speculation happening on farmland on the Saanich Peninsula. For example, prices closer to the city centre of Victoria are higher, smaller lots sell for higher prices and hobby farmers pay higher prices than conventional farmers.

3.1 Introduction

As cities grow and spread into the countryside, agricultural land is under increasing pressure from urban development. Despite programs and laws to protect agriculture, farmland prices in the rural-urban interface have increased significantly, often beyond the reach of farmers wishing to enter the sector or expand their operations. Because land prices are driven by the development and not agricultural potential of land, farming near urban areas has become more difficult both financially and logistically. As more and more land is developed into residential subdivisions and transport corridors, the remaining farmland has become increasingly fragmented. Farmers often need to buy or lease fields that are not contiguous, so they are unable to combine fields of sufficiently large size

[1] This chapter is a paper by Cotteleer, G, T. Stobbe and G.C. van Kooten, submitted to the Journal of Regional Science. The authors wish to thank John Geweke, Alison Burrell, Alison Eagle, James LeSage, Arie Oskam and participants at the 2007 SEA meeting, Cambridge, UK for helpful comments on earlier drafts of this paper, and the Farm Level Policy Network of Agriculture and Agri-Food Canada for research support.

to take advantage of scale economies. Farmers incur higher transportation costs for moving equipment, animals and produce; they encounter more nuisance complaints concerning odors, noise and slow-moving farm vehicles; and they experience higher rates of trespass and vandalism[2].

In the current study, we examine the effect of urban encroachment on farming near Victoria, the capital of British Columbia (BC), Canada's westernmost province. BC's agricultural land is limited, with the most productive land located near the most-rapidly growing urban centers – Vancouver and Victoria in the eastern part of the province and Kelowna in the Okanagan Valley in the Interior. To protect the 1.1% of the province considered prime farmland from development, the government created the Agricultural Land Reserve (ALR) in 1973[3]. The ALR is a zoning ordinance that prevents agricultural land from being subdivided or used for non-agricultural purposes without permission from the Agricultural Land Commission (ALC). The ALR designation permits only one dwelling per parcel, which is intended to serve as a farmer's residence.

Speculation by developers and purchases of farmland for residential purposes (rural estates) are the main factors that drive up agricultural land prices near urban centers. We seek to determine empirically whether speculation in anticipation of changing land designation is happening on ALR land. We hypothesize that if zoning is credible, farmland prices adjacent to urban edges should be lower due to the reduced productivity associated with negative urban externalities (Nelson, 1992). Alternatively, if landowners do not believe agricultural protection is permanent, these lands will have higher values in expectation that they will be sold to developers in the future.

We employ a GIS-based hedonic pricing model to investigate characteristics that contribute to farmland prices near the urban fringe and quantify ALR specific measures. We also employ spatial econometric techniques that take into account spatial dependencies that are not incorporated as covariates in the hedonic pricing model. Both the inclusion of GIS-data and spatial econometric techniques have proven to be important in the hedonic pricing models (Holloway et al., 2007). However, the problem with spatial econometric techniques is that they require a priori specification of a weighting matrix of spatial relations between observations, although the choice of a specific relationship is arbitrary (Anselin, 1988b). Another problem is that there is little in the way of theory to guide the choice of the covariates to be included in hedonic pricing models (Taylor, 2003). However, the empirical applications of hedonic pricing models indicate potential explanatory variables. Therefore, there are rules of thumb about which variables to include in hedonic pricing models. This implies there is specification uncertainty as there is uncertainty regarding both the choice of the explanatory variables and the spatial weighting matrix.

Our principal objective is to investigate whether the ALR has been effective in preserving farmland near Victoria, which would be the case if there is no indication of speculation happening on ALR land near urban areas. However, we wish to do so in a way that resolves uncertainty in the

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[2] Like many other jurisdictions, British Columbia has passed right-to-farm legislation that limits the ability of local governments and citizens to interfere with conventional farm operations. See the Farm Practices Protection (Right to Farm) Act (Government of British Columbia, 1996) for more details.

[3] Prime farmland is defined as Canadian Land Inventory (CLI) soil class ratings of 1 to 3. The CLI scale rates land on a 7-point scale where class 1 is land having the highest agricultural capability and class 7 is land that has no agricultural capability (Runka, 2006).

application of the spatial hedonic pricing model, and thus apply Bayesian Model Averaging in combination with Markov Chain Monte Carlo Model Composition (MC^3) to deal with model uncertainty. The benefit of Bayesian Model Averaging is that it does not assume there is only one correct model specification; rather, final parameter estimates are weighted averages based on a whole range of possible model specifications, including different explanatory variables and different specifications of the weighting matrix. Furthermore, the MC^3 framework makes sure that model specifications with high posterior probabilities are taken into account in the weighted averages.

Although the MC^3 framework has been extended to spatial econometric models by LeSage and Parent (2007) and LeSage and Fischer (2007), the current research explicitly incorporates the selection of different specifications of the weighting matrix (based on nearest neighbors, distances and spatiotemporal patterns) in both MC^3 procedures for the spatial lag and error dependence models. To the best of our knowledge, this extension of the MC^3 procedure constitutes an additional contribution of our research.

The outline of this chapter is as follows. Section 3.2 introduces the framework for the spatial hedonic pricing model with Bayesian model averaged results. This section also discusses the MC^3 procedure. The data and variables constructed for the hedonic pricing model are discussed in section 3.3, as is our study area. In section 3.4 the empirical results are presented and discussed. Section 3.5 concludes.

3.2 A Bayesian approach to the hedonic pricing model specification

To investigate the impact of British Columbia's Agricultural Land Reserve (ALR) and such things as land fragmentation on farmland prices, we specify a hedonic pricing model as follows (Rosen, 1974):

$$P = a\iota + X\beta + u \qquad [3.1]$$

where P is a vector of property prices, X is a matrix of property characteristics, β is a vector of associated coefficients to be estimated, a is a constant to be estimated and ι an associated vector of ones, and u is a vector of normally distributed error terms.

3.2.1 Spatial lag or error dependence

Given the spatial nature of the data, it is important to incorporate spatial dependence in the model. Spatial dependence will be incorporated as spatial error dependence in this chapter. Spatial error dependence (one form of spatial autocorrelation) arises if there is spatial interaction between the disturbances due to unobserved or omitted variables that have spatial patterns. Spatial lag dependence may exist when sellers and buyers use prices of parcels that were sold in the neighborhood as a reference point. Because, we use observations from 1974-2006, we have only a limited number of sales available each year. Moreover, farmland parcels are very heterogeneous. Therefore, we argue that it is more likely that farmers' willingness to pay or willingness to accept are determined by the general time trend in prices on the Saanich Peninsula, than by prices within their close neighborhood. Therefore, we include a twelve-month moving average of sale prices in the model rather than a spatial lag.

A formulation of the hedonic pricing model including spatial error dependence is given by:

$$P = a\iota + X\beta + \varepsilon \text{ , with } \varepsilon = \rho W\varepsilon + u \text{ and } u \sim N\left(0, \sigma^2 I\right), \qquad [3.2]$$

where W is the spatial weighting matrices. The spatial weights are specified a priori between all pairs of observations. In our model, where each observation i corresponds to a farmland sales transaction, each element w_{ij} weights the degree of spatial dependence according to the proximity or distance between parcel i and any other parcel j; ρ is the coefficient in a spatial autoregressive structure for the error term.

3.2.2 The choice of the spatial weighting matrix

Lacking guidance regarding the choice of a weighting matrix, we specify a variety of different types. Several variations employ binary weights, two are based on distances, and two are based on spatiotemporal patterns. In the case of binary weights, an element in the weighting matrix equals one if two observations are considered to be neighbors and zero if not. The first binary weighting matrix we specify is based on Delaunay triangulation (Zhang and Murayama, 2000), which uses non-overlapping triangles with the centroids of parcels as the vertices of the triangles. For each parcel, first-order neighbors are defined as those parcels that are directly connected to it by the edges of a triangle. Other variants of the binary weighting approach employ n-order neighbors, defined as the n neighbors that are closest in distance terms. In a weighting matrix based on n-order neighbors, there are n entries equal to one in each row. Thus, if one considers the three nearest neighbors then each row in the weighting matrix will have three elements equal to one (with zeros on the diagonal). We consider as many as ten possible neighbors. As Bucholtz (2004) points out, matrices based on a specific number of nearest neighbors have an advantage over other weighting matrices because the hypothesized spatial influence that parcels have on each other is not changed if the matrix is row-standardized (so that the sum of elements in each row equals one). Row-standardization is used for computational purposes. The number of nearest neighbors in the Delaunay-based weighting matrix depends on the number of edges within the triangulation that connect vertices. Thus, each row may have a varying number of elements equal to 1. Both matrices based on nearest neighbors and the Delaunay-triangulation are sparse, with many zeros and few ones. Sparse matrix calculations require much less computer memory and storage space (LeSage, 1998).

For weighting matrices based on distances, one employs inverse distances ($1/d$) and the other inverse squared distances ($1/d^2$). Thus, the weights are greatest for the nearest parcels. For inverse squared distances, the weights decline at an increasing rate as parcels are farther apart. The advantage of the inverse distance-based matrices is that they take the relationship between all parcels into account, but a disadvantage is that the weighting matrices are full, with only zero elements on the diagonal, making computation more difficult.

For the spatiotemporal weighting matrices, observations are ordered so that the resulting spatial weighting matrix is lower-triangular. Elements are based on the inverse distance and the inverse squared distances between parcels. The advantage in this case is that spatiotemporal weighting assumes sale prices or error terms are influenced by the sales of neighboring properties, but only if the neighboring properties were sold earlier in time (Pace et al., 1998).

3.2.3 Bayesian model averaging and the MC³ procedure

Because there is uncertainty about which weighting matrix and set of explanatory variables to use in our hedonic pricing model, we employ Bayesian techniques that allow us to specify posterior model probabilities for each specific model we wish to consider. These model probabilities tell us how likely it is that a given model is the correct one. Rather than basing parameter estimates only on the model with the highest posterior probability, we use Bayesian Model Averaging and weight the estimates of a whole range of potential models with the posterior model probabilities, which are given by (Koop, 2003):

$$p(M_i \mid y) = \frac{p(y \mid M_i) p(M_i)}{\sum_{m=1}^{M} p(y \mid M_m) p(M_m)}, \quad [3.3]$$

where $p(y \mid M_i)$ is the marginal likelihood that model M_i is the correct one and $p(M_i)$ is the prior model probability for model *i*. If, a priori, the researcher considers each model to be equally likely, all prior model probabilities are equal to $1/M$, where M is the total number of models to be considered. In this case the posterior model probabilities are determined only by the marginal likelihoods. The marginal likelihood for model *i* is (Koop, 2003):

$$p(y \mid M_i) = \int p(y \mid \theta, M_i) p(\theta \mid M_i) d\theta, \quad [3.4]$$

where $p(y \mid \theta, M_i)$ is the likelihood and $p(\theta \mid M_i)$ is the prior for the parameter vector θ. In our case, θ includes [α, β, σ^2, ρ]. The specification of the marginal likelihood for the spatial error dependence model is provided in LeSage and Parent (2007). Their specification is based on prior information on α, β and σ^2 from Fernandez, et al. (2001), and they assume a beta-prior centered about $\rho = 0$. Given that we have no information on these parameters, we assume the same priors despite their uninformative nature; however, as illustrated below, with Bayesian updating, we eventually rely on the data rather than the priors.

To derive the posterior model probabilities, we need to consider each possible model specification. With k potential explanatory variables and δ potential specifications of the weighting matrix, there are $2^k \times \delta$ models to consider, which is practically infeasible. (For example, with k=22 and δ=6, there are 25,165,824 models to consider.) Therefore, we use Markov Chain Monte Carlo Model Composition (MC³) (Madigan et al., 1995). The stochastic process generated by MC³ explores regions of the model space with high posterior model probabilities. The number of iterations in the MC³ procedure is pre-specified. At the start of the Markov chain, a regression model is chosen at random. Suppose the current model is M_i. The model that is proposed in the next step of the chain has either one variable more than the current model ('birth step'), one variable less than M_i ('death step'), or one variable of M_i replaced by a variable not currently in the model ('move step'). The proposed model M_j is then compared to the current model M_i and the probability of acceptance is given by:

$$P(accept\ new\ \mathrm{mod}\,el) = \min\left[1, \frac{p(M_j \mid y)}{p(M_i \mid y)}\right] \qquad [3.5]$$

A random draw using the probability from [3.5] of accepting the new model and not accepting it determines whether the new model indeed replaces the old, whether M_j replaces M_i.

This procedure for proposing new models is extended by LeSage and Fischer (2007) to include uncertainty with respect to the choice of the spatial weighting matrix in the MC^3 procedure. However, only different numbers and types of nearest neighbor based weighting matrices are included in their procedure. As indicated above, we specify weighting matrices based on upwards of ten nearest neighbors, as well as ones based on Delaunay triangulation, distances and spatiotemporal patterns. However, we first use the method of LeSage and Fischer (2007) to sort out which of the nearest-neighbors' weighting matrix to consider – one of the matrices with one to ten nearest neighbors; we select the binary weighting matrix with the number of nearest neighbors that had the highest model probability of being included. In addition, we extend this procedure by employing the MC^3 procedure that considers six different weighting matrices (two binary, two distance based, and two spatiotemporal).

We begin the MC^3 procedure by considering a regression model with a randomly selected weighting matrix and randomly selected variables. Next we use 100,000 iterations to determine posterior model probabilities for each of the models visited during one of the 100,000 iterations. Each iteration involves the following steps:

Current model: M_i

Step 1: Toss a fair die with two sides 1s, two sides 2s and two sides 3s

Outcome	Decision
1.	Exclude variable from model at random
2.	Add at random a new explanatory variable not currently in model
3.	Drop current explanatory variable at random from model; replace with randomly chosen explanatory variable not now in model

Choose new model M_j over M_i with probability given by [3.5].

Step 2: Toss a coin

Outcome	Decision
Heads	Retain current weighting matrix (retain model M_j or M_i)
Tails	Choose new weighting matrix at random from those not currently in model

Choose new model M_{j+} over M_j or M_i with probability given by [3.5]

This results in the model for next iteration: M_m = one of (M_{j+}, M_j, M_i) is chosen with some probability. LeSage and Fischer (2007) point out that step two is valid as long as the probabilities of change versus no change in the weighting matrix are equal, which is true for a fair coin toss.

To evaluate models given [3.5] we have to compare marginal likelihoods of different model specifications. However, given the specified priors, we can only integrate out the parameters α, β, and σ. This leaves us with a univariate integral in ρ. Similar to LeSage and Parent (2007) we use Simpson's rule to calculate the integral of the log marginal density over a fine grid of 2000 values of ρ ranging from -1 to 1.[4]

3.2.4 Inclusion probabilities for variables

Based on the MC^3 procedure, for each variable we can calculate the probabilities that this variable should be included in the model. Inclusion probabilities for variables are calculated as the proportion of models drawn by the MC^3 procedure that includes the corresponding explanatory variable (Koop, 2003).

3.2.5 Functional form

Another statistical issue is the choice of functional form. Although Cassel and Mendelsohn (1985), Rasmussen and Zuehlke (1990), and Cropper, et al. (1988), among others, have addressed this problem, there is little theoretical guidance for the choice of a functional form (Taylor, 2003). Some studies use best fit criteria but others state that shadow prices of property characteristics are not necessarily estimated more accurately if best fit criteria are used (Cassel and Mendelsohn, 1985). We specified a double-log functional form, where both the dependent and (where possible) the independent variables are in logarithmic form. This functional form is generally preferred over linear ones because linear functional forms have the disadvantage that they assume parcel characteristics can be repackaged, because the combination of arbitrage and the ability to repackage characteristics, would lead to linear functional forms (Rosen, 1974).

3.2.6 Geographical Information Systems

Finally, we use ArcGIS to calculate distances, link datasets and analyze spatial relationships in the data, and correct for spatial lag and error dependence. Although ArcGIS includes basic tools to perform tasks on spatial data, the specification of the fragmentation index involved the use of Python to build scripting procedures to standardize calculation processes for developing the fragmentation measure in GIS.

[4] To implement the MC^3 and BMA procedures, we used modified versions of the functions sem_g, sem_gcbma and hpdi from the toolbox of LeSage (http://www.spatial-econometrics.com/).

3.3 Data and variables

Our study area is the Saanich Peninsula of southern Vancouver Island, a rich agricultural area just north of Victoria (see Figure 3.1). Together with the Fraser Valley and the Okanagan, this area is home to the most important agricultural land in the province, but it is also near one of the province's largest and rapidly growing urban centers. Hence, it experiences intense development pressure.

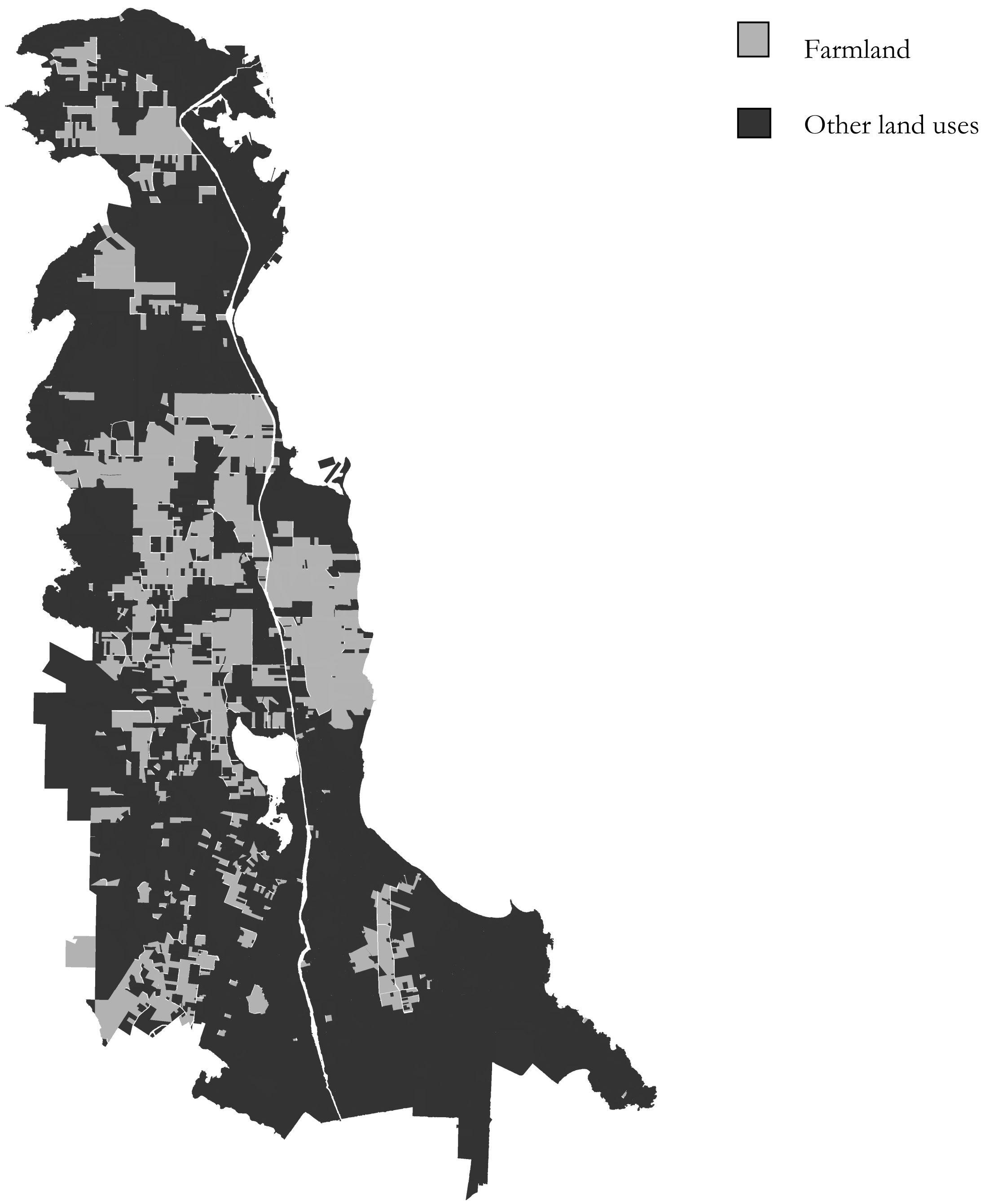

Figure 3.1 Distribution of land use on the Saanich Peninsula.
Source: Ministry of Agriculture and Lands and the Capital Regional District, edited map.

We use 534 observations of traded farmland parcels that were sold in the period 1974 (the year following creation of the ALR) to 2006. The data include all 'single cash' transactions but exclude sales that incorporated more than one parcel. As well, only parcels were selected that could be linked to all fifteen datasets we used, so that for each observation all explanatory variables were available. And because the moving average of prices was included in the model as an explanatory variable, we had to exclude the sales that took place in the first twelve months. Finally, if properties were sold more than once, we included only the most recent transaction in our analysis, because the structure of our weighting matrices cannot handle multiple sales of the same property. In total, 3,688 farm sale transactions have taken place, of which 3,201 are from the period after 1973. Of these, 1,015 were single property cash transactions, while the remaining 2,186 transactions were either multiple property cash transactions or non-cash transactions. The number of observations was further reduced to 935 as a result of linking issues between different datasets. And to 902 after the sales from the first twelve months were excluded. Finally, it was reduced to 534 observations once earlier transactions of the same property were removed.

The different data sets come from the BC Ministry of Agriculture and Lands, the BC Assessment Authority, other government agencies, and private sources. The GIS-based hedonic pricing model uses the real per hectare market value of land as the dependent variable. Prices are corrected for inflation with Consumer Price Indices (CPI), with CPI 2006 = 100. The covariates include size of the farmland parcel, type of farm, topographical features of the land, a fragmentation index, distance to Victoria, an ALR dummy variable, the number of hectares excluded from the ALR each year, a twelve month moving average of per hectare real prices, and a linear trend variable.

The specification of the ALR-dummy is based on the ALR-boundaries in place in 2005. However, this boundary has changed over the period 1974 to 2006, because exclusions of ALR land have taken place[5]. To take this dynamic aspect of the ALR into account, we included the number of hectares that were excluded from the ALR as a covariate.

The fragmentation index is specified as the percentage of the perimeter bordering other farmland parcels multiplied by the size of the total farm block of all the farmland that is adjacent to the parcel and the parcel itself. This index is designed to capture the importance of both the proximity to other farms and the total size of the farm block of which the parcel is a part.

A dummy variable ('vacant land') is used to distinguish between properties that do or do not have substantial structures, such as farmhouses, barns, poultry and milking facilities, etc. The data would be more homogeneous if parcels with structures on them could be excluded from the analysis. However, the ALR allows one structure per parcel, therefore, most parcels that were sold on the Saanich Peninsula have structures on them. According to Table 3.1 only 5% of the land is vacant. Since we do not have additional information on the structure, we include a dummy variable, similar to Cavailhes and Wavresky (2003).

[5] Exclusions of ALR land on Saanich Peninsula: Year (applied for exclusions, excluded nr of ha); 1975 (136.89, 0); 1977 (41.7, 41.7); 1981(10.3, 0); 1984(1.8, 1.8); 1995(1,1); 1996(2,2); 1997(4.5, 0); 1999(1.9,1.9); 2000(0.5,0.5); 2002(11.2,11.2); 2004(10,10); 2005(5.6,5.6); 2006(0.6,0.6).

Table 3.1 Summary statistics of variables included in hedonic pricing model (n = 534) and data sources.

Variables	Mean	St. Dev.	Data source	Year data
Sale price per ha in CA$'000s	226.3653	220.6610	LandCor, BC assessment	1974-2006
ALR (= 1 if property is within the ALR, 0 otherwise)	0.7285	0.4452	Agricultural Land Commission	2005
ALR boundary (=1 if property is at the ALR boundary, 0 otherwise)	0.3914	0.4885	Agricultural Land Commission	2005
Distance to ALR boundary in km (distance is negative if the parcel is located within the ALR, and positive otherwise)	-0.1436	0.4231	Agricultural Land Commission	2005
Excluded ha from the ALR on Saanich Peninsula	2.0436	6.0221	Agricultural Land Commission	1974-2006
Fragmentation index (proportion of perimeter bordering other farmland × size of total farm block of all adjacent farmland (ha))	3.5202	4.3821	BC Assessment, Ministry of Agriculture	2004-2006
Distance to Victoria City Hall in km	15.3126	5.8363	Capital Regional District	2005
Distance to Victoria airport in km	10.5254	4.8922	Capital Regional District	2005
Nearest distance to Patricia Bay highway in km	1.4097	1.4656	Statistics Canada	2005
Monthly time trend	232.8446	105.3864	LandCor, BC assessment	1974-2006
Twelve month moving average real prices per ha in CA$'000s	218.8603	76.5375	LandCor, BC assessment	1974-2006
Summer	0.5524	0.4977	LandCor, BC assessment	1974-2006
Maximum elevation in meters (m)	64.9251	32.6416	Municipalities (North Saanich, Central Saanich and Saanich)	2005
Difference between maximum and minimum elevation levels (Δ m)	14.0918	12.5974	Municipalities (North Saanich, Central Saanich and Saanich)	2005
Lot size in ha	3.7304	4.6869	Capital Regional District, Ministry of Agriculture	2004-2005
Hobby farm (=1 if farm is hobby farm, 0 otherwise)	0.1592	0.3662	Ministry of Agriculture	2004
Grain (=1 if grains are grown, 0 otherwise)	0.0993	0.2993	Ministry of Agriculture	2006
Vegetable (=1 if vegetables are grown, 0 otherwise)	0.0637	0.2444	Ministry of Agriculture	2006
Tree fruit (=1 if tree fruits are grown, 0 otherwise)	0.0056	0.0748	Ministry of Agriculture	2006
Small fruit (=1 if small fruits are grown, 0 otherwise)	0.0356	0.1854	Ministry of Agriculture	2006
Cows (=1 if farm is beef or dairy farm, 0 otherwise)	0.0730	0.2604	Ministry of Agriculture	2006
Poultry (=1 if farm is poultry farm, 0 otherwise)	0.0393	0.1946	Ministry of Agriculture	2006
Vacant land (=1 if land is vacant, 0 otherwise)	0.0487	0.2154	Ministry of Agriculture	2006

Although the time-aspect is an important determinant of farmland prices, we treat our dataset as a cross-section. Our data cannot be treated as a time-series or a panel dataset, because different observations refer mostly to different cross-sectional units. Moreover, there is no regular time-interval between observations. Sometimes it takes a day before a different sale is observed, sometimes it takes weeks. However, the time element is captured in this research by a linear trend variable. This variable captures rising real sales prices over time. Because we observe that farmland prices increased more than the overall price index. This linear time trend captures all time effects, including rising GDP per capita and the effect of the cumulative number of excluded hectares from the ALR. GDP per capita and the cumulative number of excluded hectares are not included in the model separately because they are too highly correlated with the linear time trend and each other.

An overview of all the variables included in the hedonic pricing model as well as the data sources used to construct these variables is given in Table 3.1.

Table 3.2 Spatial error MC^3 model selection information (100,000 draws and 18,481 unique models).

Variables	M1	M2	M3	M4	M5	Variable probabilities
ALR	0	0	0	0	0	0.078
ALR boundary	0	0	0	0	0	0.071
Distance to ALR boundary (km)	0	0	0	0	0	0.045
ALR excluded ha	0	0	0	0	0	0.053
Fragmentation index	0	0	0	0	0	0.054
Log of distance (m) to Victoria City Hall	1	0	1	0	0	0.373
Log of distance (m) to Victoria airport	0	0	0	0	1	0.065
Log of nearest distance (m) to Patricia Bay highway	0	0	0	0	0	0.058
Time trend	1	1	1	1	1	0.838
Moving average log real prices	1	1	1	1	1	0.835
Summer	0	0	0	0	0	0.064
Maximum elevation in meters	0	0	0	0	0	0.064
Average difference elevation level (Δ m/ha)	0	1	0	0	0	0.067
Log of lot size (ha)	1	1	1	1	1	0.916
Hobby farm	0	0	0	0	0	0.070
Grain	1	1	1	1	1	0.467
Vegetable	0	0	0	1	0	0.105
Tree fruit	0	0	0	0	0	0.060
Small fruit	0	0	1	0	0	0.078
Cows	0	0	0	0	0	0.054
Poultry	0	0	0	0	0	0.064
Vacant land	1	1	1	1	1	0.776
W 5 nearest neighbors	0	0	0	0	0	0.062
W Delaunay	0	0	0	0	0	0.125
W distances	1	0	1	1	1	0.501
W squared distances	0	1	0	0	0	0.123
W distances temporal	0	0	0	0	0	0.126
W squared distances temporal	0	0	0	0	0	0.062
Model probabilities	0.267	0.130	0.031	0.027	0.021	

3.4 Empirical results and discussion

The Bayesian model averaged estimates are not based on all unique models visited in each of the 100,000 iterations. Means and highest posterior density intervals (HPDI's) for the coefficients are only calculated for the 500 models with the highest marginal likelihoods in the spatial error specification. The reason that not all models are included in the Bayesian model averaging procedure is that it is too time consuming to calculate the means and dispersion measures for more than 500 models – the combination of 500 models and 8,000 draws (including 1,000 burn-in draws) per model took about 190 hours[6]. We scaled the model probabilities so that the probabilities of the 500 best models sum up to 1. This is required by the Bayesian model averaging procedure. We find 18,481 unique models in 100,000 draws.

Table 3.3 Spatial error Bayesian Model Averaging estimates (8,000 draws, 1,000 burn-in draws, based on top 500 models).

Variables	2.5% HPDI	Mean	97.5% HPDI
ALR	-0.004255	-0.002849**	-0.001453
ALR boundary	-0.004671	-0.002886**	-0.001024
Distance to ALR boundary (km)	-0.001395	-0.000874**	-0.000349
ALR excluded ha	0.000015	0.000085**	0.000152
Fragmentation index	0.000066	0.000251**	0.000433
Log of distance (km) to Victoria City Hall	-0.126876	-0.069606**	-0.009173
Log of distance (km) to Victoria airport	-0.001036	0.001785	0.004732
Log of nearest distance (km) to Patricia Bay highway	0.000465	0.000670**	0.000875
Time trend	0.001969	0.002235**	0.002508
Moving average log real prices	0.224468	0.308979**	0.387824
Summer	-0.002126	0.000158	0.002344
Maximum elevation (m)	0.000000	0.000012**	0.000024
Average difference elevation level (Δ m/ha)	0.000112	0.000167**	0.000222
Log of lot size (ha)	-0.680133	-0.662041**	-0.643905
Hobby farm	0.001746	0.005259**	0.008680
Grain	-0.193372	-0.139294**	-0.087253
Vegetable	-0.038832	-0.031182**	-0.023850
Tree fruit	-0.002492	0.000014	0.003443
Small fruit	-0.010126	0.001804	0.012854
Cows	-0.002527	-0.000490	0.001425
Poultry	-0.012117	-0.006163**	-0.000720
Vacant land	-0.404196	-0.329438**	-0.259071
ρ	0.765116	0.796991**	0.827162

** Statistically different from zero at 95% HPDI interval.

The specifications of the five models with the highest posterior model probabilities resulting from the MC^3 procedures are provided in Table 3.2. In this table, ones indicate the inclusion of a certain variable or weighting matrix and zeros indicate exclusion. Posterior model probabilities for the five 'best' models and probabilities for the inclusion of each of the variables and spatial weighting

[6] We used Matlab version 7.1 and a computer with an Intel Pentium Duo Core processor with 2.33 GHz and 1,95 GB of RAM.

matrices are also presented in Table 3.2. The Bayesian model averaged means and 95% HPDI-interval are provided in Table 3.3.

The model that includes the variables vacant land, distance to Victoria, a time trend, a moving average of past prices, the lot size and grain is preferred over larger models that include more variables. In general, smaller models with less covariates have higher posterior model probabilities than larger models with more covariates (Koop, 2003). This is similar to our findings (see Table 3.2). Lot size, the time trend, the moving average of prices and vacant land have inclusion probabilities above 0.70, grain has an inclusion probability of 0.47 and distance to Victoria of 0.37. Other than these variables, the inclusion probabilities of variables are below 0.11. However, we found that coefficients of variables with low probabilities of being included can be significantly different from zero.

We also have other reasons to assume that the significance and the magnitude of the coefficients presented in Table 3.3 are lower bounds. The benchmark priors we use assume a mean of zero for all the coefficients, but we use these because we do not have informative prior information about the coefficients of interest. And it is common practice to set priors for the coefficients of covariates to zero when there are many potential explanatory variables, and it might be expected that some of them are irrelevant (Koop, 2003).

3.4.1 Credibility of farmland protection

We hypothesized that land within the ALR would be valued lower than land outside the ALR if farmland preservation is expected to be permanent. We test this hypothesis with the ALR-dummy and conclude that land located within the ALR sells at a lower price than that outside the ALR. Although this variable does not have a high probability of being included in the models, if it is included a negative effect is found. This suggests that the ALR is at least partly credible.

Regarding the credibility of the ALR, we also tested whether increased exclusions of land from the ALR resulted in greater speculation. As expected, the estimated coefficient on this variable is positive, suggesting that, as more land is excluded from the ALR, land values are higher, which is suggestive of speculation.

Although we assume that the value of farmland is determined by, among other variables, whether the land is in the ALR, one might also argue that the causality is the other way around – as a result of urban pressures farmland prices rise and, due to higher prices, land is excluded from the ALR. If this argument is true, our ALR variables would be endogenous and our empirical results would be biased. To address this, we employed a simple OLS model with all potential explanatory variables included (in logarithmic form where permitted). We tested for endogeneity of the ALR variables using the Hausman test with indicators about the government in charge as instruments in the equation for the ALR variables (ALR dummy variable and number of ha excluded from the

ALR). These indicators are used because exclusions from the ALR often depended on the political climate. Given that these indicators are the right instruments, we find no evidence of endogeneity.[7]

We also test the hypothesis that, if zoning within the ALR is credible, ALR land close to the edges of the ALR will sell for less than ALR land in the ALR interior, due to negative urban spillovers. All the indicators we use to test this hypothesis point in the same direction. Parcels at the ALR boundary sell for lower prices than parcels farther from the boundary; parcels that are less fragmented sell for a higher price and parcels that are closer to the centre of the ALR sell for a higher price compared with parcels farther from the ALR centre. Distance to the ALR boundary takes on negative values within the ALR and positive values outside the ALR, implying that the farther a parcel is from the urban centre or ALR boundary (the deeper into the ALR), the higher is its price. These findings support the hypothesis that the ALR boundary is credible.

3.4.2 Farmland parcel size

We conclude that farmland parcel sizes are important in explaining prices per ha. The log of parcel size is statistically different from zero and has a negative effect on the log of prices per ha. This is contrary to the expectation that farmers seek to acquire large properties to realize economies of scale because larger parcels have higher productivity levels than small ones (Cavailhes and Wavresky, 2003). There are several explanations for this result. First, average parcel size is only 3.76 ha, so the likelihood that economies of scale are an issue is small. Another reason for this result is that, when agricultural land is purchased for development purposes in expectation that it will be excluded from the ALR in the future, its value is sometimes negatively related to the size of the parcel. The reason is that the costs of subdividing land increase relative to benefits as the size of the parcel increases (Colwell and Munneke, 1997; Colwell and Munneke, 1999).

Finally, since ALR land cannot be subdivided without going through the Agricultural Land Commission, the negative coefficient on parcel size suggests that much of the land in the Saanich Peninsula is bought for the purpose of rural estates and hobby farms. In British Columbia, property taxes that are some 70% lower than regular property taxes apply to land classified as 'farm status' than to equivalent land that is not in this category. The revenue threshold for attaining farm class status is quite low: The property must generate an annual gross income of $2500 or more at least once every two years if the farm is between 0.8 and 4.0 ha in size. For properties less than 0.8 ha, the gross income threshold is $10,000, while it is $2,500 plus 5 per cent of the property's assessed value if the farm exceed 4 ha. As most buyers would not be farmers, an increase in property size much beyond the 0.8 ha threshold, and especially beyond 4 ha, would be viewed negatively (Dove, 2007).

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[7] The Hausman test statistic has a value of 0.19. Under the null-hypothesis this is distributed as Chi-squared with 22 degrees of freedom. This indicates that there is no systematic difference in the parameter estimates between the consistent (Instrumental variables approach) and the efficient (OLS) estimates.

3.4.3 The time dimension

Including the time dimension in the model specifications is important, because the data span a period of more than 30 years. Although, nominal farmland prices were corrected for inflation by Consumer Price Indices, real prices have risen significantly over time. A monthly time trend was included in the model to capture this rise in real prices. Moreover, a moving average of sales prices over the past twelve months is included in the models to account for time effects. These variables capture all changes that took place with respect to time effects. We did not include information such as real GDP per capita, changes in interest rates and the decreased availability of farmland due to exclusions of ALR land directly, since these variables are all highly correlated with the time trend, and it is not clear which price effect results from which changes.

The reason for the low inclusion probabilities for variables that are not related to time, is probably that the data span more than 30 years. Therefore, the time effect is dominating other effects. However, if the time effect is captured in the right way, we do find that impacts of other variables are statistically different from zero. For example all coefficients of variables related to the ALR are significantly different from zero.

3.4.4 Other variables

Not surprisingly, vacant land is less valuable than land that has structures on it. While this result is partly accounted for by the fact that productive farm enterprises would require some structures, it is primarily driven by the existence of a residence on the property. A residence substantially increases the value of the land, but not by as much as might be expected. That is, farmland without a residence remains much more valuable than its use in agriculture would suggest.

Furthermore, the distance to Victoria city centre has a negative impact on farmland prices, meaning that the further away from the city centre, the lower the farmland prices. Von Thünen argued already in 1826 that farmland prices would be higher closer to the cities, because of higher transportation costs for more remote farmers. Although, at the urban-rural fringe, commuting costs can also play a role (Cavailhes and Wavresky, 2003). Since those who like to live in the countryside, but work in the city, or those who are (partly) employed off-farm experience higher commuting costs, the further they are from the city centre. According to Livanis, et al. (2006) the higher prices closer to urban areas can also be attributed to speculation and the higher demand for development near urban areas.

Another indicator for speculation is the positive effect of hobby farmers on farmland prices. If hobby farmers buy parcels, they pay significantly higher prices than conventional farmers and thereby drive up the price of the farmland.

3.4.5 Weighting matrices

With respect to the spatial error structure, we conclude that ρ is significant and has a positive sign as expected. Therefore, a model that includes spatial error dependence is preferred over models without this type of spatial information. With respect to the choice of the weighting matrix, we find that the inclusion probabilities for weighting matrices with different numbers of nearest neighbors (1 to 10) do not differ much. Therefore, in the final run of 100,000 draws in the MC^3 procedure for the spatial error model, we included the matrix based on the five nearest neighbors. Based on the MC^3 procedure, we can conclude that the spatial error dependence process is best described by the distance-based weighting matrices. Although, the data spans a long time period, the spatiotemporal weighting matrices are not better descriptors for this process. The nearest-neighbors based weighting matrices do not describe the spatial error and lag dependence structures very well. This also explains why the number of nearest neighbors makes little difference, as the general structure did not apply to our data.

3.4.6 Multicollinearity

Because the Saanich Peninsula is a well-defined area surrounded by ocean and it is fairly hilly, with only one city (Victoria) playing a significant role, there might be a problem with multicollinearity – many of the covariates could be inherently correlated. However, we tested an OLS specification that includes all 22 covariates with Variance Inflation Factors (VIF's) and found no evidence for multicollinearity in our model.[8] This is essential for the Bayesian Model Averaging procedure, since each model specification includes different explanatory variables, the interpretation of the coefficients associated with the included variables would change in each specification if multicollinearity would be present.

3.5 Conclusions

In this study, we were particularly interested in determining whether BC's Agricultural Land Reserve was perceived to be an effective instrument for preserving farmland. We hypothesized that, if zoning is credible, farmland prices adjacent to the edges should be lower due to the reduced productivity associated with urban spillovers and externalities. Alternatively, if agricultural landowners do not believe the preservation scheme is permanent, these lands will have higher values and lower rates of investment in expectation that the land will be sold to developers in the future. We used spatial hedonic pricing models to investigate this question.

We also wished to resolve the uncertainty of the choice of explanatory variables and the spatial weighting matrix in our model. Therefore, we used Markov Chain Monte Carlo Model Composition in combination with Bayesian model averaging to resolve this model uncertainty. Although basic model uncertainty could be resolved using these methods, we found they had some drawbacks as well. First, these methods are time consuming, although greater computing power partly addresses this issue. Further, these methods seem to result in lower bounds on the estimated means and significance of the coefficients of interest. However, with more specific prior information this issue might be partly resolved.

Using these techniques, we could nonetheless draw conclusions about the impacts of explanatory variables and which variables have high and low inclusion probabilities. With respect to

[8] All VIF's were in between 1.01 and 6.56 and the mean VIF was 2.25.

the credibility of the ALR, we conclude that the ALR is at least partly credible, since the estimated signs of the effects related to the ALR all support the hypothesis that the ALR is credible. For example, ALR land is sold for less than land outside the ALR, land at the ALR boundary sells for less, and farmland that is more fragmented and farther away from the heart of the ALR sells for less. Although all these indicators are statistically different from zero, the inclusion probabilities for these variables are all very low. This can be explained by the time horizon of this research, because sales of the period 1974-2006 are taken into account in the analysis. Therefore, some of the time effects are dominating. However, we find that there are also some indicators of speculation happening on the Saanich Peninsula. For example, prices closer to the city centre of Victoria are higher, hobby farmers pay higher prices per hectare than conventional farmers and smaller lots sell for higher prices and.

An explanation for the higher prices paid for smaller lots is that they signify that farmland is most likely bought for residential purposes by those craving a rural lifestyle in close proximity to a large urban area. To some extent, it is possible that the requirements for obtaining farm class status and thereby lower property taxes may, counter-intuitively, be working against agricultural preservation in British Columbia. As smaller farmland parcels are clearly preferred by buyers, the low threshold for achieving farm tax status makes it cheaper to own a large rural estate rather than an urban residential lot. A landowner does not need to be a professional or efficient farmer, but can simply be a hobby farmer. By raising the threshold or implementing other hurdles to achieving farm status, the government could reduce the desirability of living on large rural estates, but perhaps to the detriment of serious agricultural producers.

Overall, it appears that high prices for small farm properties and inexperienced farmer-buyers bode ill for sustaining viable commercial agriculture on the urban fringe. It may also hinder preservation of open space in the longer run if such open space is being protected under the guise of preserving farmland for agricultural purposes only.

CHAPTER 4

FARMLAND CONSERVATION IN THE NETHERLANDS AND BIRITSH COLUMBIA, CANADA[1]

Abstract

As a result of urban development farmland in many countries is under pressure. Reasons to preserve farmland are related to cultural heritage, food safety, open space, the environment, but also slowing and restricting development is a reason. To protect farmland countries use different land use policies. This paper will look specifically at two jurisdictions: the Netherlands and the Saanich Peninsula in British Columbia, Canada. For these areas we investigate how the institutions and laws present in these jurisdictions contribute to agricultural land preservation. We analyze farmland values in a GIS-based hedonic pricing framework to answer this question. This combination enables us to analyze direct impacts of laws and regulations within the hedonic pricing framework. Moreover, we can use farm values to analyze farm survivability, and the level of speculation on farmland in the urban-rural fringe, where farmland is under urban pressure.

4.1 Introduction

Many countries are concerned with the preservation of agricultural land and have a variety of programs in place to promote its protection. The reasons for preserving farmland are varied and multifaceted (Kline and Wichelns, 1996). People who live in areas with a rich, agricultural history may be primarily interested in safeguarding their rural identity and agricultural heritage, while others are concerned about food security, food safety or the adverse environmental impacts of buying food from other places. Apart from agrarian concerns, many also view local farmland preservation as important for the environmental amenities it provides, including open space, wildlife habitat, groundwater recharge and flood mitigation, and its role as a buffer against urban sprawl; indeed, some see farmland protection as a means to slow growth and restrict development (Bergstrom et al. 1985). Because agricultural land provides many externality benefits that are not efficiently transacted in existing markets, it is often undervalued and undersupplied. Meanwhile, the financial returns from

[1] This Chapter is a paper by Cotteleer, G., T. Stobbe and G.C. van Kooten, forthcoming as chapter 6 in F. Brouwer, M. van der Heide, *Multifunctional Rural Land Management: Economics and Policies.* London, UK: Earthscan. The authors wish to thank the participants of the workshop on understanding relations in nature and economy, Wageningen, NL for helpful comments on earlier drafts of this paper.

development greatly exceed those from agriculture, which widens the gap between the marginal private benefit of farmland preservation and that of development. Not surprisingly, a range of regulatory and market-based policies are used to encourage the retention of land in agricultural activities, particularly near urban areas.

The primary regulatory approach is zoning, which legislates how land can be used. Where new zoning laws are passed without compensating current landowners, income distributional issues arise because zoning dramatically impacts property values (Hanna, 1997). Zoning can be at the national, provincial or local level and is usually accompanied by preferential farmland assessments for tax purposes. In some cases, land zoned as agriculture automatically receives tax concessions, but in others landowners must meet an income threshold to qualify for special tax consideration. In some areas, zoning and preferential taxes are largely seen as incapable of impeding urban development because the returns from development are simply too large (Anderson, 1993; Conklin and Lesher, 1977; Plantinga and Miller, 2001). High returns to development create pressure on the government to change the zoning bylaws, which results in speculation in farmland (Nelson, 1992).

Market-based mechanisms for protecting agricultural land have gained prominence over time, especially in the United States (Brabec and Smith, 2002). With transferable development rights (TDRs), zoning is used to specify areas to be developed and preserved, with developers needing to buy development rights in order to build. This exchange compensates landowners for the agricultural restrictions placed on their land (McConnell et al. 2006). In the case of a purchasable development rights (PDR) system, government or a non-profit conservation group will purchase the right to develop the land, attaching a permanent easement to the property title. This should lower the value of the agricultural land and provide landowners with investment funds, thus making farming a more profitable activity. However, empirical evidence suggests that land values are not significantly affected under either system, which may indicate that speculators believe they will be able to lift the development restrictions in the future or that hobby farmers and large rural estates are ratcheting up farmland prices (Nickerson and Lynch, 2001).

Finally, there is the effect of direct agricultural support payments. Farm payments benefit current producers, but often get capitalized in land values thereby increasing the actual or shadow rents. While we expect farmland prices to be higher as a result of farm programs, this may not be sufficient to overcome development pressure near urban areas.

This chapter will look specifically at two jurisdictions: the Netherlands and a particularly rich farming area in British Columbia, Canada. For these areas we investigate how the institutions and laws in these jurisdictions contribute to agricultural land preservation. We analyze farmland values using a GIS-based hedonic pricing framework, and thereby examine the direct impacts of laws and regulations. Direct impacts of laws and regulations on land prices can be analyzed because the hedonic pricing method assumes that property prices can be explained by the sum of the value of the individual characteristics. Characteristics include, for example, the size of the parcel and the distance to the nearest city, but also the regulations and restrictions that affect prices. By including laws and regulations directly into the hedonic pricing function, we can analyze the direct impacts of these regulations on land prices. We also use the results of the hedonic farmland pricing model to draw conclusions about farm survivability in the urban-rural fringe.

Farmland values do not only reflect the discounted value of all future agricultural income, but also the option value of converting the land at any time in the future to residential use (Isgin and Forster, 2006). These option values increase land prices. Because of the zoning systems that are in place in most countries, option values are really speculative values, because there is some chance that the zoning ordinance will permit residential use in the future. Speculation on agricultural land makes it difficult for new farmers to enter and for established farmers to expand (to take advantage of economies of scale), because land prices are driven by the development potential of land and not agricultural potential. If agricultural land prices are high as a result of nearness to urban areas, output is insufficient to ensure an adequate return to the land. The land input cost is directly related to the price of farmland, whether or not the current landowner incurs that cost or not. Further, in areas that assess estate taxes when assets move from one generation to the next, oftentimes the heirs of farmland need to sell it just to be able to pay the estate taxes.

Another negative effect of escalating farmland values near urban areas is the resulting fragmentation of farmland. As subdivisions and highways are built, the landscape is partitioned into a patchwork of disparate properties that increases the costs of farming as it inhibits opportunities to take advantage of scale economies, especially as farmers are forced to buy or lease fields that are not contiguous to their existing land. Thus, they incur added costs of transporting equipment or are unable to 'package' fields together of sufficiently large size to take advantage of scale economies. As more agricultural land abuts residential areas, the potential for conflict also increases as neighbors complain about the odors and noise emanating from farms and farmers put up with trespass and vandalism (Ready and Abdalla, 2005).

We investigate these issues in greater detail using case studies of farmland prices in British Columbia and the Netherlands. In the next section we describe each jurisdiction's respective institutions and agricultural setting. We then provide background information on our methods, data and the hedonic models that we employ, and our estimation results. We end with a discussion of common features between the jurisdictions and the link between institutions and policy.

4.2 Laws and regulations

4.2.1 British Columbia

Zoning is delegated to municipal governments in British Columbia (BC) under the Local Government Act (1996). Municipalities can restrict land in any way including type of use, presence and position of buildings, density, and the configuration of parcels and how they might be subdivided. An exception is that municipalities may not prohibit or restrict agricultural activities in a farming area unless it receives approval from the minister responsible for administration of the Farm Practices Protection (Right to Farm) Act (Government of British Columbia, 1996).

To further protect agricultural land, the province created an Agricultural Land Reserve (ALR) in 1973 that supersedes the local authority. The impetus for this was the rapid pace of urban development (an estimated 6,000 ha per year) encroaching on farmland (Runka, 2006), especially near the cities of Vancouver, Victoria and Kelowna. The ALR included all lands rated between classes one and four according to the Canada Land Inventory, those zoned as agricultural by municipalities, and those favored with farm class status by BC Assessment, the provincial taxing authority. A parcel of land in the ALR may not be used for anything but agriculture without approval from the Agricultural Land Commission (ALC). It may contain one dwelling (a farmhouse) and other agricultural buildings and may not be subdivided.

The ALR and ALC have survived several changes in government and seem to be a permanent fixture, but they are not without controversy (Garrish, 2002/2003). In recent years, there has been increasing public debate about whether the ALC is too lenient in approving exclusions (Green, 2006), which contributes to speculation on farmland. Concerned groups point to statistics showing that, although ALR area has increased since 1973, most of the exclusions have come from the urban fringe in the fertile south while most inclusions have come from the more arid and less populated northeast.

Municipalities' largest source of revenue (about 40 percent of their budgets) comes from taxes on land and buildings. BC Assessment determines land values and preferential tax policies for agricultural land and those properties with farm class status. Farm status (and thus lower taxes) are determined by gross agricultural sales and the size of a property: parcels of less than 0.8 ha must have farm revenues of at least $10,000 (€7,000) per year, those between 0.8 and 4 ha must have at least $2,500 (€1,750) in gross sales, and those greater than 4 ha must have sales of $2,500 (€1,750) plus 5 percent of the land value. This threshold must be met every second year.

4.2.2 The Netherlands

Zoning and land use policy in the Netherlands are based on the Spatial Planning Act (WRO) (Van Geest and Hödl, 2002). As a result of the WRO, the organization of land use policy can be thought of as an onion, with layers of responsibility resting with the central government, the twelve provinces and the 483 municipal governments.[2] Development planning and spatial policy have undergone a transition over the past 15 years, resulting in more market-oriented land use policies based on public-private partnerships (Louw et al. 2003).

In the past, land use planning and land development was handled mainly at the municipal level since needs for residential development and industrial parcels are dealt with at that level. However, it is clear that local governments are losing their grip on land markets as market forces play an increasing role and municipal land ownership is no longer a given. The primary response to this new institutional environment has been for municipalities to form public-private partnerships, though participation in these is usually a defensive move as a result of landownership by developers. So-called 'red-for-green' projects are examples of public-private partnerships, where 'red' refers to the land in residential and industrial use, and 'green' to agriculture, nature, landscape, outdoor recreation and environment uses. 'Red-for-green' refers to the investment in the construction of

[2] As of 1 January 2007, there are 483 municipalities a decrease from early years as a result of the regrouping and merging of various local authorities.

public 'green' areas, using money earned with the development of 'red' areas by private organizations.

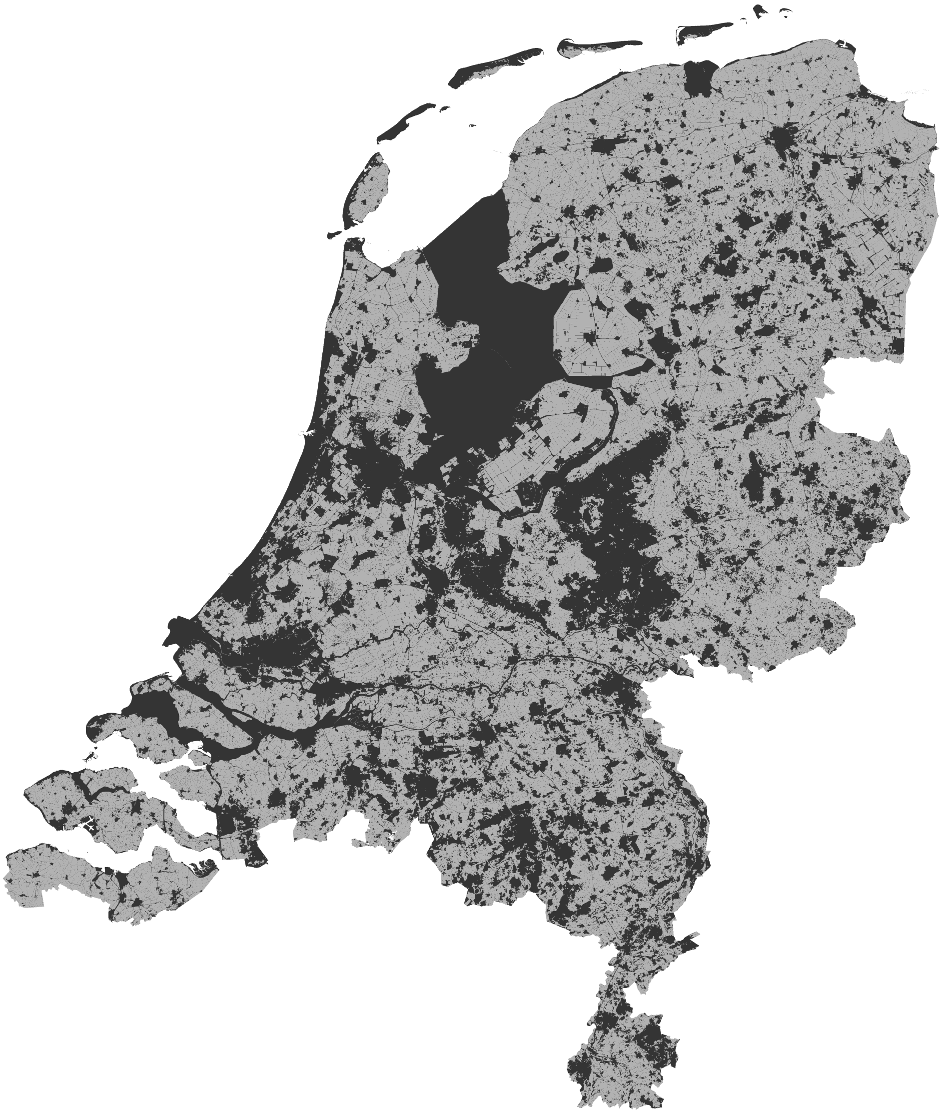

Figure 4.1 Net EHS regions appointed in 2004 in the Netherlands.

Provincial governments are an intermediary in the land development process, as their role has traditionally been more limited than the role of municipalities. Their primary concern is the 'green' function of land. Provinces would handle the planning of these natural areas, but left the implementation to the central government's Rural Area Department (*Dienst landelijk Gebied, DLG*) of the Ministry of Agriculture, Nature and Food Quality, which operated under its own guidelines (Louw et al. 2003). The DLG purchases land in order to complete the National Ecological Network (*Ecologische Hoofdstructuur, EHS*) introduced in 1990 (LNV, 1990).[3] The aim of the EHS is to connect nature areas in the Netherlands, so that these areas are not isolated and the survivability of animal and plant species is improved. Provincial governments play a key role in deciding which areas should be zoned as future nature areas. Provinces face ambitious targets in terms of the number of hectares

[3] Aside from the involvement of the DLG, the central government only acquires land for its own purposes (offices, prisons, etc.) and hardly ever takes on land development (Louw et al, 2003).

that are to be protected; this task is increasingly challenging as land values rise (especially near the urban fringe) and speculation drives farmland values up in the hope of converting it to more lucrative 'red' function uses (Louw et al. 2003). A picture of the net EHS region appointed in 2004 is shown in Figure 4.1.

Initially, the selection of the EHS areas was based on Land Use Planning projects, which rearranged land use function within certain areas. About 70 percent of all purchases of land by the DLG was made within these projects. Land Use Planning projects are a result of the Land Use Planning Act of 1985 (Van Klaveren, 2005). Within these projects, the focus of land use planning takes into account agriculture, forestry, nature, landscape, recreation and cultural heritage, but infrastructural projects and water management can also be a part of Land Use Planning projects. Traditionally these projects focused on the fragmentation issue by enabling voluntary exchange of parcels among farmers with financial government support. These projects could benefit farmers as they could obtain parcels adjacent to their existing properties in exchange for parcels located further away. Nowadays, provincial governments are responsible for Land Use Planning projects. Some projects are voluntary as farmers do have a vote, but others are mandatory with farmers forced by law to meet the requirements resulting from the government's planning decisions.

As a result of the Spatial Planning Act, all land in the Netherlands is zoned, implying that all land currently in agricultural production is zoned as agricultural land. At the central government level, there is only one agricultural zoning category, but, at the municipal level, specific regulations allow for particular types of agriculture in various areas. Residential buildings on farmland are not allowed in principle, although existing structures including residences are preserved. Additional farm buildings can only be built if the municipality in charge changes its zoning plan.

The Dutch agricultural sector is not only protected by zoning regulations, but farmers also receive direct income support, which is based on European legislation, specifically the Common Agricultural Policy (CAP) (European Commission, 2003). However, the effect of direct income support on farm-survivability cannot be investigated within the hedonic pricing framework as it is unknown how much support different sellers and buyers receive.

Upon comparing land use policies between these jurisdictions, we conclude that different strategies are used to prevent 'scattered' landscapes. In contrast to the ALR's objective of protecting farmland, Dutch policy is focused more on the preservation of 'green' areas, with less emphasis on agricultural use and more on nature reserves and parks, even though land is zoned for agriculture and there is a desire to support farming.

4.3 Agricultural background

4.3.1 British Columbia

Only three percent of British Columbia's land is suitable for agriculture, and only 0.6 percent of this is classified as prime farmland (or class one land) according to the Canadian Land Inventory soil and climate classification system (Runka, 2006). Although British Columbia's class one land is some of

Canada's most fertile, it is chiefly located in three areas – the Fraser Valley (near Vancouver in the southwest), southern Vancouver Island (near Victoria, the capital city), and the Okanagan Valley in the south-central interior. Thus, the best farmland is coincident with the largest and fastest growing urban areas, putting strain on the farm economy.

Figure 4.2 Distribution of land use on the Saanich Peninsula.
Source: Ministry of Agriculture and Lands and the Capital Regional District, edited map.

In terms of cash receipts, British Columbia's major crop types are floriculture and nursery, potatoes and vegetables, and dairy products, followed by poultry and eggs, calves and cattle, and greenhouse vegetables; berries and grapes, tree fruits, and grains and oilseeds contribute much less (MAL, 2006a). The province's cropping regions are segregated by climate, with hay, grains and oilseeds constituting the major crops in the northeast, which is part of Canada's grain belt and thus benefiting most from Canada's agricultural support programs and falling under the jurisdiction of the Canadian Wheat Board. Cattle and livestock dominate the north and central interior; the south-central Okanagan Valley is the centre of British Columbia's rapidly growing wine industry and produces large quantities of fruit; the Fraser Valley in the southwest produces a large variety of crops, including field crops, berries and greenhouse products; and, finally, southern Vancouver Island can grow any non-tropical crop (MAL, 2006a). Unlike the northeast, these areas generally do not benefit from direct forms of farm subsidies, although milk, egg and poultry producers throughout the province participate in Canada's supply-management (quota) regimes and livestock producers benefit from transportation subsidies that lower feed costs.

The focus in our study is the Saanich Peninsula, near the provincial capital of Victoria on southern Vancouver Island. The peninsula contains three municipalities (Saanich, Central Saanich and North Saanich) and has climate capable of supporting a large variety of crops. The distribution of land use on the Saanich Peninsula is indicated in Figure 4.2.

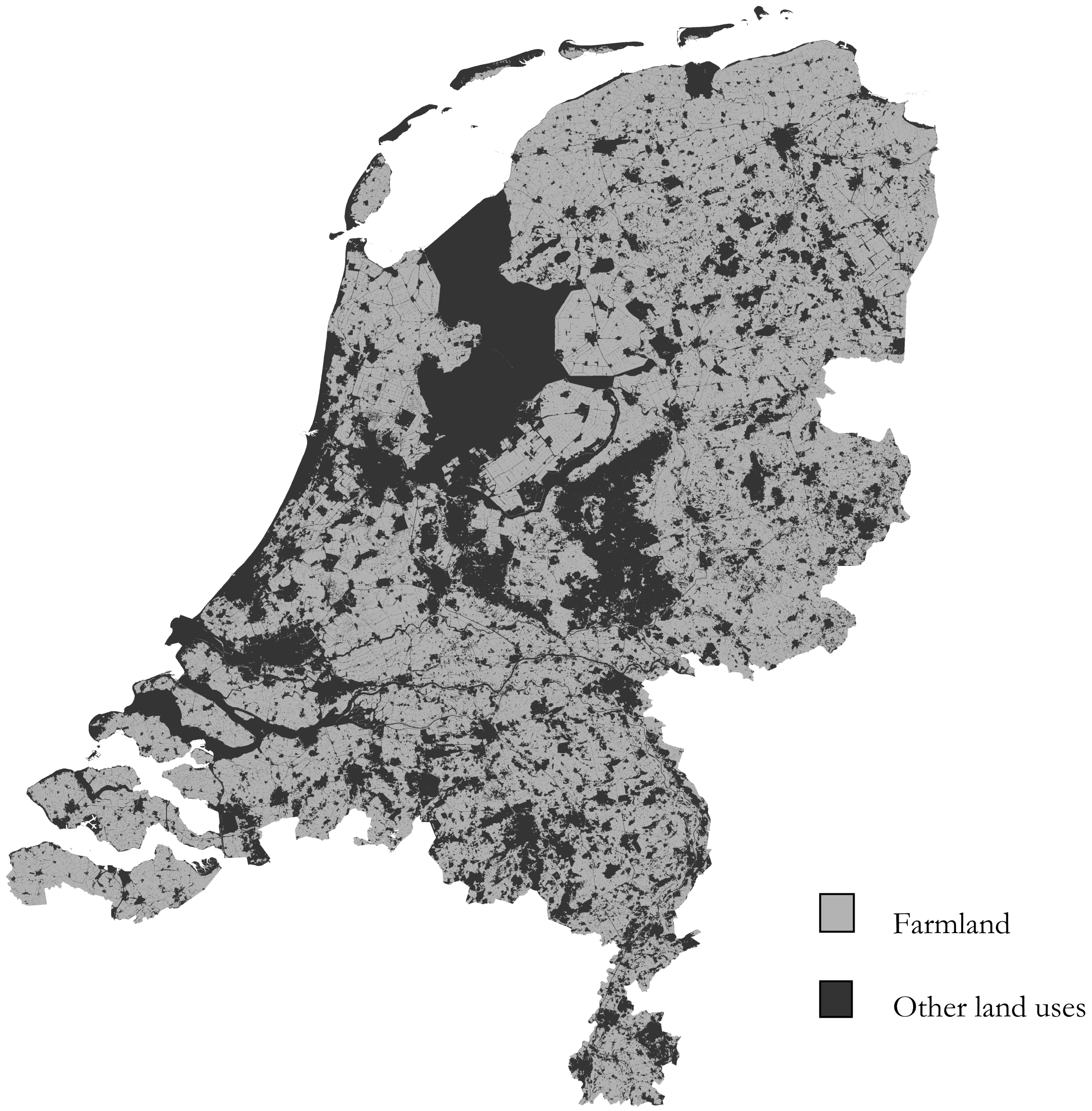

Figure 4.3 Distribution of land use in the Netherlands.
Source: Statistics Netherlands, edited map.

4.3.2 The Netherlands

The Netherlands is quite flat with most of its area suitable for agricultural production. More than 46 percent of total land area is under seasonal or permanent crop production (Statistics Netherlands, 2003). Grasslands account for about 51 percent of all agricultural land, much of which provides forage for the country's dairy cows. Because of its large claim on land, dairy farms have a profound effect on the country's landscape. A variety of other crops are also grown, including sugar beet, potatoes, wheat and bulbs. The distribution of farmland and other land uses is indicated in Figure 4.3.

Although the situation in each of these jurisdictions appears very different, British Columbia is significantly larger (94.78 vs 3.39 million ha) and much less densely populated (4.5 vs about 400 people per km^2). Yet the same threats apply to farmland in both jurisdictions and farmers face similar challenges. Although British Columbia is about 28 times as large as the Netherlands, it has only 2.5 times more land in agricultural use because, while nearly all land in the Netherlands is suitable for agriculture, British Columbia's mountains and climate (rainfall on the west coast, extreme cold in the north) restrict crop and pasture area. Urban pressures are, surprisingly, comparable in both jurisdictions. In the Netherlands urban and agricultural uses compete everywhere for land, while prime farmland in British Columbia is located mainly close to the three major and rapidly-growing cities (Vancouver, Victoria, Kelowna). These urban pressures result in similar land conversion patterns. During the period 1975 to 2003, total farmland in the Netherlands declined by 158,880 ha to 1,923,084 ha; in British Columbia over a similar period, land excluded from the ALR amounted to 137,271 ha compared to a total in 2007 of 4,759,668 ha. (Although the ALR does not represent all the agricultural land in British Columbia, it is a pretty good proxy.)

4.4 Hedonic pricing model, data and variable specification

To investigate the impact of farmland and other characteristics on agricultural land prices, hedonic pricing models (Rosen, 1974) are specified for the Saanich Peninsula of Vancouver Island, British Columbia, and the Netherlands. These models are specified as:

$$P = X\beta + \varepsilon, \qquad [4.1]$$

where P is a vector of property prices, X a matrix of property characteristics, β a vector of associated parameter coefficients to be estimated, and ε the vector of error terms.

4.4.1 Data

The data consist of 932 farmland parcels that were sold in the period 1974 to 2006 on the Saanich Peninsula. Observations begin with the introduction of the ALR. All 'single cash' transactions that took place within the farming sector in the specified period were taken into account. Transactions that included more than one parcel were discarded. Further, only parcels that could be linked to all other datasets were selected, so that for each observation all explanatory variables were available.

For the Netherlands, a sample of 947 transactions that took place in 2003 was used in the analysis. For all transactions, both sellers and buyers were farmers. And no buildings were present and parcels were only selected if all explanatory variables were available (see also Chapter 2). In the Dutch sample, it was possible to include transactions that consisted of more than one parcel because of the way the transaction database was constructed. Because regional differences are expected to drive transacted prices due to different motives for selling and buying land in different areas, the sample of 947 sales was split into transactions that occurred in urban, rural and semi-urban areas.[4] The division between urban and rural areas was based on the level of urbanization of the area in which a parcel is located. This level was based on the Reilly index (Shi et al. 1997).

The Reilly-index for parcel *i* is given by

$$R_i = \sum_{k=1}^{K} \frac{Pop_k}{d_{i,k}^2}, \qquad [4.2]$$

where Pop_k is the population of urban area *k* and $d_{i,k}$ the distance between parcel *i* and the *k*-th urban area. All urban areas within 100 km of the parcel are taken into account.

In the Netherlands, transactions in a single year were selected, whereas sales over a period of more than thirty years were used for the Saanich Peninsula. The reason for this is that the Saanich Peninsula is smaller in area and population, so fewer transactions take place in a given year. The time span of the data poses an additional challenge with respect to controlling for inflation of prices over time.

4.4.2 Variable specification and functional forms

For both study areas, many different data bases were collected from various government and private sources; these were used to construct the dependent and explanatory variables. ArcGIS was used to link data sources and construct distance and other location variables. In both studies, the price of farmland per hectare (ha) was used as the dependent variable. For Saanich, the dependent variable was obtained from LandCor (a private company) and BC Assessment; for the Netherlands, it was obtained from DLG's Cadastral Land Sales Database.

In order to analyze farmland values on the Saanich Peninsula, the following explanatory variables were defined: parcel size, indicators of the profitability of land (e.g., dummy variables for fruit trees, cows, poultry), ALR designation, exclusions from the ALR, elevation levels, presence of buildings on the lot, hobby farmers and macroeconomic variables, such as mortgage rates and GDP. The ALR-dummy variable only represents the situation in 2005, so the number of hectares excluded from the ALR each year was also included as an explanatory variable. Using ArcGIS, we calculated a variety of distance measures, including distance to Victoria and the major highway that transverses

[4] Only results of urban and rural areas are discussed in this paper, as the transaction prices in semi-urban areas were hard to explain.

the peninsula, and created an index of fragmentation for each parcel. The fragmentation index was specified as the percentage of the perimeter bordering other farmland multiplied by the size of the total farm block of all the farmland that was adjacent to the parcel.

In the Dutch farmland model, some indicators of the agricultural profitability of land, such as standard size units per ha (NGE per ha), soil type and a dummy for livestock grazing were specified as explanatory variables. GIS was used to determine distances to residential areas, industrial areas, recreational areas, (wet) nature areas, greenhouse horticulture, fresh water and the nearest highway. Zoning indicators were specified, such as the dummy variables for land within the EHS and land within Land Use Planning projects, though indicators for agricultural zoning schemes are not included in the model as all farmland is also zoned as agricultural land. Land Use Planning projects are divided into projects where farmers participate voluntarily and those where participation is mandatory. Parcel size and the level of urbanization represented by the Reilly index (Equation [4.2]) were taken into account as well as rented land. (In the Netherlands, lessees are protected by law, resulting in low lease prices and leaseholders cannot prematurely abort leaseholds without the lessee's consent.) Furthermore, a dummy variable was specified for transactions between family members and an indicator of market power of either buyers or sellers was specified. This indicator was specified as (number of sellers – number of buyers)/(number of sellers + number of buyers). Market power supposedly influences prices because farmers do not wish to purchase land too distant from their currently owned lands, which results in a localized markets for farmland with few participants and significant market power effects.

The reason for specifying different variables for the two hedonic pricing models is that different factors influence transaction prices of farmland in these two jurisdictions. The Saanich Peninsula is a well-defined hilly area, surrounded by ocean and affected only by the city of Victoria. The Netherlands is a larger area where elevation plays no role because of the flatness of the countryside, and a greater number of factors affect farmland prices. There are also many more urban areas exerting influence on farmland prices. Another reason for using different explanatory variables is due to data availability.

In the Saanich model many of the explanatory variables are inherently highly correlated. For example, the fragmentation measure is related to the ALR designation because farmland within the ALR is less fragmented than farmland outside the ALR. The variable indicating soil quality is correlated with the ALR-dummy because only lands with a high soil quality were included in the ALR. By definition one expects correlation between these variables. Furthermore, elevations are correlated with distance to the highway because the highlands are located in the western part of the peninsula whereas the main north-south highway runs along the lower eastern portion. Finally, distance to the Swartz Bay ferry terminal (to Vancouver) and distance to Victoria are almost perfectly correlated as the ferry terminal is situated on the northern tip of the peninsula while the city of Victoria is located at the southern end. Multicollinearity is addressed by leaving some of the explanatory variables out of the regression model (Wu et al. 2004). The reason why multicollinearity is not a major concern in the Dutch farmland model is that not all the explanatory factors are so dependent on one another – the area is larger and not isolated as with a peninsula.

Different functional forms are used for the study regions – a double-log functional form was specified for the Saanich Peninsula and a linear function for the Dutch data. The former is generally preferred because linear functional forms have the disadvantage that they suggest that parcel characteristics can easily be repackaged, so that nonlinearities will not exist as a result of arbitrage (Rosen, 1974). In the Dutch model, a linear functional form was chosen to focus on the symmetric results of market power. However, nonlinearities in the form of inverse transformations were allowed for explanatory variables related to distance.

Table 4.1 Regression Results of the Hedonic Pricing Model of Farm Land Markets on the Saanich Peninsula (n = 932), with robust standard errors.

Dependent variable: Price per ha	Parameter estimates	Probability
Land use policy indicators		
ALR (=1 if parcel is located within the ALR, 0 otherwise)	-0.1128**	0.035
Excluded number of hectares in the transaction year	0.0015	0.497
Distance to ALR boundary in km (distance is negative if the parcel is located within the ALR, and positive otherwise)	-0.1473**	0.048
Fragmentation index ((proportion of perimeter bordering other farmland × size of total farm block of all adjacent farmland in metres)/100,000)	0.0112*	0.077
Land use indicators		
Log of distance to Victoria city centre (City Hall)	-0.0842*	0.090
Log of distance to highway	0.0170	0.120
Profitability of farmland indicators		
Log of parcel size (ha)	-0.7109***	0.000
Tree fruit (=1 if tree fruits are grown on parcel, 0 otherwise)	-0.0294	0.856
Cows (=1 if farm is beef or dairy farm, 0 otherwise)	0.0321	0.631
Poultry (=1 if farm is poultry farm, 0 otherwise)	-0.1857*	0.056
Vacant land (=1 if no building is present, 0 otherwise)	-0.4749***	0.000
Hobby farmers (=1 if farm is a hobby farm, 0 otherwise)	-0.0560	0.256
Macro economic indicators		
Log of GDP	1.0249***	0.000
Log of mortgage rates	-0.2361***	0.007
Constant	-0.2162	0.804
R^2	0.7561	

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels.

4.5 Empirical results

4.5.1 Hedonic pricing results for the Saanich Peninsula

The regression results for the Saanich Peninsula are reported in Table 4.1. About 76 percent of the total variation in the logarithm of sales prices is explained by the model. Land located within the ALR sells at a significantly ($p<0.10$) lower price than that outside the ALR. This corresponds with the idea that prices in different submarkets are related to the profitability of the permissible land uses, with land in agriculture having lower value than that used for commercial and residential purposes (see also Chapter 2). Indeed, the statistical significance for the ALR dummy variable might even be higher except that on some parcels there is speculation that land in the ALR might be removed at some time in the future (Shi et al. 1997). We do not find a significant effect of the number of hectares excluded from the ALR in each year on farmland values. This means that we do not find evidence for an increase in the speculation on farmland as a result of the exclusions of ALR land that take place.

Although we hypothesized that farmland values are determined by the ALR, one could argue that causality is the other way around – farmland prices increase because of urban pressure and, as a result, it is excluded from the ALR. If this argument is true, our ALR variables would be endogenous and our empirical findings would be biased. Thus, we tested for endogeneity using the Hausman test, and included indicators about the party in government as an instrument for the ALR variable. The indicators were the percentage of votes garnered by the four largest parties (New Democratic Party, Social Credit, Liberals and Greens) and dummy variables for the parties that formed the government. These indicators were used because we assumed that exclusions from the ALR depend on the political climate. Given that these indicators were the right instruments, we found no evidence for endogeneity in our model.[5]

We found a significant ($p<0.10$) negative effect for distance to the ALR boundary. Because this variable takes on negative values within the ALR and positive values outside the ALR, this implies that the closer a parcel is to the centre of the ALR, the higher its price. As land closer to the centre of the ALR is less fragmented, this supports our finding for the fragmentation variable. Parcels that are less fragmented, and often located closer to the centre of the ALR, sell for significantly ($p<0.10$) more than parcels that are fragmented and probably closer to residential and commercial properties. This finding also suggests that externalities caused by nearby residences and other non-farm uses lower farmland values.

Parcel size also plays an important role in the determination of price. The log of the lot size is highly significant ($p<0.01$) and has a negative effect on the log of prices. This is contrary to the expectation that farmers seek to acquire large properties to realize economies of scale, because with respect to agriculture, larger parcels should have higher productivity levels than small ones (Cavailhes and Wavresky, 2003). However, Colwell and Munneke (1997; 1999) point out that when parcels are purchased for development purposes, prices are negatively correlated with increasing parcel size due to subdivision costs of parcels if the land would ever be excluded from the ALR and used for development purposes. Further, since ALR land is difficult to subdivide, larger properties would be a deterrent to those wanting rural estates or hobby farms, although, as noted above, there are some tax advantages to having parcels greater than one ha (Dove, 2007). Hobby farmers do indeed buy smaller lots than regular farmers. On average hobby farmers buy parcels of 1.91 hectares, whereas regular farmers buy 3.75 hectares.

Macroeconomic variables are important in the model because the data span a period of more than 30 years. Prices are expected to rise and fall jointly with macro-economic changes. For example, we find that farmland prices rise significantly ($p<0.01$) with increasing Gross Domestic

[5] The Hausman test-statistic had the value 5.45. Under the null hypothesis this is distributed as Chi-squared with 14 degrees of freedom. So the null hypothesis is not rejected ($p= 0.9785$).

Product (GDP). As the country's GDP increases, people are wealthier and able to spend some of the additional income on land purchases, increasing the demand for land and its price. Furthermore, as interest rates increase, borrowing is less affordable and demand for property decreases (and property prices fall). This is in line with the significant ($p<0.10$) negative impact of mortgage rates on farmland prices.

Finally, vacant land is significantly ($p<0.01$) less valuable, indicating that structure add to the value of a property, ceteris paribus. The presence of poultry farms also decreases land values significantly ($p<0.10$), perhaps because poultry farms do not need high quality land, which is usually more valuable. Further, poultry farms would be less appealing for people purchasing farms for other purposes (residence, hobby, agro-tourism) and they would be more costly to develop.

4.5.2 Hedonic pricing results for the Netherlands

With respect to the Dutch model, we provide only the key results (Table 4.2). Some non-significant control variables, such as soil variables and variables related to the personal characteristics of buyers and sellers are not presented. For a discussion of the full model, see Chapter 2. Separate regression results are provided for farmland in rural and urban areas. The model for the urban areas explains about 76 percent of the total variation of farmland prices. In these areas, prices are mainly driven by the level of urbanization as represented by the Reilly index ($p<0.01$). The nearer that parcels are to urban areas, or the larger the nearby urban area, the higher are farmland prices, indicating that speculation is taking place even though agricultural zoning is in place. With respect to zoning schemes, only the obligatory Land Use Planning projects have a significant ($p<0.01$) negative impact on prices. Within these projects participation is obligatory for farmers, so land use must be changed within these areas. Other characteristics of farmland only explain a small amount of agricultural land prices. For example, family relationships between buyers and sellers have a significant ($p<0.05$) negative effect on prices and rented land is sold for significantly ($p<0.10$) less. Further, the proximity to recreational areas has a positive effect on farmland prices, indicating either speculation or the positive effect of possibilities to start up non-agricultural activities such as campsites.

With respect to the more rural farmland areas, about 35 percent of the total variation in land prices could be explained within the model. In these areas prices are mainly driven by farm activities and speculation plays almost no role as indicated by the statistical insignificance of the Reilly-index. Further evidence that farming is the dominant activity comes from the negative externalities created by nearby residential areas and highways. Examples of negative externalities from residential uses on farmland are mobility and environmental effects as well as fragmentation of farmland and complaints from residents about noise and odors from farming activities. Also, as a result of accessibility and because many industrial parks are built along the highway, we would expect a positive impact of proximity to highways and residential areas if speculation plays a role. On the contrary, because farming is still viable in these areas, highways have a negative effect perhaps because nearby highways make it harder for farmers to extend their farming area in the future.

With respect to other surrounding land uses, nearby greenhouse horticulture has a positive impact on farmland prices. As greenhouse horticulture is not allowed everywhere, speculation on future zoning takes place. Nearby recreational areas have a positive effect on farmland values. If recreational activities already take place in the area, the profitability of additional on-farm non-agricultural activities such as campsites is very likely to be higher. Finally, the nearness of wetlands has a negative impact on the prices of farmland, due to higher ground water levels in these areas.

Table 4.2 Regression Results of the Hedonic Pricing Functions of Farmland Markets in the Netherlands, with robust standard errors.

Dependent variable: Price per ha (in €10,000)	Rural model Reilly <0.005 (n = 393)		Urban model Reilly >= 0.010 (n = 226)	
	Coefficient	Prob.	Coefficient	Prob.
Land use policy indicators				
Reilly index	75.8890	0.436	27.4892***	0.000
EHS (parcel within EHS = 1, 0 otherwise)	-0.8957**	0.013	-0.5083	0.408
Land use planning mandatory (=1, 0 otherwise)	-0.4231*	0.076	-1.6134***	0.004
Land use planning voluntarily (=1, 0 otherwise)	-0.0260	0.886	-0.6411	0.270
Land use indicators				
1 / distance to nearest residential area (km)	-0.1506**	0.022	-0.0778	0.437
1 / distance to nearest industrial park (km)	0.0226	0.450	0.1136	0.537
1 / distance to nearest recreational area (km)	0.4236*	0.070	0.2613*	0.053
1 / distance to nearest nature area (km)	-0.0085	0.219	-0.0006	0.986
1 / distance to nearest wet nature (km)	-0.2005**	0.019	0.1974	0.391
1 / distance to nearest greenhouse horticulture (km)	0.2684**	0.021	0.1353	0.108
1 / distance to nearest fresh water (km)	0.0167	0.780	-0.0750	0.218
1 / distance to nearest highway (km)	-0.3548***	0.009	0.0055	0.981
Profitability of farmland indicators				
Parcel size (ha)	-0.0113	0.722	0.0463	0.771
NGEperHabuy if seller and buyer are not family, 0 otherwise	1.5435	0.431	-28.7638***	0.008
NGEperHasell if seller and buyer are not family, 0 otherwise	-10.5301	0.417	82.9490	0.451
GrazingFarmAnimalsbuy if seller and buyer are not family, 0 otherwise	-0.5053**	0.020	-1.3748**	0.048
GrazingFarmAnimalssell if seller and buyer are not family, 0 otherwise	-0.3772*	0.073	1.2922*	0.080
Other indicators				
Market power if seller and buyer are not family, 0 otherwise (N1)	-2.3751**	0.014	2.2467	0.262
Land is rented (=1, 0 otherwise)	-0.1828	0.746	-1.5490*	0.071
Buyer and seller are family (=1, 0 otherwise)	-2.6712***	0.004	-8.9309**	0.025
Constant	4.2956***	0.000	12.7091***	0.003
R^2	0.3527		0.7571	

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels. Probabilities in parentheses.
Source: modified from Table 2.3 in Chapter 2 and used with permission of *Land Economics*.

With respect to zoning, we find a negative impact of land zoned for future nature purpose. Within EHS areas, statistically significantly ($p<0.05$) lower prices were paid for agricultural land, probably because land in these areas does not have potential future farm or urban use, which lowers its option value. Restrictions on farm uses, such as agro-environmental schemes, are likely in place in these areas. No significant effects are found for voluntary participation within land use planning projects, although, for mandatory projects, a significant ($p < 0.10$) negative effect on farmland prices is found. These mandatory projects might not serve farmers' best interests because farmers have no say in the way land is redistributed between different land use functions.

Although, farming is the main activity in more rural farmland areas, indicators of farmland profitability are not very significant in our model estimates. Proxies, such as soil type and NGE per ha, are not statistically significant although evidence suggests that farmers who 'graze farm animals' value land less ($p<0.10$) than other farmers. As farms that graze farm animals require mainly pastureland, land quality is lower and so are prices. The reason that indicators of farmland profitability are not very important is likely due to technical improvements in agriculture.

Not surprisingly, market power has a significant ($p<0.05$) impact in rural land markets. With relatively more buyers than sellers on the market, sellers have market power and prices are higher. On the other hand, with a relatively low number of buyers compared to sellers, buyers have market power, generally resulting in lower prices.

Finally, no significant impact of parcel size is found in this model. Therefore, it is not clear that the 'economies of scale' argument of Cavailhes and Wavresky (2003) or the subdivision cost argument of Colwell and Munneke (1997; 1999) is more appropriate for describing the situation within rural farmland markets in the Netherlands.

4.6 Conclusions and discussion

Using empirical results from two studies in different political jurisdictions, we examined whether farmers can survive in the urban-rural fringe, given extant legislation to protect farming. The answer seems to depend partly on how vigorous agricultural zoning is within those areas: If zoning plans change easily, zoning is less credible and speculation about the future ability to develop farmland increases (Blewett and Lane, 1988; Nickerson and Lynch, 2001; Shi et al. 1997).

On the Saanich Peninsula of British Columbia, the price of farmland within the ALR is lower than that outside the ALR, indicating that zoning schemes are at least partially credible, even though exclusions of ALR land have occurred. Further, farm parcels that are less fragmented are slightly more valuable than those that are not, and this partly offsets speculation. Yet, some agricultural activities occur outside the ALR, indicating that some farmers are able to survive without ALR zoning and amid highly fragmented landscapes, oftentimes taking advantage of agro-tourism opportunities that are in demand near the urban fringe (Dove, 2007).

Our findings also indicate that speculation or 'rurbanization' is taking place on a large scale in the Saanich Peninsula, particularly as smaller agricultural lots sell for relatively higher prices. Smaller lots are more attractive to hobby farmers and buyers of rural estates, though they are less attractive to farmers. Higher prices signify that these lots are likely bought for residential or hobby farm purposes by those craving a rural lifestyle in close proximity to a large urban area. Overall, the higher prices for small farm parcels and inexperienced buyers bode ill for sustaining viable commercial agriculture on the urban fringe (Millward, 2006).

In British Columbia, the requirements for farm class status and lower tax rates favor farms of one to four ha and may, counter-intuitively, work against agricultural preservation as 0.8-4 ha parcels are clearly preferred by hobby farmers; the low threshold for achieving farm class status makes it cheaper to own a large rural estate that is not farmed efficiently or professionally. If the purpose of preferential tax treatment is to slow down development and retain open space, the policy employed by BC Assessment may be efficient. The literature shows that, although preferential tax rates cannot halt conversion of agricultural land, they can alter the timing decisions for conversion (Anderson, 1993; Conklin and Lesher, 1977). However, if the purpose of farm class status is to help support a viable farm economy, then preferential taxes seem to contribute to the growth of hobby farms and large rural estates by changing the relative price of land (Blewett and Lane, 1988). By raising the threshold or implementing other hurdles to achieving farm class status, the government could reduce the desirability of living on large rural estates.

In the Netherlands, we find that agricultural zoning is more credible in more rural areas than urban ones, as prices in urban areas are affected by speculation to a greater degree. In urban areas, pressures to change zoning plans are much stronger and re-zoning usually favors developers. Therefore, the degree of urban development pressure determines farm profitability and survivability as agricultural returns might then be insufficient to cover higher land costs.

In more rural areas, in contrast, nature and recreational uses of farmland compete with agricultural use. Farmland prices in rural areas are impacted by future nature zoning. The reason is that green development is often loss-generating, and prices in rural areas are still relatively low, so these are the areas where the DLG can still compete with other buyers of land. In urban areas, land values are too high for future zoning of the EHS to be credible because farmers are reluctant to sell land to the DLG because they would earn much more selling at some future date to a developer for commercial or residential use. Furthermore, in both urban and rural areas farmers find that recreational activities, such as campsites, are becoming relatively more lucrative. As a result, more and more farmers are engaging in non-agricultural activities that compete with agriculture uses of land. Dutch farmland is consequently under development pressure in both rural and urban regions, albeit the form of development is much different in the two areas.

We can conclude that farmland in the Netherlands and in rural-urban areas near British Columbia's fastest growing cities is under serious threat, although these threats are expressed in different ways. Urban development and nature preservation, especially in the Netherlands, compete with agriculture for land, while the types of activities constituting agriculture are shifting as well. In order to make land more competitive with urban and other uses, owners of agricultural land in both areas increasingly engage in non-agricultural, tourism-oriented activities (e.g., bed and breakfasts, camping, horse stables, u-pick berry, renting of garden plots) that enable them to earn revenues that cover land costs in addition to labor and other variable inputs. An alternative strategy involves more intensive agriculture, such as greenhouses, or a focus on speciality products, such as organic farming, intensive horticulture and grape growing (Cardone, 2007). In any event, it is clear that agriculture in highly urbanized regions is changing.

CHAPTER 5

HOBBY FARMS AND PROTECTION OF FARMLAND IN BRITISH COLUMBIA[1]

Abstract

Agricultural land protection near the urban-rural fringe is a goal of many jurisdictions, and none more so than British Columbia, Canada, which uses province-wide zoning to prevent subdivision and non-agricultural uses of zoned land. Preferential farmland taxes are also in place in many jurisdictions, as are small-scale hobby farms near major urban centers. In the study area, the Saanich Peninsula near the capital Victoria, hobby farms are found both inside and outside of the Agricultural Land Reserve (ALR). We investigate whether or not hobby farms are an obstacle to agricultural land preservation. We make use of a geographic information system (GIS) model to construct detailed spatial variables and employ two approaches to analyze parcel-level data – a hedonic pricing model and the propensity score method. Results from both approaches indicate the existence of hobby farms has served to raise land prices within the ALR. Outside the ALR, however, hobby farms are worth less per ha than conventional farms.

5.1 Introduction

Protection of agricultural land, especially near urban areas, is an important public policy objective in many jurisdictions. Zoning is the most widely used instrument for protecting agricultural land, and it is used in British Columbia (BC), Canada, where most agricultural land is in the province's Agricultural Land Reserve (ALR). One of the downsides of zoning is that it creates an incentive for landowners to lobby for variances so they can transfer land from lower-valued agricultural uses to more valuable ones. In jurisdictions where the probability of being granted an exclusion is high enough, those wishing to develop the land or otherwise change its use have bid up the price of farmland beyond its agricultural value. In British Columbia, the primary policy response to speculation has been to provide landowners with tax breaks (farmland is taxed at much lower rates than developed land) to encourage retention of land in active agriculture. But this creates a whole other set of incentives, especially along the rural-urban interface, as illustrated in this chapter.

The lower tax burden on farmland might be partially responsible for the growing number of hobby farms and large rural estates in the urban fringe. In some jurisdictions, the threshold for

[1] This chapter is a paper by Stobbe, T., G. Cotteleer and G.C. van Kooten, submitted to the Canadian Journal of Regional Science.

qualifying for preferential taxation rates is set deliberately low in order to make agriculture an attractive land use, although this has the unintended consequence of subsidizing wealthy landowners pursuing a rural lifestyle in proximity to the urban area (see also Chapter 4). Given that property taxes account for about 40 per cent of municipal revenues in British Columbia, residents might not support tax regulations that favor hobby farmers. Nickerson and Lynch (2001) indicate that residents dislike the fact that tax dollars are spent on hobby farmers who do not use the land in pursuit of 'traditional' agricultural activities.

When surveyed, British Columbia residents indicated strong support for agricultural land protection; for instance, in 1997, 90 per cent said they favored limits to urban development to protect farmland (Quayle, 1998) and, in 2005, 94 per cent of Central Saanich residents said they felt agriculture contributed greatly to the community (Walker, 2005). However, researchers and policy-makers alike should question why so many people favor protection of agricultural land as a matter of principle. Hobby farms might be a positive development if the purpose of agricultural land protection is to slow development and retain open space and if hobby farming is not a first step in the direction of urban use of the land. If, on the other hand, the purpose of the ALR is to help support a viable farm economy, growth in hobby farming could be considered a step in the wrong direction as it could exert pressure on farmland values within the ALR thereby driving out conventional farmers.

In this research, we investigate whether the establishment of hobby farms is detrimental to the goal of agricultural land preservation. We do so by focusing on the role of hobby farming within and in close proximity to the ALR. We test whether hobby farmers affect prices inside and outside the ALR, and identify what implications this has for the effectiveness of the ALR and other policy measures to protect agriculture in the urban shadow. We compare the results of two approaches for investigating the divergence between the price paid by conventional and hobby farmers in relation to the ALR. First, the hedonic pricing model employed in Chapter 4 is extended to allow for divergence between the two farming types. Second, the propensity score method is used to control for a potential endogeneity bias with respect to hobby farms in the hedonic pricing model.

The outline of the remainder of the paper is as follows. In section 5.2, we consider why government intervention is needed to protect farmland. In section 5.3, we provide background information about agriculture in British Columbia and the Agricultural Land Reserve as an instrument for protecting farmland. The methods we employ are described in section 5.4, followed by a discussion of the data and variables in section 5.5, the estimation results in section 5.6. Our conclusions and policy implications follow in section 5.7.

5.2 Government interference and externalities at the urban-rural fringe

Legislation, policies and other instruments to protect farmland are justified on the grounds that the protected good is a public good or provides positive externalities, with farmland being under provided if left to markets and private individuals. The main output from farmland is marketable goods, but farmland also provides a variety of positive externalities. One might identify four types of value associated with agricultural land protection (Kline and Wichelns, 1996): (i) agrarian values relate to food production and protection of the agricultural heritage and traditions of an area; (ii) environmental values concern protection of wildlife habitat, flood prevention and other environmental services; (iii) aesthetic values focus on the preservation of open space; and (iv) anti-growth values see land protection as a safeguard against urban sprawl. Roe et al. (2004), Irwin (2002), Curran (2001), and others have shown that citizens are willing to pay significant amounts to protect these amenities.

While positive externalities can be used to justify zoning and other legislation to protect farmland (such as beneficial tax regimes for agricultural producers), it is more difficult to justify protecting agricultural land because society needs to retain the ability to produce farm products in the future (though many make this argument). For example, in a study completed for the provincial government, Quayle (1998) concludes that agricultural land should be preserved at all costs and that golf course development should not be permitted because it violates the ALR mandate. She argues that the magnitude and importance of the province's agricultural sector represent a sufficient reason to preserve all farmland via the ALR instrument.

Protection of agricultural land for the purpose of maintaining future agricultural production potential cannot be viewed as a public good because, if this is indeed a concern, the value of land in agriculture would rise relative to that in other uses in anticipation, thereby causing more agricultural land to be protected privately. Although agricultural production is important in some jurisdictions, especially where food security is a concern, the impetus for protecting farmland in British Columbia's urban fringe has more to do with a desire to protect a way of life, open space, access to farms for educational purposes, and other factors.

5.3 Agricultural land protection in British Columbia

British Columbia is Canada's westernmost province. It is characterized by rugged terrain, fertile valleys and, in some areas, the country's mildest climates. Its arable regions include part of Canada's grain belt (in the northeast), an intermountain region of livestock grazing and forage production, a Mediterranean inland lake region (the Okanagan Valley) noted for its orchards and vineyards, and wet mild areas in the southwest of the province. The latter consists primarily of the Fraser Valley on the mainland (near Vancouver) and the Saanich Peninsula near Victoria on southern Vancouver Island that offers a climate capable of growing the widest variety of crops in Canada.

Primary agriculture in British Columbia generates approximately $2.2 billion in farm gate sales and more than 30,000 jobs (MAFF, 2004; MAL, 2006b). When food processing and other related industries are taken into account, the totals become even more significant for the provincial economy – some $21.9 billion and more than 280,000 jobs. Yet only 2.7 per cent of the province is capable of growing a reasonable range of crops (Runka, 2006), and much of this land lies near the rapidly developing urban areas of Victoria, Vancouver and Kelowna, and thus is under increasing development pressure.

The provincial government created the ALR in 1973 after it was estimated that 6,000 ha of farmland were being lost to development annually. Included in the ALR at inception was all farmland of two or more acres (0.81 ha or more) that was assessed as farmland for tax purposes, zoned as agricultural land by local governments, or rated in land classes one to four according to the Canada Land Inventory.[2] Though ALR lands remain in private hands, owners cannot subdivide them, build more than one dwelling or use them for non-agricultural purposes. The ALR is overseen by the Agricultural Land Commission (ALC) which adjudicates applications for exclusions, sub-divisions or non-farm uses. A map of British Columbia's ALR is provided in Figure 5.1.

Figure 5.1 British Columbia's ALR and the study area.
Source: Smart Growth BC 2004, edited map.

[2] The Canadian Land Inventory rates land according to soil class on a seven-point scale, where class one land has the highest agricultural capability and class seven land no agricultural capability. Classes one to three constitute prime farmland (Runka 1973; van Kooten 1993, pg 271-274).

At the time of its formation, the ALR measured 4,715,897 ha, but it had grown to 4,759,219 ha by 2007, a net increase of 43,322 ha (Agricultural Land Commission, 1974-2007). These figures belie the true state of agricultural protection, however, because most of the land excluded over time has come from the fertile south while most additions have come from the more arid northeast. According to Statistics Canada's Agricultural Census (Statistics Canada, 1971-2001-2006), the number of farms in British Columbia has increased by 7.8 per cent since 1971 – a trend opposite that of the rest of Canada, although some turnaround in this trend was seen in the last agricultural census.[3] This suggests that farms consisting of two or more adjacent or non-adjacent parcels, whether in the ALR or not, are not being sold as a single unit. This is consistent with the observation that more hobby farms are found near major urban areas. As a result, the increase in farms is not necessarily an indication that the farm sector is thriving, but rather that it is dwindling, especially near urban centers.

Besides zoning policies to preserve farmland, British Columbia also utilizes beneficial property tax regulations to reduce farmers' financial burdens. A farm property attains farm class status (and thus lower taxes) if it meets the restrictions described in Table 5.1. The gross agricultural income threshold is quite low and a property between 0.8 and 4.0 ha can meet it, for example, by harvesting and selling approximately 0.07 ha of Christmas trees, the eggs from approximately 70 chickens, alfalfa from about 1.2 ha, a few head of livestock (depending on quality and species), or a combination of products.[4] It is also possible to attain farm status if the land is leased to another operator who meets the threshold, as long as the land makes a "reasonable contribution" to the overall farm operation (BC Assessment, 2005).

Table 5.1 Thresholds for properties to qualify for farm class status.

Parcel size	Annual revenue threshold to be met once every two years
< 0.8 ha	Gross farm revenues ≥ \$10,000
≥ 0.8 ha, < 4 ha	Gross farm revenues ≥ \$2,500
≥ 4 ha	Gross farm revenues ≥ \$2,500 plus 5% of land's assessed value

5.4 Methodology

The current research employs two approaches to investigate whether hobby farmers drive up prices in the ALR. The first is a general OLS model that is used to estimate a hedonic pricing function. Hedonic pricing functions are used to parse out effects of covariates that determine the prices of farmland in order to derive shadow prices for property characteristics. In the model, we include a

[3] The number of farms in BC declined by 2.2 per cent between 2001 and 2006, while the number of farms in Canada declined by 7.2 per cent during the same period, and by 37.3 per cent since 1971 (Statistics Canada, 1971-2001-2006 2006 #977). So BC farms are being lost or amalgamated at a slower rate than the rest of the country.

[4] This information comes from a 2007/2008 survey of twenty-five Saanich farmers and discussions with various provincial government staff. We discovered a certain laxity in the enforcement of farm status requirements. This may be to prevent developers from making a case before the ALC that some ALR lands should be excluded because they cannot meet minimal farm-status standards.

dummy variable indicating whether a farm parcel is inside the ALR or not and one indicating whether the farm is operated by a conventional or a hobby farmer. We include both dummies in the hedonic pricing model to highlight price differences paid by disparate types of farm operations and landowners inside or outside the ALR. We also included an interaction term between the ALR and the hobby farm dummy variable to test whether the use of land for hobby purposes affects land prices differently within and outside the ALR.

If the farmland has development rights so that it could be converted to residential use at any time, there is a potential endogeneity problem in the hedonic pricing equation regarding (Lynch et al. 2007). That is, the distribution of land use for residential versus agricultural purposes might be an endogenous process. However, endogeneity with respect to the ALR variable is not considered a problem because of historical factors and the fact that the ALR is a zoning ordinance. As already noted, all land assessed as farmland, municipally zoned as agriculture or rated in Canada Land Inventory classes 1-4 was included in the ALR in 1973. Subsequently, in Saanich until 2006, there had been only 16 applications to the ALC to remove land from the ALR, constituting a total of 228 ha; while 13 were successful, total exclusions amounted to only 76 ha (as the ALC might not grant a request to remove the full amount in the application). Clearly, land cannot be easily converted to residential use nor has a large proportion of the ALR in the study area been in land use flux.

We also might worry about the potential endogeneity of the hobby farm variable. It is very likely that hobby farmers select to buy parcels based on unobserved characteristics that are also affecting the prices of those parcels directly. To address this potential problem, we employ a non-parametric approach known as Propensity Score Matching (PSM), which was first introduced by Rosenbaum and Rubin (1983). It was applied to farmland markets by Lynch et al. (2007) to resolve endogeneity associated with an agricultural easement dummy variable. The PSM approach deals with treatment effects – the effects that a certain treatment has on a variable of interest. In our model, treatments occur when parcels are bought by hobby farmers, while the non-treatment or control group consists of parcels purchased by conventional farmers. The difference between the prices paid by the two groups of farmers can be viewed as the treatment effect.

The PSM method consists of two steps. In the first, the propensity score for each farmland parcel is calculated (in the current research) using estimates from a probit model. Propensity scores indicate how likely it is that a farmland parcel with certain characteristics is bought for hobby versus conventional purposes. In the second step, treated parcels are matched with non-treated ones so that the parcel characteristics are as similar as possible. The propensity score is used to match the treated and control parcels. Propensity scores are not likely to be exactly the same because the propensity score is a continuous variable between zero and one. We pair treated and control units using the (1) stratification, (2) nearest-neighbor, (3) kernel and (4) radius-matching techniques (Becker and Ichino, 2002). Since each measure has its advantages and disadvantages, we display the results of all four to indicate the robustness of the estimated treatment effects. After matching each treated unit to control units, average price differences between the two groups are calculated.

5.5 Data and variables

Based on the actual use codes recorded by BC Assessment, a total of 1,017 parcels of agricultural land on the Saanich Peninsula are included in the analysis. Because we had to exclude parcels due to linking problems with information from other datasets or because the full set of explanatory variables was not available for each observation, we ended up with 323 observations of sales that took place in the period 1990-2005 for use in the hedonic pricing model but 893 observations for use in the probit model. The numbers of observations differ because we were able to use information about all farmland parcels in the probit model, and not just those that were sold in the relevant timeframe. In the hedonic pricing model and for the computation of the average treatment effects, we used sales transaction data for the period 1990-2005 but only included data about the most recent sales transaction if a parcel was sold more than once during this timeframe. In this way we ensure that the current owner is correctly classified as a hobby farmer or conventional farmer. In addition, sales of multiple parcels bundled together were excluded because it was not clear how we could attribute the total price to the separate parcels in the bundle. Of the 893 observations of farmland that were used in the probit model, 117 are categorized as hobby farms, with the remainder considered conventional farms.

The Saanich Peninsula study area consists of 17,593 ha north of Victoria, the provincial capital, on southern Vancouver Island. It enjoys Canada's most temperate climate and contains some of the province's best farmland, growing a variety of crops such as fruits, vegetables and floriculture, as well as supporting livestock. In Figure 5.2, we provide a GIS map of the Saanich Peninsula that highlights land use and shows where hobby farmers are located. In addition, conventional farmland is distinguished from other uses, including residential, commercial and First Nations' lands (formerly known as Indian reservations).

A variety of GIS databases was used to develop the covariates of the regression equations. Data were obtained from the BC Ministry of Agriculture and Lands, the BC Assessment Authority, other government agencies, the Capital Regional District (CRD), and private sources (such as LandCor). We use ArcGIS to link datasets, calculate distances, and analyze other spatial relationships in the data.

The dependent variable in the probit model and the variable of interest in the hedonic pricing model is a binary variable that takes on a value of one if the land parcel is used for hobby purposes and zero if it is used for conventional farming. Although there is no one universally accepted definition of a hobby farm, Statistics Canada classifies a hobby farm as one in which the main operator reported 190 days or more of off-farm work and no other labor was employed year-round (Boyd, 1998). In Canada, hobby farmers tend to cluster around certain crops and animals as evidenced by the fact that 35 per cent of all horse operators were labeled as hobby farms in 1991, and more than 30 per cent of all sheep and goat enterprises were hobby farms; among hobby farms, cattle rearing is most pronounced, accounting for 30.8 per cent of hobby farmers, followed by wheat (12.2%) and horses (9.7%) (Boyd, 1998). Other studies have used different definitions of what constitutes a hobby farmer, generally based on farm size or gross receipts. The 2006 Agricultural Census stated that 9,466 of British Columbia's 19,844 farms reported less than $10,000 in gross farm receipts and that 5,335 were less than 4 hectares in size (Statistics Canada, 1971-2001-2006).

The Agricultural Land Use Inventory (2004) compiled by the former British Columbia Ministry of Agriculture, Food and Fisheries provides information about whether or not properties are hobby farms. Their description of a hobby farm is a property "with agricultural activity, but for amenity use only, i.e. no indication of farm products for sale (e.g. residential property with one horse)." The distinction between hobby and conventional farms is determined somewhat arbitrarily, but, given no other information, we must rely on the government's own assessment.

Figure 5.2 **Distribution of land use on the Saanich Peninsula, Vancouver Island.**
Source: Ministry of Agriculture and Lands and the Capital Regional District, edited map.

The dependent variable in the hedonic pricing model is farmland price per ha adjusted for inflation using the Consumer Price Index with base year 2005. The hedonic pricing model also included dummy variables to capture price variation over time. The 2005 dummy was excluded, so 2005 is the base year. Explanatory variables in both models are roughly similar and include, among others, size of the farmland parcel, topographical features of the land, distance to Victoria, distance to the highway, and an ALR dummy variable. Also included in the model are dummy variables indicating the type of agricultural activity occurring on the parcel in 2004. The base case refers to parcels with grain, vegetables and mixed activities. We also included a fragmentation index (FI), which is calculated as follows: FI = proportion of perimeter bordering other farmland × size of total farm block of all adjacent farmland (including own parcel) measured in ha

5.6 Empirical results

We start by discussing summary statistics that emerge from the data and then address some general empirical issues with respect to our model specifications. Then we provide estimates regarding the effect of hobby farms on prices within and outside the ALR, and finally compare the results of the hedonic pricing model with those of the propensity score method. We also discuss more general findings from the hedonic pricing and the binary choice (probit) models.

Summary statistics about the farms in our sample are presented in Table 5.2. Hobby farms in the ALR are generally smaller than those outside it, although the differences in size are not statistically significant. The average size of conventional farms in the ALR (4.65 ha) is larger than when they are located outside it (2.89 ha). Finally, for both hobby and conventional farms outside the ALR, there is a tendency for size to fall in the range 0.8 to 4.0 ha, likely in response to tax incentives. There is also considerably more variation in parcel size for conventional than hobby farms with a standard deviation of 5.4 to 6.9 for the former and 1.0 to 1.1 for the latter.

Table 5.2 Summary statistics for farmland parcel sizes, conventional and hobby farms in and outside the ALR.

	Number of observations	Mean	Standard Deviation	Minimum	Maximum
Hobby farms					
Within the ALR	27	1.7656	1.0165	0.2954	5.2609
Outside the ALR	90	2.0215	1.1507	0.3399	6.7178
Conventional farms					
Within the ALR	641	4.6511	5.3964	0.0486	40.4361
Outside the ALR	135	2.8900	6.8892	0.0850	76.7162

Hobby farmers also differ from conventional farmers in other ways. For example, they are more often located outside the ALR than conventional ones. From Table 5.2, we see that 77 per cent (90 out of 117) of all hobby farmers use non-ALR land compared to 17 per cent (135 out of 776) of conventional farmers. This result provides an important clue to a question concerning the ALR:

How are so many farms outside the ALR able to survive? The reason appears to be that many farms outside the ALR are not conventional enterprises but hobby farms.

Table 5.3 Regression results of the hedonic pricing model, Saanich Peninsula (n = 323), with robust standard errors.

Dependent variable: Price per ha corrected for inflation (in 2005 Canadian $100,000s)	Parameter estimates	t-statistic
Hobby farm	-0.8231*	-1.86
ALR (= 1 if parcel located in the ALR, 0 otherwise)	-0.8467**	-2.22
Hobby farm × ALR	1.7247***	3.09
Distance to ALR boundary from outside (km)	1.7381*	1.70
Distance to ALR boundary from inside (km)	-0.1455	-0.37
Fragmentation index	0.0202	0.44
Distance to Victoria city centre (City Hall)	0.0174	0.90
Distance to highway	-0.1180	-1.58
Distance to recreational centers	-0.1696***	-3.14
Tree fruit (=1 if tree fruits are grown on the parcel, 0 otherwise)	-0.6184	-1.01
Small fruit (=1if small fruits are grown on the parcel, 0 otherwise)	-0.1340	-0.32
Cows (=1 if farm is beef or dairy farm, 0 otherwise)	-0.4959*	-1.72
Poultry (=1 if farm is poultry farm, 0 otherwise)	-0.0369	-0.08
Parcel size (ha)	-0.1809***	-3.73
Vacant land (=1 if land is vacant, 0 otherwise)	-0.3285	-0.65
Maximum elevation level (meters)	-0.0026	-0.76
Difference in elevation level (meters)	-0.0069	-0.82
Year 1990	-1.3816***	-3.43
Year 1991	-0.7741**	-2.09
Year 1992	-0.5240	-1.11
Year 1993	-1.0078***	-3.16
Year 1994	0.4856	0.88
Year 1995	-0.1736	-0.42
Year 1996	-0.9541**	-2.52
Year 1997	-0.5580	-1.62
Year 1998	-1.3015***	-3.37
Year 1999	0.0237	0.04
Year 2000	-0.7246**	-2.06
Year 2001	-1.0951***	-3.34
Year 2002	-0.3569	-0.83
Year 2003	-0.1440	-0.42
Year 2004	0.3165	0.65
Constant	5.1300***	8.07
R^2	0.4153	

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels.

A number of aspects arising from the empirical results are worth noting. First, about 42% of the total variation in farmland prices could be explained in the hedonic pricing model (Table 5.3). The explanatory variables included in the hedonic pricing model differ slightly from those included in the probit models (Table 5.4) used to estimate the likelihood that a farm parcel (within or outside the ALR) is owned by a hobby farmer versus a conventional one. The reason is that results from the probit models were used to estimate propensity scores for farm parcels and a necessary condition for PSM is that the propensity scores are balanced (Rosenbaum and Rubin 1983). If the balancing property is satisfied, the distribution of observable and unobservable characteristics is the same if propensity scores are similar, and this relationship is not affected by whether or not a property is in the treatment or control group. To meet this requirement, we had to include some squared terms in the probit models (e.g., distance to the highway). This was also the reason that the probit models for ALR and non-ALR parcels differ slightly. Other reasons for the slight divergence are that hobby farmers within the ALR never have poultry and never leave a property vacant. Therefore, these variables had to be excluded from the ALR probit model.

Another empirical issue concerns the potential for multicollinearity in our models. This problem might occur in our data because we analyze farmland prices on a small peninsula where different land use indicators are related. In our OLS specification, we tested for multicollinearity using Variance Inflation Factors (VIFs) (Hill and Adkins, 2001). All VIFs were between 1.05 and 7.13, so that the highest VIF is still lower than the often suggested critical value of 10. Therefore, we conclude that multicollinearity is not a problem in the hedonic pricing model. Since similar explanatory variables are used in the probit models, we argue that these findings also apply there.

Both the hedonic pricing model (Table 5.3) and the propensity score method (Tables 5.4 and 5.5) indicate that hobby farmers pay significantly more for ALR land than conventional farmers (see also Figure 5.3). Looking more closely at the results from the hedonic pricing model, we observe that the interaction term between the ALR and hobby farm variables is highly significant, indicating that hobby farmers have a different effect on farmland prices within and outside the ALR. We observe that conventional farms inside the ALR are worth $84,670 less per ha than conventional farms outside the ALR, while the opposite is true for hobby farms – they are worth $87,800 more per ha if located in the ALR than outside it. Outside the ALR, we find that hobby farms are worth $82,310 less per ha than conventional farms. Inside the ALR, however, hobby farms are worth more than conventional farms by $90,160 per ha. It would appear from this that hobby farms pay a premium for ALR land and, as a result, drive up prices inside the ALR. All prices are expressed in real 2005 Canadian dollars.

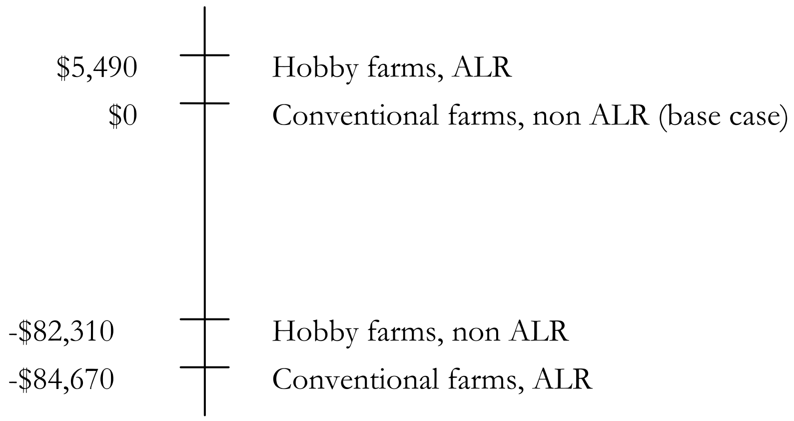

Figure 5.3 Price differences per ha paid by hobby farmers versus conventional farmers within and outside the ALR as derived from the hedonic pricing model.

Table 5.4 Probit regression model used to estimate propensity scores within and outside the ALR.

Dependent variable: Hobby farm=1; conventional farm=0	ALR	t-stat	Non-ALR	t-stat
Distance to ALR boundary in km from inside the ALR, 0 otherwise	1.0840***	3.22		
Distance to ALR boundary in km from outside the ALR, 0 otherwise			3.6776**	2.09
Squared distance to ALR boundary in km from outside the ALR, 0 otherwise			-5.3306**	-2.55
Fragmentation index ((proportion of perimeter bordering other farmland × size of total farm block of all adjacent farmland in meters) / 10,000)	-0.0299	-0.31	0.0674	0.69
Distance to Victoria city centre (City Hall) in km	-0.0183	-0.83	-0.1003***	-3.35
Distance to highway in km	-1.0564***	-3.45	0.5425*	1.83
Squared distance to highway in km	0.2321***	3.32	-0.0835	-1.27
Distance to recreational centers	-0.3059***	-3.68	-0.1736*	-1.71
Parcel size (ha)	-0.2917**	-2.18	-0.1653*	-1.85
Vacant land (=1 if land is vacant, 0 otherwise)			-1.7858***	-2.72
Poultry (=1 if farm is a poultry farm, 0 otherwise)			-0.7903	-1.52
Maximum elevation level (meters)	-0.0025	-0.56	0.0061	1.30
Difference in elevation level (meters)	0.0215*	1.84	-0.0087	-0.80
Constant	0.7097	1.29	0.7705	1.27
Number of observations	668		225	
LR $\chi 2(16)$	48.46		104.30	
Log likelihood	-88.846		-99.277	
Pseudo R^2	0.2143		0.3444	

Parameter estimates are indicated with t-statistics in parentheses; *** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels.

As indicated in section 5.4, the hedonic OLS results in Table 5.3 might be biased, because they fail to take into account the potential endogeneity of hobby farms. However, the average treatment effects based on the propensity score measures (Tables 5.4 and 5.5) lead to similar findings. Again, there is a difference between the sales price per ha for hobby farms and conventional farms within the ALR, similar to the results from the hedonic pricing model in Table 5.3. Depending on the matching method used, the prices vary between \$61,700 and \$162,200. (This brackets the effect of \$90,160 found in the hedonic model.) Regardless of which PSM approach is used to analyze the data, the results indicate that people purchasing farmland for what can best be classified as hobby purposes drive up prices of such properties if land is located inside the ALR. (Three out of four of the estimates are statistically significant.) For properties outside the ALR, we again find similar results to those obtained from the hedonic pricing model – hobby farms are worth between \$40,100 and \$124,100 less per ha than conventional farms, although these differences are not statistically significant. Outcomes of the PSM approach are not very robust, because they tend to vary depending on the matching method used. This is very likely due to the small number of observations. Although we might not be able to put an exact number on hobby farm prices inside and outside the ALR, we can be confident that hobby farmers pay higher prices inside the ALR and lower prices outside the ALR compared to conventional farmers, since both the hedonic pricing method and PSM scores point in that direction.

Table 5.5 Average treatment effects of the treated (ATT) for ALR and non-ALR parcels.

	Number of treated units	Number of controls	ATT	t-statistic
ALR				
Kernel matching, bootstrapped std. err.	14	222	1.038***	2.77
Stratification method, bootstrapped std. err.	13	223	1.019*	1.79
Radius matching, analytical std. err.	13	222	1.622***	3.25
Nearest neighbor matching, analytical std. err.	14	12	0.617	0.98
Non ALR				
Kernel matching, bootstrapped std. err.	31	56	-0.843	-1.06
Stratification method, bootstrapped std. err.	23	64	-0.401	-0.68
Radius matching, analytical std. err.	31	50	-0.543	-1.07
Nearest neighbor matching, analytical std. err.	31	13	-1.241	-1.40

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels.

From the probit model results provided in Table 5.4, we find that, when hobby farms are located inside the ALR, the land tends to be located farther from the ALR-boundary than for conventional farmers. This may indicate a preference on the part of hobby farmers for the open space and guarantee that surrounding land will not be developed that the ALR provides. The results also indicate that a farm is more likely to be a hobby farm the farther away it is from the ALR boundary when outside the land reserve. This seeming contradiction with the previous result can be explained by grouping hobby farmers according to those who wish to maintain easy access to urban amenities (reduced commuting time for work, public transit, recreation, etc) and those who prefer a rural lifestyle and avoid the noise, congestion and other disamenities associate with being closer to the city. This conjecture that there may be two types of hobby farms owners is supported by the findings on the distance variables. The distance to Victoria variable is significant for non-ALR land but not for properties located in the ALR. This could be because the 'commuting' hobby farmer seeks to minimize travel time and is more likely to live on land outside the ALR. This conclusion is supported by the estimated coefficients on both the linear and the quadratic distances to the highway.

Within the ALR, hobby farmers have a tendency to live either close to the highway or far away from it, while conventional farmers in the ALR tend to be located in between. Outside the ALR the distance to the highway only moderately affects the probability of being a hobby farmer. These findings support other findings that some hobby farmers wish to be near the highway (the more-likely-to-commute group), while others wish to be farther from it. Since hobby farms are more likely to include a residence, as indicated by the negative sign on the coefficient of the vacant land dummy variable, most owners of hobby farms are likely living on the farm and thus care about their location on the peninsula.

Parcel size also seems to be an important factor. From the probit model, as parcel size increases, the probability that the farm is used for hobby purposes declines significantly regardless of location inside or outside the ALR. From the hedonic pricing model (Table 5.4), per ha value significantly decreases with parcel size. This makes sense given the institutional environment that hobby farmers live under in the province. Favorable tax rates are possible and easily achieved for farms of a certain size range. This finding indicates that hobby farmers have bid up the price of smaller agricultural parcels.

5.7 Conclusion and policy implications

To date there has been little research into hobby farming because its effect on the agricultural sector is generally considered positive at best and benign at worst. As a result, little is known about its impact on land prices. Given that the number of hobby farms near major urban areas is growing, there is a need to investigate this phenomenon further if agricultural policies to protect small farms and farmland more generally are to be effective. For example, our study indicates that incentives created by farm assessment and taxation policies may result in added financial hardships for conventional farmers by raising farmland prices.

The findings from both the hedonic pricing model and the propensity score matching method indicate that the existence of hobby farms drives up prices of ALR land. According to the PSM method, hobby farming can increase values by between $61,700 and $162,200 per ha, while the estimated impact from the hedonic pricing model is an increase of $90,160 per ha. Outside the ALR hobby farms tend to be worth less per ha than conventional farms; although these findings are corroborated by PSM estimates, the difference in that model was statistically insignificant.

Hobby farms seem to benefit from British Columbia's favorable property tax treatment of agricultural land, which sets a low threshold for obtaining tax benefits. Potential hobby farmers are very likely to seek parcels that provide them the lowest threshold for qualifying for farm class status, avoiding parcels smaller than 0.8 ha that would place them into the category with the highest threshold for farm class status and ones greater than 4.0 ha that would require them to become 'serious' farmers. Hobby farmers seem to actively seek farm class status to reduce their property tax burden, even though they view their property primarily as a residence. Hobby farm owners may be motivated by a desire to produce and sell agricultural commodities, but they might also simply want a rural lifestyle – a retreat – or want to avoid high residential prices in urban areas; or some combination of these factors may be at work.

British Columbia residents clearly support protection of agricultural land, and would favor the protection offered by the ALR as well as taxes that favor farmers. However, the research reported here suggests that, in some cases, these policies could possibly have a deleterious effect on the survivability of farming in the longer term. This is especially true in how farm legislation treats hobby farmers. Our research suggests that current policies need to be modified if agricultural production is to be protected in the long run, especially in how it treats small, unprofitable farming operations that are classified as hobby farms but might well serve another purpose. Despite good intentions on the part of current policy and perhaps even hobby farm owners, hobby farming might simply be a means of converting agricultural land locked into a land reserve into residential properties, resulting in what we term 'rurban' development – sprawling residential developments.

Nonetheless, it is not entirely clear whether hobby farming is something to be encouraged because of the amenity benefits that it is still capable of providing (open space, views, wildlife habitat) and the fact that hobby farmers are often located outside the ALR, or whether it simply constitutes 'rurbanization' of the countryside (urban development of rural areas subject to minimum lot size constraints) with all pretence of farming disappearing as conventional farms rollover. Further research and monitoring of this phenomenon is certainly warranted.

CHAPTER 6

EXPERT OPINION VERSUS TRANSACTION EVIDENCE; USING THE REILLY INDEX TO MEASURE OPEN SPACE PREMIUMS IN THE URBAN-RURAL FRINGE[1]

Abstract

Due to economic and population growth farmland and to a lesser extend other undeveloped areas are under pressure in the urban-rural fringe in British Columbia, Canada. The objectives of this paper are to determine if residential property values near Victoria, British Columbia include open-space premiums for farmland, parks or golf courses, and to determine if using assessed values instead of market prices of properties result in the same findings. We estimate a Seemingly Unrelated Regression (SUR) model with two hedonic pricing equations, one with actual market values as the dependent variable and one with assessed property values, and compare the resulting estimates of shadow prices for open space amenities. Furthermore, we take account of spatial autocorrelation and combine Method of Moment estimates of the spatial parameters in both equations.

6.1 Introduction

Hedonic pricing models are often used to estimate the value of open space and the externalities that different types of land use impose on one another because these values are at least partly tractable through market values of private properties. In particular, the prices of residential properties in close proximity to positive and negative externalities resulting from nearby land uses can be used to value these non-market amenities.

If we look at open space amenities provided by farmland near urban areas we observe that, as the urban fringe is pushed out, fragmentation of surrounding farmland increases as do incidences of trespass and vandalism. Externalities are also associated with the intensification of agriculture in the rural-urban fringe. Externalities flow in both directions, with urban development impacting farmland and agriculture affecting urbanites. On the negative side, there are nuisance complaints from neighboring urban residents who object to the sounds and smells of farming operations and the added traffic congestion caused by slow-moving farm equipment traversing from one field to

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another some distance away (with the spatial fragmentation also adding to farming costs) (Hardie, et al. 2004). Nonetheless, Kline and Wichelns (1996) indicate that urban residents enjoy living near open spaces as these provide pleasant agrarian landscapes during commutes, opportunities for recreation and habitat for wildlife that facilitates viewing. Indeed, real estate brokers include farmland views and proximity to natural areas as selling features of houses. For example, a property in our study area was recently listed as follows: "Central Saanich – Victoria: This .28 acre view property … overlook[s] the Marindale Valley and farm fields, …. Only 15 minutes from downtown and 10 minutes from ferry and airport…." (MLS, 2007).

Nature parks and golf courses are other open space providers and both positive and negative externalities can be associated with these land uses. Nearby forest land was found to be negatively associated with house price in Geoghegan et al. (2003), perhaps due to externalities associated with deer (landscape damage, car accidents and the spread of Lyme disease). This negative effect of nearby forest was also found in Paterson and Boyle (2002), indicating people do not enjoy views of trees. However, most studies have found positive impacts from nature areas, such as in Cho et al. (2006) and Irwin and Bockstael (2001). With respect to golf courses, Nicholls and Crompton (2007) found a positive impact of golf courses due to it's popularity as a recreational activity. However, golf courses can also be associated with negative externalities as recognized by Asabere and Huffman (1996). Hedonic pricing studies can be used to study whether people will pay more for a house with these open space amenities.

Hedonic pricing models require actual property transaction data as inputs, because these values reflect property characteristics which can then be decomposed into their constituent parts. However, sales values are not always readily available; therefore, some researchers have employed approximations of sales values in hedonic pricing models. Thus, Chay and Greenstone (2005), and Isgin and Forster (2006), relied on a survey instrument to elicit estimates of property values. For practical reasons, it is very useful to know which approximations of property values will give valid and consistent results when transaction data is not available.

Using assessed values as approximations of market values has the advantage that these values are available for each property in each year. So, the estimation of a hedonic panel data model, including dynamic effects, is possible if this strategy is valid. In addition, the use of assessed values would facilitate non-market valuation since assessed values are much more widely available, at least in jurisdictions where properties are assessed annually for tax purposes. In some jurisdictions, a government agency may collect information on sale prices, but in others, where information on selling price is not readily available for a large data set, it would be helpful if researchers could use assessed values in place of market price with confidence. Some studies support the idea that assessments and market values work in step (Berry and Bednarz, 1975). Nicholls and Crompton (2007) visually compared estimates for the value of open space based on an equation with sales values versus assessed values as the dependent variable. However, they didn't develop test statistics to compare these estimates.

The objective of this paper is therefore to test whether assessed values are good proxies for actual sales values in a hedonic pricing model that is used to estimate the value of open space on the Saanich Peninsula, British Columbia, Canada. The value of open space provided by farmland is compared to that provided by parkland and golf courses. We estimate a Seemingly Unrelated Regression (SUR) model with two equations, one with actual market values as the dependent variable and one with assessed property values, and compare the resulting estimates of shadow prices for open space amenities. Furthermore, we take account of spatial autocorrelation and combine Method of Moment estimates (Kelejian and Prucha, 1999) of the spatial parameters in both equations (Kelejian and Prucha, 2004).

A variety of authors have estimated open space premiums using a proxy variable to measure open space benefits. Irwin and Bockstael (2001) and Irwin (2002) use the percentage of open space within a specified buffer zone around each property, while Ready and Abdalla (2005) construct an index that allows the value of the open space amenity to decrease to zero in a nonlinear fashion as distance increases up to a certain point, beyond which open space is assumed to no longer effect residential property prices. The problem with distance measures, like that used by Ready and Abdalla (2005), is that large and small open space areas are treated equally; the problem with area percentages, like that used by Irwin (2002), is that arbitrary buffer zones around each property have to be specified and open space outside those boundaries is not taken into account. We address this issue by explicitly combining the distance and percentage measures using a Reilly index. In this way, all nature areas, parks, farmland and golf courses are taken into account, insuring that both the size and distance measures are represented.

6.2 Methods

Given that both the distance to a particular open space and its size influence residential property values, we construct a Reilly index that combines these two aspects of open space. The Reilly index derives from Newton's law of gravitation, where gravity is stronger for larger 'bodies' and gravitational strength is inversely related to the distance between 'bodies'. It was originally applied to the study of retail markets (Reilly, 1931), to reflect the attractiveness of different retail areas (cities) in terms of the tradeoff between consumers' travel costs and the size of alternative retail areas. In this case, Reilly's law is:

$$\frac{R_{xi}}{R_{xj}} = \frac{Pop_i}{Pop_j}\left(\frac{D_{xj}}{D_{xi}}\right)^2, \qquad [6.1]$$

Where R_{xi} and R_{xj} are the retail sales at location x accounted for by each of the cities i and j; Pop_i and Pop_j are the respective populations (size) of the two cities; and D_{xi} and D_{xj} are the distances from the retail location x to cities i and j, respectively. In this case, it is possible to determine the location of retail center x so as to attract the most customers (Yrigoyen and Otero, 1998). This optimal location or 'breaking point' is given by

$$d_{xj} = \frac{d_{ij}}{1+\sqrt{Pop_i / Pop_j}}, \qquad [6.2]$$

where the breakpoint lies at distance d_{xj} from the centre j, d_{ij} is the total distance between the two retail centers, and, of course, $d_{xj} < d_{ij}$.

Shi et al. (1997) were the first to employ the concept of gravitation in a hedonic pricing model. However, they modified the concept in order to evaluate the impact of multiple urban centers on farmland values. Their Reilly index is specified as:

$$R_i = \sum_{j=1}^{J} \left(Pop_j / D_{ij}^2 \right), \qquad [6.3]$$

where R_i is the Reilly index for property i, Pop_j is the population of the j-th urban area, and D_{ij} is the distance from property i to the j-th urban center.

We modify the Reilly index to calculate the impact of open space (farmland and parkland) on residential property values. Rather than distance to urban centers, we employ distance to open areas and, rather than population, we use size of the open space (measured in square meters). Thus, we specify

$$R_i = \sum_{j=1}^{J} \left(S_j / D_{ij}^2 \right), \qquad [6.4]$$

where R_i is the value of residential property i and D_{ij} is the distance (in meters) from residential property i to open space j that is of size S_j (in square meters). Thus, we can take all parks and farmland within our research area into account, insuring that both the size and distance measures are represented.

For golf courses we also constructed a measure similar to the Reilly index. The only difference is that instead of using the size of the golf course, we specified S_j as one for nine-hole golf-courses and as two for 18- or 19-hole golf-courses.

6.2.1 Model specification

To investigate the open space premium associated with residential properties, prices from actual market transactions are usually employed as the dependent variable. However, we also specify a model that uses assessed property values as the dependent variable, as this enables us to investigate the validity of assessed values in lieu of market values in hedonic pricing models. For each of the properties for which actual sales and assessed values are both available, we paired the actual and assessed values and specified a SUR model. By working with both equations in one model, relevant test statistics can be derived to test the hypothesis that parameters in the equation with actual market prices as the dependent variable are equal to the parameters in the equation with assessed values as the dependent variable.

Properties are also spatially related. An assumption of spatial econometrics is that observations that are located closer to each other are more correlated than observations that are farther apart. Spatial autocorrelation is often caused by unobserved variables. For example, if several residences have a beautiful view because they are located on a hilltop, and there is no variable in the model that takes this view into account, then the error terms associated with each of these residences will be correlated.

To address this issue, we first define the spatial SUR model, including a spatial autocorrelation component, as follows:

$$P_m = X\beta_m + \varepsilon_m,\ \varepsilon_m = \rho_m W_m \varepsilon_m + \mu_m,\ \mu_m \sim N(0,\sigma_m^2) \ni (I_N - \rho_m W_m)\varepsilon_m = \mu_m, \quad [6.5]$$

where P_m is a vector of property prices, X_m a matrix of property characteristics, β_m a vector of associated parameters to be estimated, and ε_m is the spatially auto correlated error term. Further, m identifies the equations with market values (m=1) and assessed values (m=2) as dependent variables.

We assume that $Cov(\mu_{1i}, \mu_{2j}) = \sigma_{12}$ for i=j and $Cov(\mu_{1i}, \mu_{2j}) = 0$ for $i \neq j$; where μ_{mi} reflects the i-th error term in the m-th equation. If we define $B_m = I_N - \rho_m W_m$ and $\varepsilon_m = B_m^{-1}\mu_m$, the overall error structure becomes:

$$V = Cov(\varepsilon) = \begin{bmatrix} \sigma_1^2 (B_1' B_1)^{-1} & \sigma_{12} (B_2' B_1)^{-1} \\ \sigma_{21} (B_1' B_2)^{-1} & \sigma_2^2 (B_2' B_2)^{-1} \end{bmatrix}. \quad [6.6]$$

Although, it is possible to use maximum likelihood to estimate a model that includes both SUR and spatial dependence (see Anselin (1988b)), we have more than 10,000 observations for the period 2000-2006 which is (depending on the efficiency of the programmed routines) too much for maximum likelihood estimation of spatial models. Maximum likelihood requires the calculation of either the eigenvalues of the spatial weighting matrix or the determinant of B_m, which Kelejian and Prucha (1999) could only do in a reliable way for dimensions up to 400. Bell and Bockstael (2000) restricted their weighting matrices to be sparse and reported problems for dimensions of roughly 2,000 x 2,000. Pace and Barry (1997) were able to work with matrices up to 20,000 x 20,000 by imposing additional restrictions. Huang, et al. (2006), among others, even aggregated their data to the county level, because they were unable to handle the huge weighting matrix caused by spatial dependence within 64,000 observations. Therefore, we use the full information estimator developed by Kelejian and Prucha (2004). This procedure uses the Method of Moments (MM) estimator proposed by Kelejian and Prucha (1999) to estimate ρ_1 and ρ_2 in B_1 and B_2, but extends this method so that these estimates can be used in a system of interrelated cross sectional equations.

If we assume that B_m are known, we can rewrite the two equations as:

$$P_m = X\beta_m + B_m^{-1}\mu_m \Rightarrow B_m P_m = B_m X\beta_m + \mu_m \Rightarrow P_m^* = X^*\beta_m + \mu_m,$$

where $P_m^* = B_m P_m$ and $X_m^* = B_m X_m$. For this transformed model, it is easy to calculate the inverse of the covariance matrix. Because the covariance matrix is $Cov(\mu) = \quad \Omega = \Sigma \otimes I_N$, where $\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{21} & \sigma_2^2 \end{bmatrix}$. The inverse of this matrix is very easily calculated by $\Omega^{-1} = \Sigma^{-1} \otimes I_N$ even for large N. We define $\Sigma^{-1} = \begin{bmatrix} \sigma^{11} & \sigma^{12} \\ \sigma^{21} & \sigma^{22} \end{bmatrix}$.

The moment conditions for the spatial error model (Kelejian and Prucha, 1999) are used to estimate ρ_1 and ρ_2 . Let $\bar{u}_m = W_m u_m$, $\bar{\varepsilon}_m = W \varepsilon_m$, $\bar{\bar{\varepsilon}}_m = W_m W_m \varepsilon_m$, $u_m = \varepsilon_m - \rho_m \bar{\varepsilon}_m$, and $\bar{u}_m = \bar{\varepsilon}_m - \rho_m \bar{\bar{\varepsilon}}_m$. The moments we use are:

$$E\left[\frac{1}{N} u_m' u_m\right] = \sigma_m^2,\ E\left[\frac{1}{N} \bar{u}_m' \bar{u}_m\right] = \sigma_m^2 \frac{1}{N} Tr(W_m' W_m) \text{, and } E\left[\frac{1}{N} \bar{u}_m' u_m\right] = 0$$

To define the sample analogue of the population moment conditions, we define the following predictors: $\tilde{\varepsilon}_m$ is a predictor for ε_m. Correspondingly $\tilde{\bar{\varepsilon}}_m = W_m \tilde{\varepsilon}_m$ and $\tilde{\bar{\bar{\varepsilon}}}_m = W_m \tilde{\bar{\varepsilon}}_m$. For the sample moments we can define the following conditions:

$$G_N \left[\sigma_m^2, \rho_m, \rho_m^2\right]' - g_N = v_N(\sigma_m^2, \rho_m), \qquad [6.7]$$

where $v_N(\sigma_m^2, \rho_m)$ is the vector of residuals;

$$G_N = \begin{bmatrix} 1 & -\frac{2}{N} \tilde{\bar{\varepsilon}}_m' \tilde{\varepsilon}_m & \frac{1}{N} \tilde{\bar{\varepsilon}}_m' \tilde{\bar{\varepsilon}}_m \\ \frac{1}{N} Tr(W_m' W_m) & -\frac{2}{N} \tilde{\bar{\bar{\varepsilon}}}_m' \tilde{\bar{\varepsilon}}_m & \frac{1}{N} \tilde{\bar{\bar{\varepsilon}}}_m' \tilde{\bar{\bar{\varepsilon}}}_m \\ 0 & -\frac{1}{N}\left(\tilde{\bar{\bar{\varepsilon}}}_m' \tilde{\varepsilon}_m + \tilde{\bar{\varepsilon}}_m' \tilde{\bar{\varepsilon}}_m\right) & \frac{1}{N} \tilde{\bar{\bar{\varepsilon}}}_m' \tilde{\bar{\varepsilon}}_m \end{bmatrix}; \text{and } g_N = \begin{bmatrix} -\frac{1}{N} \tilde{\varepsilon}_m' \tilde{\varepsilon}_m \\ -\frac{1}{N} \tilde{\bar{\varepsilon}}_m' \tilde{\bar{\varepsilon}}_m \\ -\frac{1}{N} \tilde{\bar{\varepsilon}}_m' \tilde{\varepsilon}_m \end{bmatrix}$$

Restrictions have to be imposed on the estimates of ρ_m and ρ_m^2. The MM estimator for $\{\sigma_m^2, \rho_m\}$ can be defined as a nonlinear least squares estimator:

$$\left(\hat{\sigma}_m^2, \hat{\rho}_m\right) = \arg\min\left\{v_N\left(\sigma_m^2, \rho_m\right)' v_N\left(\sigma_m^2, \rho_m\right)\right\}. \qquad [6.8]$$

The OLS residuals for both the assessed and the sales equation can be used as starting values in the MM optimization procedures and the systems can be solved using non-linear least squares. The estimate of ρ_m , $\hat{\rho}_m$, results from MM minimization of $v_N\left(\sigma_m^2, \rho_m\right)' v_N\left(\sigma_m^2, \rho_m\right)$, with respect to those parameters. The standard error for ρ_m is based on Kelejian and Prucha (2008).

After obtaining estimates of ρ_m, EGLS is used to derive estimates for β_m, a measure of its dispersion, and so on, in the SUR model, where $X_m^* = (I - \hat{\rho}_m W_m)X$ and $P_m^* = (I - \hat{\rho}_m W_m)P_m$ [2]. We then test whether the restriction that $\beta_1 = \beta_2$ holds, where β_1 are the estimated parameters for the market values equation and β_2 are the estimates for the assessed values equation. Thus, we compare the restricted model to the unrestricted model. The unrestricted model is given by:

$$\begin{bmatrix} P_1^* \\ P_2^* \end{bmatrix} = \begin{bmatrix} X_1^* & 0 \\ 0 & X_2^* \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \pi_2 \end{bmatrix}, \qquad [6.9]$$

where P_m is the vector of sales ($m = 1$) or assessed values ($m = 2$); the vector of explanatory variables is the same in both equations; and β_m is the vector of parameters for the m-th model. Finally, ε_m is the vector of errors of the m-th model.

The restricted model is given by:

$$\begin{bmatrix} P_1^* \\ P_2^* \end{bmatrix} = \begin{bmatrix} X_1^* \\ X_2^* \end{bmatrix} \beta + \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}. \qquad [6.10]$$

The only difference between models [6.9] and [6.10] is that, in the restricted case [6.10], β is the vector of parameters that is assumed to be the same for the market and the assessment equations.

We can derive a Wald-test with the restrictions described above. If the restriction is valid, the vector of constraint(s) should be close to zero. R is a matrix with restrictions on the parameters in the model, b is a vector of parameters estimated in the unrestricted model, and the size of the matrix R is J by k where k is the number of parameters in b and J the number of restrictions. We test whether $Rb = q$, where q is a vector of zeros. In this case, a Wald test statistic would be: $(Rb)'\{Cov(Rb)\}^{-1}(Rb) = b'R'\{RCov(b)R'\}^{-1}Rb \sim \mathrm{X}^2(J)$, where

$$Cov(b) = \left(X'V^{-1}X\right)^{-1} = \left(\begin{bmatrix} X_1^* & 0 \\ 0 & X_2^* \end{bmatrix}' \begin{bmatrix} \sigma_1^2(B'B)^{-1} & \sigma_{12}(B'B)^{-1} \\ \sigma_{12}(B'B)^{-1} & \sigma_2^2(B'B)^{-1} \end{bmatrix}^{-1} \begin{bmatrix} X_1^* & 0 \\ 0 & X_2^* \end{bmatrix} \right)^{-1}$$

$$= \begin{bmatrix} \sigma^{11} X_1^{*\prime} X_1^* & \sigma^{12} X_1^{*\prime} X_2^* \\ \sigma^{21} X_2^{*\prime} X_1^* & \sigma^{22} X_2^{*\prime} X_2^* \end{bmatrix}^{-1}, \qquad [6.11]$$

and σ^{ij} are elements of Σ^{-1} (given above).

[2] We used several Matlab functions from the LeSage toolbox (http://www.spatial-econometrics.com/) to implement the estimation procedure to obtain estimate for β_m, ρ_m, σ_{ij} and σ^2_m. First, the function sem_gmm to get estimates of ϱ_m. Next X_m and P_m were transformed to X^*_m and P^*_m, using the estimates of ϱ_m. Next, the function SUR from the toolbox was used to obtain full information estimates.

6.2.2 Choice of the spatial weighting matrix

The spatial weighting matrices W_1 and W_2 have to be specified for each of the equations a-priori. There are many potential candidates, but the choice is rather limited in this study, because we have more than 10,000 observations in our dataset. We have to specify sparse weighting matrices and not weighting matrices with non-zero weights in each of the elements of the 10,000×10,000 matrices. W_1 and W_2 are the same as they are based on the five nearest neighbors to each observation, with elements for each of the five-nearest neighbors assigned a 1 and all other observations a 0 in the weighting matrices. Further, the weighting matrices are row-standardized (each row sums to 1) for computational reasons.

6.2.3 Other empirical issues

Another empirical issue to be addressed concerns the choice of functional form, and there is little theoretical guidance regarding this choice (Taylor, 2003). Although goodness-of-fit criteria can be used to choose a functional form, Cassel and Mendelsohn (1985) argue that this strategy does not necessarily lead to more accurate parameter estimates. The debate also concerns the choice of a simpler versus more advanced functional form. While the choice of a simple linear form overlooks statistically significant relationships (Halstead et al. 1997), Rasmussen and Zuehlke (1990) argue that the parameter estimates might be less precise when unnecessary nonlinearities are introduced and the problem becomes over-parameterized. Further, Cropper, et al (1988) found that, when some variables are not observed or proxies are used, simple (linear or double-log) functional forms perform better. Nonlinear functional forms are generally preferred over linear ones because linear functional forms have the disadvantage that they assume that parcel characteristics can be easily repackaged, precluding nonlinearities as a result of arbitrage (Rosen, 1974). Because we already have a high number of explanatory variables (and parameters to estimate), we consider a linear functional form with transformed explanatory variables. An advantage of these simple forms is that interpretation of the results is more straightforward.

Finally, we need to take into account the endogeneity problem identified by Irwin (2002). Endogeneity could result if the open space has development rights so that it could be converted to residential use at any time. If that case, the same factors that determine the value of nearby residential property also influence the likelihood that the open space will be developed. We assume that endogeneity is not a problem because both parks and farmland are under zoning restrictions and cannot be easily converted to residential use. Developments rights on the other hand are more flexible than zoning in allowing for changes in land use.

6.3 Data and variables

The setting for our study is the Saanich Peninsula, just north of Victoria (on Vancouver Island) – the capital city of the province of British Columbia, Canada. The Saanich Peninsula is an area historically dominated by farms and contains some of Canada's most fertile farmland and best climate for growing a wide range of crops.

Agricultural land in BC is scarce (just 2.7% of the province is considered good farmland) and under increasing pressure (Runka, 2006). Most of the best farmland is coincident with the largest and rapidly-expanding urban areas of Vancouver, Victoria and the Okanagan Valley. In 1973, the provincial government created an Agricultural Land Reserve (ALR) to preserve agricultural land after it was estimated that 6,000 ha of farmland was being lost annually. At its inception, the ALR comprised all land of a certain soil quality, land that municipalities already zoned as agricultural, and land that was already assessed as farmland for tax purposes.[3] Although ALR lands remain privately-owned, they cannot be used for non-agricultural activities, subdivided or developed without the consent of the Agricultural Land Commission (ALC).

In total 511 nature areas and parks were taken into account in the analysis. All parks were either located on the Saanich Peninsula, or within a boundary of 3.5 km of our research area. Of these 511 nature areas, 152 were small parks (less than 2,000 m^2), 301 were medium sized parks between 2,000 and 50,000 m^2 and 58 were parks with an area over 50,000 m^2.

Furthermore, golf seems to be a very popular recreational activity, since there are 16 golf courses on the southern part of Vancouver Island. Of these 16 golf courses only seven are nine-hole golf courses, the others have 18 or 19 holes. Furthermore, eight golf courses are located within the Saanich area and the other eight are located either in Victoria, or further up on Vancouver Island.

The current study employs parcel-level GIS data collected from the Ministry of Agriculture and Lands, data on assessed values and house characteristics from BC Assessment, market values from a private company (LandCor), and other sundry GIS datasets such as elevations, roads and parks from the Capital Regional District government and the Federal Government. Relevant characteristics for the hedonic pricing model were obtained by linking properties using their identification numbers (jurols) or spatial location (in GIS). Distance data were constructed using spatial location information from GIS.

Table 6.1 Reilly index, an example.

		Property 1		Property 2	
	Park size (m^2)	Distance (m)	Size / distance^2	Distance (m^2)	Size / distance^2
Park 1	1,000,000	1,000	1.00000	1,400	0.51020
Park 2	500,000	2,100	0.11338	400	3.12500
Park 3	200,000	600	0.55556	700	0.40816
Park 4	900,000	1,200	0.62500	900	1.11111
Reilly index		2.29393		5.15448	

An example of the construction and implementation of the Reilly index is given in Table 6.1 and Figure 6.1. In Figure 6.1 two residential properties are shown in proximity to four different parks.

3 Since then, the ALR boundaries have been fine-tuned to better reflect actual agricultural usage and capability. The ALC also adjudicates several hundred applications a year from landowners who wish to have their land removed, subdivided or be permitted to use it for non-agricultural purposes.

Distances between the residential properties and the four parks are given in Table 6.1. From Table 6.1 and Figure 6.1, it is apparent that the Reilly for property 2 much larger is than for property 1 because property 2 is located much closer to one of the parks. Although park 2 is not the largest park, the short distance from property 2 to this park is largely responsible for the larger Reilly score for this property. The Reilly index for parks is constructed for small, medium and large parks. The reason is that small parks are expected to attract only the locals that live nearby while larger parks also attract people that live farther away and therefore are valued differently. With respect to the Reilly index for farmland, we construct separate measures for animal farms and for non-animal farms because animal farms are assumed to impose more negative externalities on their neighbors, such as bad smells from manure.

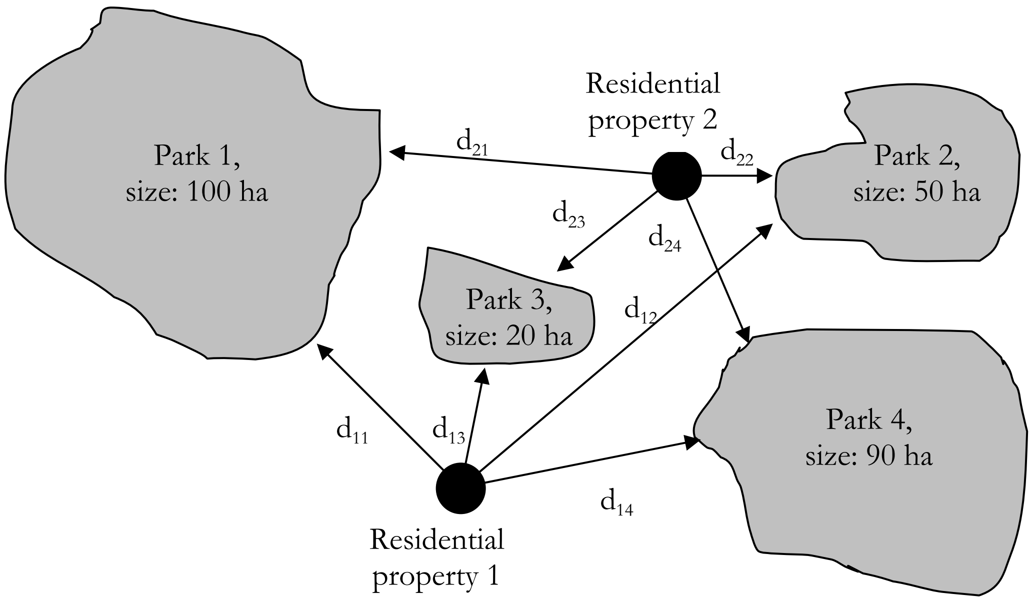

Figure 6.1 Example of Reilly index.

BC Assessment attempts to value all residential properties at their market value. Although farm properties can qualify for beneficial tax regulations by meeting certain agricultural income thresholds, here we focus on residential uses and ignore other uses. It is important to note that property assessment systems may be very different in other jurisdictions in North America or Europe, which could affect the validity of applying these results to other locations.

In British Columbia assessors take into account many factors when deciding on a property's assessed value. Properties are primarily categorized by the year in which they are built or the year of the last major renovation; whichever it is, we refer to this as the effective year. The reason for using effective year is that building codes and construction materials and methods change over time. Properties are then subcategorized on the basis of age, design and quality. After that, the number of bedrooms and other structural characteristics become important. At this point, market values of properties in the same subcategory and in the same 'market area' (as defined by BC Assessment) enter the equation. An overview of all the variables included in the hedonic pricing model can be found in Table 6.2. All of the databases used to construct these variables are listed in Appendix 6.1.

Because properties at the urban-rural fringe are our main interest, we include properties in the municipalities North Saanich, Central Saanich and Saanich in our analysis. Properties in the city of Victoria are excluded as this is an urban area, not part of the urban-rural fringe. The data consist of actual transactions and assessments of residential properties for the period 2000 to 2006. The LandCor and BC Assessment databases record 19,246 transactions for 2000 to 2006 for which both sales and assessed values are available. The data were filtered so that only 'single-cash' transactions are included, because transactions that do not involve cash or involve the sale of multiple properties at once are not suitable for our hedonic analyses. Next, we incorporated only detached family dwellings in the analysis; strata blocks, duplex buildings, seasonal dwellings and apartment blocks were excluded to focus the analysis on more homogeneous properties. This reduced the sample to 13,532 transactions. Upon excluding properties with missing information on some of the variables of interest, and focusing only on transactions between $100,000 and $5 million (CA), we are left with 13,254 observations. This number of observations was further reduced if measures of lot size differed by more than 100 m^2 between the two datasets. Properties without three or four piece bathrooms were removed as well. This reduced the number of observations to 12,628.

Table 6.2 Summary statistics dependent and explanatory variable(s), n = 10,133.

Explanatory variable	Database nr*	Mean	St dev	Min	Max
Sale amount (million CA$)	1, 14	0.33108	0.15517	0.09625	2.80851
Assessed value (million CA$)	2, 14	0.27727	0.11651	0.03156	1.71339
Lot size (ha)	3	0.11200	0.11581	0.02190	3.15655
Effective year: last mayor renovation of the property (years)	3	1973.15257	19.21750	1901	2005
Finished area (meters)	3	189.71599	75.51331	35.48894	886.29425
Number of 3- or 4-piece bathrooms	3	1.72525	0.78144	1	7
Number of 2-piece bathrooms (toilet and wash basin)	3	0.46097	0.57808	0	4
Number of bedrooms	3	3.51554	1.08869	1	10
Number of multi car garages	3	0.42149	0.51323	0	3
Number of single car garages	3	0.30662	0.46960	0	2
Number of car ports	3	0.19402	0.39746	0	2
Pool (=1 if there is a pool, 0 otherwise)	3	0.01155	0.10684	0	1
Other buildings (=1 if there are other buildings, 0 otherwise)	3	0.09533	0.29369	0	1
Corner lot (=1 if the lot is at the corner of a street, 0 otherwise)	3	0.10412	0.30543	0	1
Waterfront lot (=1 if the lot is on the waterfront, 0 otherwise)	3	0.01777	0.13210	0	1
Reilly for parks larger than 50,000 square meters	7	35.09508	302.34953	0.15586	12686.22452
Reilly for parks between 2,000 and 50,000 square meters	7	5.12092	23.58490	0.05603	897.14276

(Table continued on next page)

((Table continued)

Reilly for parks smaller than 2,000 square meters	7	0.07669	0.50439	0.00120	14.34686
Adjacent to a park (=1, 0 otherwise)	7	0.13668	0.34353	0	1
Reilly for farms with animals	4, 5, 6	1.90451	19.36042	0.06026	1002.45573
Reilly for farms without animals	4, 5, 6	6.97171	39.18529	0.16134	1694.97793
Distance (meters) to the ALR boundary if property is located within the ALR boundary, 0 otherwise	10	33.48121	184.41807	0	1657.48386
Distance (meters) to the ALR boundary if property is located outside the ALR boundary, 0 otherwise	10	617.79360	555.62314	0	3042.90310
Reilly for golf courses (multiplied by 1,000)	8	0.00149	0.00418	0.00008	0.16898
Adjacent to golf course (=1, 0 otherwise)	8	0.00484	0.06937	0	1
Distance to Victoria City Hall (km)	8	8.94066	6.73937	2.29488	30.67183
Distance to Pat bay highway (km)	11	2.11177	1.73142	0.00054	8.24230
Pat bay highway within 100 m (=1, 0 otherwise)	11	0.09198	0.28901	0	1
Distance to nearest standard school (km)	8	0.70449	0.48980	0.01359	3.68549
Standard school within 100 m (=1, 0 otherwise)	8	0.00947	0.09688	0	1
Distance to nearest recreational centre (km)	8	2.09116	1.89975	0.06804	8.88096
Recreational centre within 100 m (=1, 0 otherwise)	8	0.00089	0.02979	0	1
Distance to Victoria airport (in km)	8	17.04632	6.09687	0.97451	24.98897
Maximum elevation (metres)	9	44.14537	26.42494	0	170
Elevation difference	9	1.58541	4.23425	0	50
Real interest rate (%)	12, 14	1.61825	1.18898	0.31296	4.44841
Real GDP expenditure based Canada (billion (long scale) CA$)	13, 14	1.16039	0.06799	1.07658	1.26543

*For a description of the databases see Appendix 6.1. The numbers in this column refer to the database identifiers in Appendix 6.1.

Finally, the number of observations was reduced due to the spatial dependence in the model. In order to construct the spatial weighting matrix, properties cannot be incorporated in the analysis more than once. Therefore, if a property is sold more than once during 2000 to 2006, only the most recent transaction is included in the analysis. This refinement led to a total of 10,133 observations. The locations of these properties are indicated in Figure 6.2, which also shows the locations of parks and farmland on the peninsula. Because our data span seven years, we had to adjust prices, assessed values, GDP and interest rates for inflation. We used the Consumer Price Index (CPI) to make the appropriate adjustments as others have done in this situation (e.g. Cho, et al. (2006)).

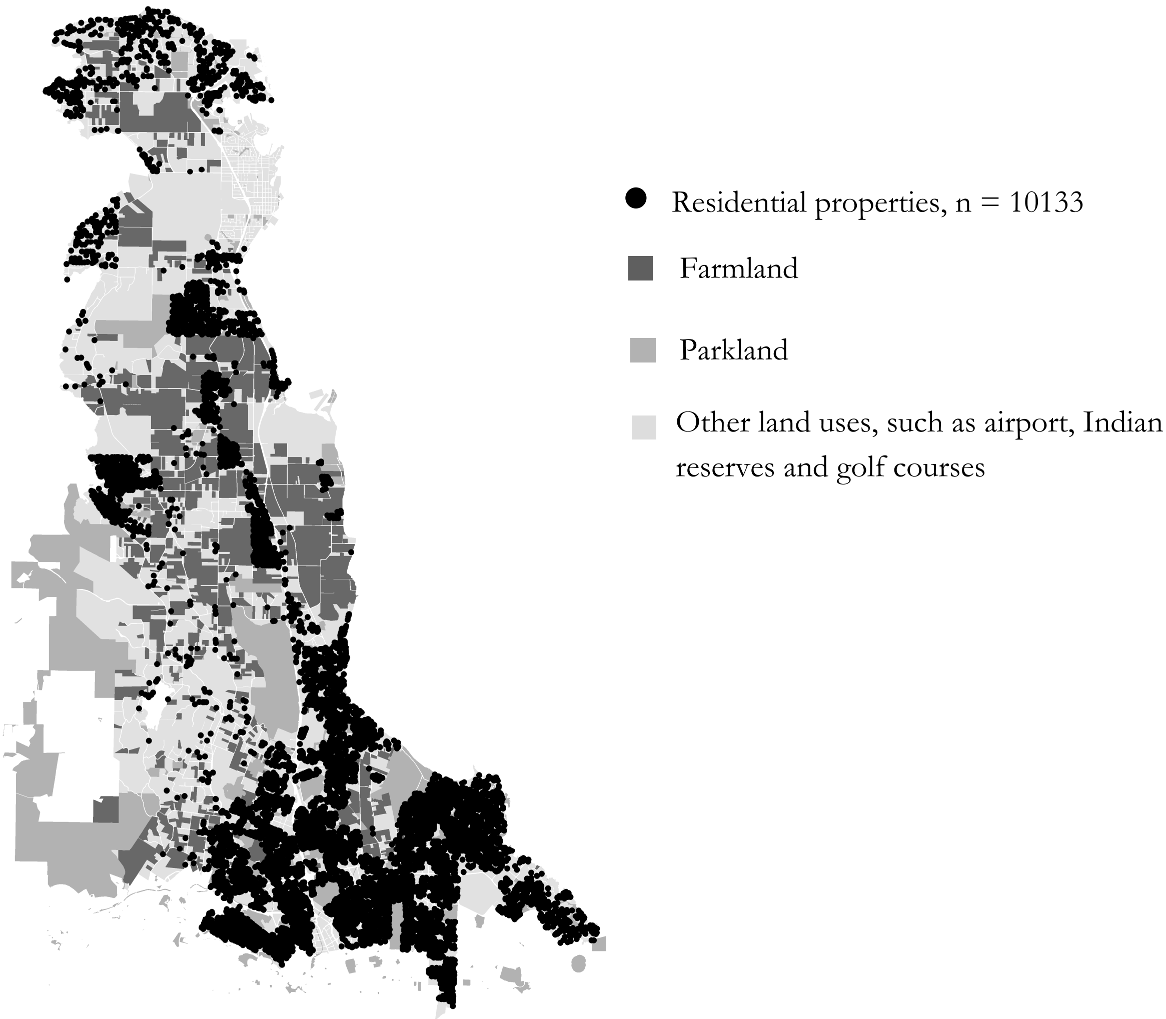

Figure 6.2 Land use and location of residential properties on the Saanich Peninsula.

6.4 Empirical results

6.4.1 Assessed versus sales values

First we consider whether or not there are any significant differences between actual transactions and assessed values. The correlation coefficient between assessed and actual sales values for our 10,133 observations is 0.88. Though this is rather high, the overlap is not perfect. Actual transaction values are generally higher and have a larger standard deviation than assessed values, as indicated in Table 6.2. This is also apparent from Figure 6.3 where histograms of both assessed and sales values are provided. The distribution of assessed values has a mean closer to the mode and fewer observations in the tails of the distribution compared to sales prices. Though BC Assessment's stated goal[4] is to have assessments match market prices, we believe the reason assessed values tend to be lower than market values is that the assessment authority wishes to avoid criticism and large numbers of appeals of assessments to reduce tax bills. Because BC Assessment uses sales prices as part of their formula to determine assessed values, we may also see less variation in the assessed values due to the fact that very expensive and very cheap properties are sold less often than average properties. Therefore, there are fewer such reference prices for BC Assessment to use compared to average properties.[5]

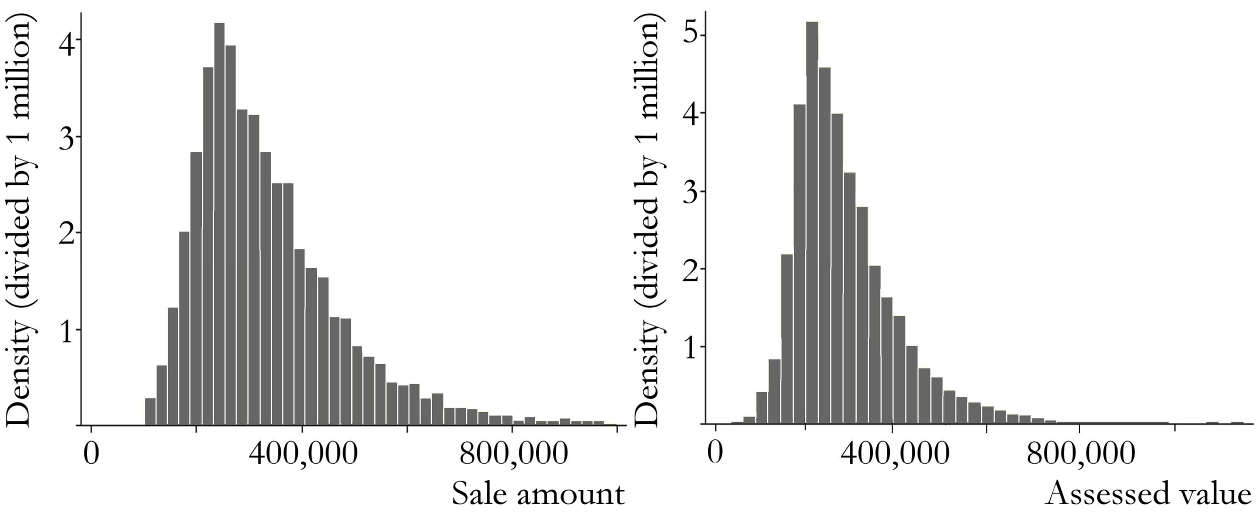

Figure 6.3 Land use and location of residential properties on the Saanich Peninsula.

In the SUR model, we partly correct for the difference between sales and assessed values by using a scaling factor (a) that minimizes

$$\sum_{i=1}^{n}\left(Assess_i - a \times Sale_i\right)^2. \qquad [6.12]$$

This factor equals 0.81, so each assessed value was divided by 0.81. The corrected assessed values were then used in the SUR model with results presented in Table 6.3. A visual inspection of the parameter estimates in the SUR model indicates that all parameters have similar signs in the actual sales and assessed values equations, except for the dummy variable of adjacency to a golf course, the log of distance to the highway and the log of distance to the nearest recreational centre, but these have no significant impact on sales or assessed values.

[4] See their website http://www.bcassessment.bc.ca/about/index.asp

[5] For instance, the lack of high property value benchmarks may suggest that assessors rate these properties closer to the average values than market prices would predict. There may be nonlinearities in prices for very large and luxurious houses and estates which are not captured well by BC Assessment's assessors.

Based on the SUR model, however, we must reject the hypothesis that all 35 parameters included in the model (excepting the intercept) are equal across the two equations. The Wald statistic is 420.98 and, under the null hypothesis (that all parameters are equal), this is distributed as a $\chi2$ with 35 degrees of freedom. Therefore, we reject the null-hypothesis with near certainty. We also test for the parameters of particular interest – the Reilly indices for parks, farms and golf courses, adjacency dummy variables for parks and golf courses, and the distances to the ALR boundary. The Wald statistic for this test is 8.59 and is distributed as a $\chi2$ with 10 degrees of freedom; under these assumptions, we accept the null-hypothesis that the parameter estimates are equal. (The p-value of the statistic is 0.57.) We conclude, therefore, that on first inspection the signs and sizes of estimated parameters look rather similar in the assessed and sales equation. However, they are not similar enough to assume that they are all the same in both equations. Yet, for the parameters of interest, the hypothesis that the estimated effects are the same is accepted.

Table 6.3 Estimation results for the spatial Seemingly Unrelated Regression (SUR).

Dependent variable	Sales value property (CA$ millions)		Adjusted assessed value property (CA$ millions)	
	Parameter	t-statistic	Parameter	t-statistic
EGLS estimation				
Log of the lot size (meters)	0.064851***	21.41	0.065666***	25.04
Effective year: the last major renovation of the property (year – 1900)	0.000568***	7.33	0.000237***	3.68
Log of the finished area (meters)	0.086742***	20.40	0.082719***	23.66
Number of 3- or 4-piece bathrooms	0.010232***	5.95	0.011233***	7.97
Number of 2 piece bathrooms (toilet and wash basin)	0.008051***	4.38	0.008646***	5.72
Number of bedrooms	-0.002884**	-2.67	-0.003538***	-3.98
Number of multi car garages	0.021264***	7.51	0.023177***	9.95
Number of single car garages	0.006476***	2.60	0.008508***	4.17
Number of car ports	0.002853	1.03	0.002956	1.30
Pool (=1 if there is a pool, 0 otherwise)	0.015698*	1.85	0.042155***	6.07
Other buildings (=1 if there are other buildings, 0 otherwise)	0.015142***	4.78	0.005232**	2.02
Corner lot (=1 if the lot is at the corner of a street, 0 otherwise)	-0.002801	-0.93	-0.003383	-1.37
Waterfront lot (=1 if the lot is on the waterfront, 0 otherwise)	0.334534***	39.31	0.318199***	43.91
Log of Reilly for parks larger than 50,000 square meters	-0.003162**	-2.65	-0.002322**	-2.05
Log of Reilly for parks between 2,000 and 50,000 square meters	-0.002640	-2.12	-0.002644**	-2.30
Log of Reilly for parks smaller than 2,000 square meters	0.002368**	1.87	0.000277	0.23
Adjacent to a park (=1, 0 otherwise)	0.011378***	2.82	0.009521***	2.76
Log of Reilly for farms with animals	-0.018892***	-9.02	-0.017024***	-8.67
Log of Reilly for farms without animals	-0.001357	-0.87	-0.003341**	-2.27

(Table continued on next page)

(Table continued)

Inverse squared distance (meters) to the ALR boundary if property is located within the ALR boundary, 0 otherwise	1.566763	0.67	0.026082	0.01
Inverse squared distance (meters) to the ALR boundary if property is located outside the ALR boundary, 0 otherwise	2.768818	1.38	2.724761	1.62
Log of Reilly for golf courses	0.011200***	5.26	0.009621***	4.57
Adjacent to golf course (=1, 0 otherwise)	0.001560	0.10	-0.001479	-0.11
Log of distance to Victoria City Hall (meters)	0.079979***	10.26	0.086910***	11.35
Log of distance to Pat bay highway (meters)	-0.00864	-0.50	0.001407	0.87
Highway within 100 m (=1, 0 otherwise)	-0.024874	-3.03	-0.015488**	-2.06
Log of distance to the nearest standard school (meters)	0.014787***	5.91	0.013165***	5.38
Standard school within 100 m (=1, 0 otherwise)	0.009155	0.83	0.012275	1.31
Log of distance to nearest recreational centre (meters)	-0.002415	-0.82	0.000078	0.03
Recreational centre within 100 m (=1, 0 otherwise)	-0.037487	-1.08	-0.008156	-0.28
Log of distance to Victoria airport (meters)	0.079422***	12.08	0.085155***	13.18
Maximum elevation (meters)	0.000395***	6.04	0.000523***	8.22
Elevation difference (meters)	-0.000328	-1.00	-0.000423	-1.51
Real Interest rate (%)	0.003126***	4.06	0.012003***	19.07
Real GDP expenditure based Canada (billions (long scale) of CA$)	1.104587***	81.64	1.039136***	93.92
Constant	-3.321660***	-30.26	-3.383954***	-31.44
R^2	0.5754		0.6289	
Adjusted R^2	0.5740		0.6276	
System R^2	0.4880		0.4880	
Number of observations	10133		10133	
Σ				
σ_1^2	0.0084			
σ_{12}	0.0045			
σ_2^2	0.0057			
MM estimation				
ρ	0.3363	30.08	0.4544	46.58

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels.

6.4.2 Impact of open space and the ALR

The impact of open space on property prices is rather mixed (see Table 6.3). Residents assign positive value to being adjacent to open space provided by parks and they also enjoy small open spaces in their neighborhood. Small parks are frequently used by parents if there is a children's playground and by pet-owners to exercise their dogs. Larger parks, which frequently provide recreation benefits (such as hiking, picnicking and wildlife watching), are also valued but these parks are often used by citizens outside the immediate neighborhood who access the park with a car.

Larger parks therefore result in negative externalities associated with noise, parked cars, and so on. This explains the finding of non-significant signs for the medium sized parks and a significant negative impact of the Reilly index for large parks.

The impact of nearby farms on residential properties is negative. The parameter for the Reilly score for farms with animals is negative indicating that the detrimental impacts of noise, odors, dust and other negative spillovers are more prominent than the positive, open-space attributes of farmland. The Reilly index for non-animal farms has a negative impact on residential property values, though it is insignificant in the market sales equation. This may indicate that there is a lot of variation in the value people attach to open space provided by farmland, perhaps reflecting the variation in the types of externalities generated by agricultural activities. Another interpretation of these findings is that, although property owners value open space provided by agriculture, they do not have confidence that the farmland will remain in agriculture, or even worse, that farmland could be converted to a less desirable use in the future (e.g, a shopping center, high-rise apartment, industrial park). Nelson (1992) hypothesized that, if buyers of residential properties expect farmland to remain in agriculture, an open space premium should be observed, but if buyers expect that neighboring land will be developed in the future, no such premium should exist. Given that speculation is happening on the Saanich Peninsula (see Chapter 3 and 4), this is not an implausible explanation.

The two variables that indicate the distance to the ALR boundary from inside and outside the ALR are both insignificant, indicating that the ALR boundary has no impact on residential property prices. The reason is that proximity to farmland is already taken into account directly in the model.

The final open space indicators are provided by the Reilly index for golf courses and whether the property is adjacent to a golf course. While the Reilly score has a significant and positive effect on the sales prices of properties, the adjacency dummy is not significant (and even negative but still not significant for assessed values). This is contrary to the findings of Nicholls and Crompton (2007) who found positive impacts on properties that were adjacent to golf courses. The insignificance of this variable in our model may result from negative spillovers caused by parked cars, noise from the clubhouse, and so on. On the other hand, golf is a popular recreational activity, especially with older demographics (which comprise a significant proportion of the area's population). Golf courses nearby seem to be desirable as evidenced by the positive impact on property prices by the Reilly for golf courses. Both distance to the golf course and the number of holes matter in the Reilly index. Therefore, we can conclude that golf courses are less attractive land uses as providers of open space than as providers of recreational activities. This is contrary to findings of Asabere and Huffman (1996) who found a positive impact of adjacency to golf courses, but a negative impact of the reciprocal of distance to the entry gate of the golf course.

6.4.3 Spatial allocation

It is important to be aware of potential problems concerning multicollinearity of the explanatory variables in hedonic pricing models. In the current data we find that some of the explanatory variables are correlated. This correlation is mainly due to the spatial location of properties and the time properties were developed. For example, newer and larger properties with multi-car garages instead of single-car garages are found farther north on the peninsula. Properties on hill tops were generally developed later than properties at lower elevation levels. Newer properties tend to be located farther out from the city centre, in areas where population rates are (currently) low, and tend to be more spatially distant from standard schools and recreational centers.[6] However, we do not find symptoms of severe multicollinearity in our data, such as low significance of explanatory variables and high R^2s at the same time. Therefore, we will discuss individual findings separately to illuminate the impact that the correlation between variables has in our model.

Examining the findings of other studies (e.g. Ready and Abdalla (2005)) we would expect that distance to Victoria would be inversely related to residential property prices because people value a shorter commute to work. Other spatial features, such as the Swartz Bay ferry terminal (which provides access to the mainland), the main commuting corridor (the Patricia Bay highway) and schools, are expected to have a positive effect on sales price. However, we find a negative effect of proximity to the main business district of Victoria. There are two explanations for this. The first is that the distance to the Swartz bay ferry terminal and the distance to Victoria are almost perfectly negatively correlated. The ferry terminal is located at the northern tip of the peninsula and the city centre is located at the southern end. These are opposite effects, and currently the positive effect of Swartz bay seems to be stronger than the positive effect of being close to the city centre. Another explanation is that in general more expensive properties are built farther north on the peninsula, both farther away from the city centre and most other facilities. This automatically influences the prices in different regions of the peninsula. Furthermore, being within a region of 100 meters from the highway has a negative effect on property prices, due to negative externalities of the highway such as noise and pollution. Proximity to standard schools also seems to have a significant negative impact on property values perhaps due to the vandalism and loitering associated with some schools.

We did not only incorporate spatial explanatory variables in our model, we also included spatial error dependence. Sure enough, we did find evidence for this type of spatial dependence, meaning that the error terms of relatively close properties are correlated (though error terms of properties which are relatively farther away from each other do not show the same effects). This type of correlation is higher for assessed values than for sales values, which makes sense as assessments specifically take neighboring property values in account while sales prices don't.

6.4.4 Housing characteristics

Most housing characteristics in our model have the expected sign that past literature and intuition dictates. Lot size, finished area and the number of bathrooms all positively indicate a more valuable house as does the effective year. Beyond size and newness, there is a puzzling finding though. One would expect the number of bedrooms to positively affect housing value as they can be seen as indicators of property size and degree of luxury. However, we found negative effects. Perhaps

[6] Presumably, once the density is high enough and the population demographics demand it, schools and recreation centers will be built in areas of new subdivisions.

buyers do not regard a bounty of bedrooms as positive because, for a given house size, they prefer fewer but larger bedrooms as opposed to more numerous and smaller rooms.

The impact of garages is fairly predictable with multi-car garages being more highly valued than single-car garages which are more highly valued than car ports. Car ports are more valued than no parking structures (though this is not significant). Also as expected, water front lots are significantly more valued than non-water front, owing to the views and the recreational opportunities. Similarly, the presence of other buildings or a pool on the lot adds to the overall property value. Though they tend to be slightly larger, corner lots are less private and experience more traffic and noise externalities, and so it is not surprising that they are not valued significantly different than non-corner lots.

6.4.5 Other characteristics

With respect to elevation levels, we find that properties that are located higher up on a hill sell and are assessed for more than similar properties located at lower elevations. Hilltop locations in this area afford views of farmland and the ocean and buyers are willing to pay a premium for these properties. Elevation differences per property have a slightly negative though non-significant effect.

Because our data span about seven years, we included macroeconomic information (interest rates and GDP) to reflect the general state of the economy. To correct for inflation over this time period, both variables where adjusted by the Consumer Price Index (CPI). Real GDP has a significantly positive impact on property prices, indicating that the higher GDP rises, the higher the demand for houses is, which directly translates into increases in property prices. The impact of interest rates is also positive, which seems counterintuitive as mortgage rates and interest rates are linked and higher mortgage rates mean housing is less affordable. However, a possible explanation could be that the real interest rates were not very high during this period (varying between 0.31% to 4.45%). Therefore, paying a slightly higher interest rate did not scare people off from buying properties as the rate of increase in housing prices more than compensated for the money spent on interest payments on loans and mortgages. Another explanation could be that in times of recession the central banks tend to decrease their interest rates.

6.5 Conclusion and discussion

In this research we investigate whether assessed values were good proxies for actual sales values in a hedonic pricing model that we use to estimate the value of open space on the Saanich Peninsula, British Columbia, Canada. In particular, open space provided by farmland, parkland and golf courses is examined and also open space under semi-permanent protection in the Agricultural Land Reserve.

A spatial Seemingly Unrelated Regression model is estimated to construct a test statistic for the comparison of the parameters in the assessment and sales equations. The results indicate that although not all parameters in the assessment and sales equations are the same, we accept the hypothesis that the impacts of open space on property values are valued in the same way in both equations. However, we do observe some differences between the distributions of assessed versus sales values. Specifically, we observe that average assessed values are lower than average sales values and the variation in assessed values is smaller than in the sales prices. To overcome the difference in means, we divided the assessed values by a factor 0.81, resulting from the factor, *a,* that minimized [6.12]. These findings imply that assessed values may be used in place of market values as the dependent variable in hedonic pricing models if one is interested in the impact of open space on property values. Though it may be necessary to scale the distribution of assessed values. To do this, average sales values can be used to scale assessed values. In our research the factor assessed / sales values results in 0.84, which is rather close to the factor we used (0.81). Using average sales values is not necessarily an insurmountable problem because these values are much more accessible than parcel-by-parcel information. Furthermore, it is important to note that property assessment systems may be very different in other jurisdictions in North America or Europe which could affect the validity of applying these results to other locations.

With respect to open space we find somewhat mixed results. The reason is that open space in all three capacities (nature, agriculture and golf courses) imposes both positive and negative externalities on surrounding residential properties. Properties adjacent to nature parks sell for a premium, but people seem to prefer smaller parks instead of larger parks close to their homes. The smaller parks can be used for short term recreation but do not cause the inconveniences that large parks do when people visit them by car. Furthermore, open space provided by agricultural land is not valued positively by residents, at least as far as housing prices go. The negative externalities associated with farmland seem to override the positive externalities, especially for animal farms. The uncertainty surrounding future land uses of undeveloped land may also play a part in this finding. Finally, we find that golf courses provide positive benefits for residents. Residents pay higher prices for houses that are located closer to (larger) golf courses, although having a house adjacent to a golf course does not increase its value ceteris paribus.

The inclusion of spatial autocorrelation in the model is very important. Spatial autocorrelation was taken into account in both the sales and the assessment equation with the Method of Moment estimator as specified by Kelejian and Prucha (2004). We found highly significant positive spatial correlation between the error terms of properties that are located close to each other. With respect to spatial explanatory variables, we found that some are correlated with property characteristics. Newer properties are built further north on the peninsula, on higher elevation levels, are larger on average and more often come with multi car garages.

This research provides a geographic example of how housing prices respond to open space at the urban fringe and how agricultural land preservation systems (in this case zoning) interact with price. Answers to these questions can be used to inform urban planners, geographers, policy makers and others about issues related to taxes, urbanization and the preservation of agricultural land and parkland.

Appendix 6.1

Table A6.1 Data sources used in this research.

Nr	Name database	Data source	Year data
1	Sales history	LandCor	1974-2006
2	Assessment information	LandCor (originating from BC Assessment)	2000-2006
3	Property information	LandCor	2006
4	Actual use codes	BC Assessment	2006
5	Cadastral information	Capital Regional District (CRD)	2005
6	Cadastral information	Ministry of Agriculture	2004
7	Nature parks	Capital Regional District (CRD)	2006
8	Points of interest (schools, airport, Victoria city centre, golf courses, ferry terminal, recreational centers)	Capital Regional District (CRD)	2005
9	Elevation data	Municipalities (Saanich, Central Saanich and North Saanich)	2005
10	ALR	BC Assessment (originating from Agricultural Land Commission (ALC))	2005
11	Road Network	Statistics Canada	2005
12	Interest rates Canada	Bank of Canada	1951-2005
13	GDP annual data Canada	Statistics Canada	1961-2005
14	CPI Canada	Statistics Canada	1981-2006

CHAPTER 7

EXTERNALITIES IMPOSED ON RESIDENTIAL PROPERTIES IN HIGHLY URBANIZED AREAS[1]

Abstract

In highly industrialized areas open spaces such as farmland and nature are under pressure since urban areas are expanding at their expense. Because of the high opportunity costs of development in urban areas, a high price has to be paid for the maintenance or creation of open space. The question is if this high price can be justified by the value of the open space. We estimate the value residents attach to surrounding open space in a hedonic pricing model. More specifically, we investigate in a highly urbanized area in the Netherlands how the externalities of farmland, nature, and other uses, such as industrial areas and the sea affect residential property prices. Moreover, spatial lag and error dependence are corrected for in the hedonic pricing model used to estimate the value of open space and other externalities. According to our results premiums are paid by residents who buy properties close to urban parks and the North Sea and for properties with views on open space.

7.1 Introduction

In highly urbanized areas different types of land use compete for space. Open spaces such as farmland and nature are under pressure since urban areas are expanding at their expense. Because of the high opportunity costs of development in urban areas, a high price has to be paid for the maintenance and creation of open space. The question is if this high price can be justified by the value of the open space. Similarly, choices have to be made regarding the location of greenhouse horticulture and industrial areas. Although these types of land use create a high value added, they also create externalities that affect the surrounding users of the land. If they have a negative impact on the users of surrounding land their total added value is lower than the value indicated by their profit.

The area around Midden-Delfland, incorporating cities like Rotterdam and Delft, in the Western part of the Netherlands, is a highly urbanized area, where many different types of land use are combined. It contains the main greenhouse horticulture activities of the Netherlands and the harbor of Rotterdam, one of the largest harbors in the world, with all its industrial activities. In

[1] This chapter is a working paper by Cotteleer, G. and J.H.M. Peerlings. The authors wish to thank the Dutch Association of Real Estate Agents for providing data on transactions of residential property sales.

between the villages, cities, industrial areas and greenhouses there is space for nature, recreation and agricultural activities. The agricultural sector is traditionally characterized by dairy operations, and therefore, the landscape by meadows with grazing dairy cows. Strict land zoning policies make that these different forms of land-use take place but they also create high opportunity costs of land used for nature, recreation and agricultural activities.

In order to support decision-making, quantifying the value residents attach to the land use, with its externalities, surrounding them is important. One way of doing this is by quantifying the premium or loss generated for real estate properties by nearby open space, industrial and greenhouse horticultural areas. Hedonic pricing models (Rosen, 1974) are often used to calculate such premiums. In these models the value of each property is regressed on the factors that determine property prices.

Although, the value of open space has often been investigated (e.g. Geoghean (2002), Wu, et al. (2004) and Cho, et al. (2006)), less attention has been paid to the value of other land uses. Although, the impact of hazardous waste sites was investigated by Ihlanfeldt and Taylor (2004), and Kaufman and Cloutier (2006) investigated the impact of small brownfields on residential properties, these studies were all focused on specific sources of pollution. For the Netherlands, Rouwendal and Van der Straaten (2007) examined the value of open space within cities. Open space outside cities and impacts of other land uses on residential properties were not investigated. The current research investigates the impact of land use surrounding residential properties, and its externalities, on residential property prices. Since our research area combines many different types of land uses on a relatively small area, this assures that it is the right setting to investigate these issues.

However, some issues have to be addressed while applying hedonic pricing models. First, data on property characteristics are required. These can be categorized as size characteristics (indicators for the size of the lot and the building on it), quality indicators (e.g. age of the structure, maintenance level), neighborhood characteristics (racial composition, mean income) and location. Location does not only include information about the proximity to public transport and downtown, but also about the proximity to open space, such as farmland or nature areas (Taylor, 2003). This requires linking data from different sources by Geographical Information Systems (GIS).

Second, there might be a problem of spatial dependence (Anselin, 1988b). Corrections for spatial error dependence should be applied if non-observed property characteristics are similar for neighboring properties. Spatial lag dependence might be an issue if buyers and sellers determine their willingness to pay or willingness to accept for properties based on properties that were sold in the neighborhood. This results in direct dependence of the property prices located close to each other. Because, we have over 70,000 observations, we use the Method of Moments estimator proposed by Kelejian and Prucha (1999) to correct for spatial error dependence and the instrumental variable approach proposed by Kelejian and Prucha (1998) to account for spatial lag dependence.

The objective of this paper is to determine the impact of land use surrounding residential properties, and its externalities, on residential property prices in Midden-Delfland. This research uses spatial econometric techniques to estimate a hedonic pricing model of residential property prices.

Section 7.2 presents the empirical model. The data are described in 7.3 and estimation results are discussed in section 7.4. Finally, section 7.5 concludes.

7.2 Empirical model and estimation

7.2.1 Measuring externalities

Hedonic pricing models reveal implicit prices of property characteristics from overall property prices. These characteristics also incorporate measures of the presence of different types of land use. Implicitly, this research assumes that the more land use of a certain type surrounding a residential property, and the closer by, the more externalities of this type of land use are imposed on the residential property. Examples of measures that take account of the surrounding land use are the distance from the residential property to the nearest lot with a specific use (e.g. Wu (2001), Ihlandfeldt and Taylor (2004) and Wu, et al. (2004)), the percentage of a certain type of land use in a zone around each property (e.g. Irwin and Bockstael (2001), Kestens, et al. (2004), and Gheoghegan (2002)), or adjacency of other types of land use to the property (e.g. Nicholls and Crompton (2007) and Spalatro and Provencher (2001)). This research extends the use of the Reilly index, as proposed in Chapter 6 to all types of land use, and not just open space. Incorporated land use types are agriculture, nature areas, urban recreational parks, greenhouse horticulture, recreational services, waste sites, recreational waters and industrial areas. In addition dummy variables are specified regarding the adjacency to nature areas, water, parks and other types of open space. If the property is adjacent to one of these types of open space, the associated dummy variable has the value 1, and otherwise the value is 0.

7.2.2 The generalized spatial two-stage least squares procedure

In the hedonic pricing model residential property prices are explained by property characteristics and measures of land use surrounding the residential properties. Moreover, we include spatial lag and error dependence in the model. Spatial lag dependence refers to the direct spatial relationship between property prices of properties that are located near each other. It is assumed that price information from neighboring properties that were recently sold are incorporated in current property prices. Spatial error dependence refers to the spatial relationship in the error term. Error terms are assumed to be spatially related, due to spatially related omitted variables. The hedonic pricing model that incorporates both spatial lag and error dependence is specified as follows:

$$\begin{aligned} P &= X\beta + \lambda MP + \varepsilon, \quad &|\lambda| < 1 \\ \varepsilon &= \rho W\varepsilon + u, \quad &|\rho| < 1, \end{aligned} \tag{7.1}$$

where P is a vector of property prices; X is the matrix of property characteristics; β the associated coefficient vector; λ the spatial lag parameter; M the spatial weighting matrix associated with the spatial lag in the model; ε the spatially correlated vector of residuals; ρ the spatial error parameter; W the spatial weighting matrix associated with the spatial error term; and u is the remaining error term, with an expected value of 0 and a variance of σ_u^2.

Because our dataset contains more than 70,000 observations, we use the Generalized Spatial Two-Stage Least Squares (GS2SLS estimator) procedures (Kelejian and Prucha, 1998) to estimate the model. These procedures are specifically developed to estimate spatial models in combination with large datasets. Kelejian and Prucha (1998) propose a three step Generalized Spatial Two-Stage Least Squares Procedure to estimate the model. In the first step the regression model is estimated by two-stage least squares (2SLS) using instruments H and without incorporating the spatial error structure. H is a $n \times p$ matrix, containing a set of instruments used to instrument Z, where $Z = (X, My)$. Furthermore define $\delta = (\beta', \lambda)'$. In this procedure we use X, MX and M^2X as instruments in H. The two-stage least squares estimator is then given by:

$$\tilde{\delta} = \left(\hat{Z}'\hat{Z}\right)^{-1}\hat{Z}'y\,, \qquad [7.2]$$

where $\hat{Z} = PZ = (X, \overline{My})$; $\overline{My} = PMy$; and $P = H(H'H)^{-1}H'$. Although this estimator is consistent, the spatial correlation in the error term is not incorporated yet in this estimate.

Therefore, the second step in the procedure uses the Method of Moment (MM) estimator from Kelejian and Prucha (1999) to estimate ρ and σ_u^2. We will use the following notation $\bar{u} = Wu$, $\bar{\varepsilon} = W\varepsilon$, $\bar{\bar{\varepsilon}} = WW\varepsilon$, $u = \varepsilon - \rho\bar{\varepsilon}$, and $\bar{u} = \bar{\varepsilon} - \rho\bar{\bar{\varepsilon}}$. The following moments are used:

$$E\left[\frac{1}{N}u'u\right] = \sigma_u^2,\; E\left[\frac{1}{N}\bar{u}'\bar{u}\right] = \sigma_u^2\frac{1}{N}Tr(W'W) \text{ and } E\left[\frac{1}{N}\bar{u}'u\right] = 0. \qquad [7.3]$$

Because we cannot use the population moment conditions, sample analogues to the population moment conditions have to be specified. Therefore, the following predictors are defined: $\tilde{\varepsilon}$ is a predictor for ε. Correspondingly $\bar{\tilde{\varepsilon}} = W\tilde{\varepsilon}$ and $\bar{\bar{\tilde{\varepsilon}}} = W\bar{\tilde{\varepsilon}}$. This leads to the following conditions for the sample moments:

$$G_N\left[\sigma^2, \rho, \rho^2\right] - g_N = v_N(\sigma^2, \rho)\,, \qquad [7.4]$$

where $v_N(\sigma^2, \rho)$ is the vector of residuals;

$$G_N = \begin{bmatrix} 1 & -\frac{2}{N}\bar{\tilde{\varepsilon}}'\tilde{\varepsilon} & \frac{1}{N}\bar{\tilde{\varepsilon}}'\bar{\tilde{\varepsilon}} \\ \frac{1}{N}Tr(W'W) & -\frac{2}{N}\bar{\bar{\tilde{\varepsilon}}}'\bar{\tilde{\varepsilon}} & \frac{1}{N}\bar{\bar{\tilde{\varepsilon}}}'\bar{\bar{\tilde{\varepsilon}}} \\ 0 & -\frac{1}{N}\left(\bar{\bar{\tilde{\varepsilon}}}'\tilde{\varepsilon} + \bar{\tilde{\varepsilon}}'\bar{\tilde{\varepsilon}}\right) & \frac{1}{N}\bar{\bar{\tilde{\varepsilon}}}'\bar{\tilde{\varepsilon}} \end{bmatrix}; \text{ and } g_N = \begin{bmatrix} -\frac{1}{N}\tilde{\varepsilon}'\tilde{\varepsilon} \\ -\frac{1}{N}\bar{\tilde{\varepsilon}}'\bar{\tilde{\varepsilon}} \\ -\frac{1}{N}\bar{\tilde{\varepsilon}}'\tilde{\varepsilon} \end{bmatrix}.$$

Furthermore, restrictions have to be imposed on the estimates of ρ and ρ^2. Otherwise, the estimate of ρ^2 is not equal to $\rho \times \rho$. The MM estimator for $\{\sigma^2, \rho\}$ can be defined as a nonlinear least squares estimator:

$$\left(\hat{\sigma}^2, \hat{\rho}\right) = \arg\min\left\{v_N\left(\sigma^2, \rho\right)' v_N\left(\sigma^2, \rho\right)\right\}. \qquad [7.5]$$

The residuals from the two stage least squares procedure in the first step can be used as starting values in the MM optimization procedure and the systems can be solved using non-linear least squares.

Given the estimate of ρ, in the third step the following Cochrane-Orcutt type transformation can be applied to the model:

$$y^* = Z^*\delta + u, \qquad [7.6]$$

where $y^* = y - \rho Wy$ and $Z^* = Z - \rho WZ$. This results in the generalized spatial 2SLS estimator, or GS2SLS estimator. This estimator is given by:

$$\hat{\delta} = \left[\hat{Z}^{*\prime}\hat{Z}^*\right]^{-1}\hat{Z}^{*\prime}y^*, \qquad [7.7]$$

where $\hat{Z}^* = PZ^*$.[2] According to Kelejian and Prucha (1999) this GS2SLS estimate of δ is consistent and small sample inference can be based on:

$$\hat{\delta}_{GS2SLS} \dot{\sim} N\left[\delta, \hat{\sigma}^2\left(\hat{Z}^{*\prime}\hat{Z}^*\right)^{-1}\right] \qquad [7.8]$$

7.2.3 The specification of the weighting matrix

Because we include both a spatial lag and a spatial error term in our model (see equation [7.1]), we have to specify two weighting matrices a-priori and because our dataset contains over 70,000 observations, we will only consider sparse weighting matrices. Furthermore, in this research we derive locational aspects of properties from geographical information of 6-digit postal code areas, since we do not have information about the specific location of each property. We combine the geographical information of 6-digit postal code areas with postal code information of residential properties. Within our research area, the average size of the 6 digit postal code areas is 0.021 km^2, with larger postal code areas in the more rural areas and smaller ones within city centers. Especially in urban areas, 6-digit postal code areas are good approximations of the location of properties. In comparison, the average size of the postal code areas within urban areas is 0.005 km^2, and the average size of postal code areas within agricultural areas is 0.203 km^2.

For, the weighting matrix associated with spatial error dependence, *W*, we assume that properties within the same 6 digit postal code areas affect each others error terms (resulting in an associated

[2] We used the sac_gmm Matlab function from the LeSage toolbox (http://www.spatial-econometrics.com/) to implement this estimation procedure.

weight of 1) and properties in different postal code areas do not affect each other (resulting in an associated weight of 0). In the weighting matrix associated with spatial lag dependence, *M*, we incorporate the time dimension as well. Our dataset consists of sales that took place in the period 1996-2006. Prices of future sales are not informative. Moreover, we cannot assume that for example the price of a property that was sold in 2006 was influenced by a sale of a neighboring property that was sold in 1998. Therefore, we assume that future sales and sales that took place more than a year prior to another sale, do not impact the other properties transactions price. Elements of the weighting matrix, m_{ij}, are equal to 1 if property *i* and *j* are within the same 6-digit postal code area and if property *j* was sold before *i*, but not more than a year before i was sold. Therefore, we end up with a specification of the spatial lag structure that is similar to a moving average, but also incorporates spatial aspects of the data. After specification *M* and *W* are both normalized, so that each row in the weighting matrices sums to 1 (or 0).

The current specifications of the weight matrices imply that observations within the same postal code areas are related, but not with observations outside this postal code area. This is a rather strong assumption, but given the size of the dataset and the available locational indicators, this is a workable specification. Note that Kelejian and Prucha (2002) and Kelejian et al. (2006) point out that including a weight matrix constituting blocks of equal elements in a spatial lag model causes identification problems. However, our specification of the weight matrix associated with the spatial error dependence constitutes a matrix with such properties, not the weight matrix associated with the spatial lag dependence.

7.3 Data and research area

In 2006 our research area in and around Midden-Delfland contained twelve different municipalities in the province of South-Holland, the Netherlands. Within the research period 1996-2006, some of the municipalities merged as a consequence of a general policy to increase efficiency and effectiveness of municipalities. The size of the research area is about 580 km^2 and the average population density over all twelve municipalities is 2,423 inhabitants per km^2. Figure 1 depicts the research area. Agricultural, greenhouse horticulture and nature areas are indicated with light grey shades, urban and industrial areas with dark grey and the location of the river "de Nieuwe Waterweg" is indicated in white.

Sales of residential properties are recorded in the database from the Dutch Association of Real Estate Agents. This database consists of 83,620 observations of transactions that took place in the period 1996-2006 in the research area. Both sales prices and property characteristics are contained in it. The market share of the association ranged from 56% in 1997 to 73% in 2006. Not all transactions available were included in the hedonic pricing model. For example, only dwellings were included in the final dataset. Lots without buildings on them, garages that were not directly linked to dwellings, houseboats, mobile homes, recreational properties and large rural estates were excluded. Also, properties that were bought as investments and properties that lacked information for all explanatory variables were excluded. Finally, transactions that were sold for nominal prices over €9,075,150 or under €11,345 were excluded. Transactions with higher or lower prices were indicated as unreliable by the Dutch Association of Real Estate Agents. Therefore, we ended up using 74,959 observations. These observations include both apartments and houses. However, we define different dummy variables for subcategories of apartments and houses to capture differences in prices between apartments and houses. Subcategories are ground-floor apartments, upstairs apartments, combined ground floor and upstairs apartments, maisonettes, gallery apartments, homes for the elderly, terraced houses, semi-detached houses[3], corner houses, free standing houses and apartment buildings with closed entrances to the front doors are the base case.

Figure 7.1 Research area and land use.

Since the time horizon is 1996-2006, we have to take the time dimension of the data into account. Figure 7.2 shows the nominal versus real price changes of apartments and houses captured by the 74,959 transactions that we analyze.

To correct for inflation, we use real prices in the hedonic pricing model, but Figure 7.2 indicates that residential sales prices have risen by more than the overall rate of inflation during our research period. Therefore, we also include a linear time trend in our model. This time trend has a value of 1 in January 1996 and a value of 132 in December 2006. It captures macro-economic changes, such as changes in GDP per capita, population growth, changes in interest rates etc.

[3] Next to each other, or linked through garages.

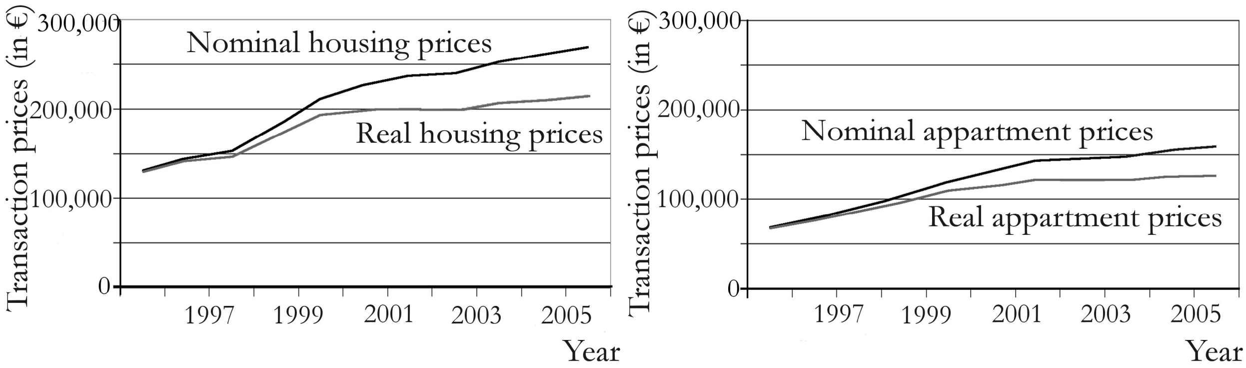

Figure 7.2 Nominal versus real price changes of apartments and houses.

To define explanatory variables for the hedonic pricing model we used information about property characteristics from the database of the Dutch Association of Real Estate Agents. However, we also linked information about land use to the transaction database. The land use database categorizes land use in the Netherlands and is supplied by Statistics Netherlands[4]. Based on this database, we calculated the Reilly indices for different types of land use surrounding each parcel. Reilly indices are given by:

$$R_i = \sum_{j=1}^{J} \left(S_j / D_{ij}^2 \right), \qquad [7.9]$$

where R_i is the Reilly index for residential property i and D_{ij} is the distance (in meters) from residential property i to area j with a specific land use type of size S_j (in square meters). All Reilly indices are scaled (divided by 1 million). A further explanation and the choices made regarding the Reilly indices can be found in Appendix 7.1. Moreover, section 6.3 gives an example of the Reilly index. The overview statistics in Appendix 7.2. give a good idea of the land use within the research area. Relatively large averages of Reilly indices indicate that relatively a lot of land is used by the associated type. Furthermore, we linked information about real average incomes, immigrants and population density in neighborhoods from the 'Wijk- en Buurtgegevens' database originating from Statistics Netherlands[5]. We distinguished 465 neighborhoods within our research area. Data about elevation levels and distances to highway exits originated from the Land use scanner[6], and data about the distance to the highway, railways and railway stations originates from the Ministry of Transport, Public Works and Water Management[7]. It is apparent from Appendix 7.2. that elevation levels are sometimes negative, indicating land that is located below sea level. Finally, we used 6 digit postal code maps from Bridgis[8] to locate the properties that were sold. An overview and summary statistics of all variables included in the hedonic pricing model can be found in Appendix 7.2.

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[4] The name of this database is Land Use Statistics (*Bestand Bodemgebruik, BBG*).

[5] Information from the 'Wijk en Buurtgegevens' is online availabe at: http://statline.cbs.nl/statweb/.

[6] For more information about the land use scanner see http://www.lumos.info/news.php.

[7] This database is called het National Transport Database (*Nationaal Wegenbestand, NWB*).

[8] Information about Bridgis can be found on http://www.bridgis.nl/.

7.4 Empirical results

Estimates of the hedonic pricing model, including spatial lag and error dependence are shown in Table 7.1. The model explains about 80% of the total variation in real transaction prices. Furthermore, most explanatory variables are highly significant. One reason for this high significance of the coefficients is the large dataset we use. Because we include many explanatory variables in the hedonic pricing model, we test for multicollinearity in an OLS specification of the model using Variance Inflation Factors (VIF's) (see Hill and Adkins (2001)). Because the mean VIF is 1.67 and the highest and lowest VIF's were respectively 5.96 and 1.00, we conclude that multicollinearity is not a problem in our specification.

Table 7.1 Estimation results for the hedonic pricing model including spatial lag and error dependence, with real sale prices in €100,000 as the dependent variable (n = 74,959).

	Coefficient	t-statistic
Adjacent to forest	0.10052***	4.59
Adjacent to water	0.15289***	24.95
Adjacent to park	0.07047***	8.08
Adjacent to other open space	0.03351***	7.69
Garden	0.04762***	9.92
Reilly for nature areas	0.01293	1.36
Reilly for urban parks	0.03698***	8.66
Reilly for recreation (hotels, campsites etc)	-0.00135	-0.29
Reilly for recreational water	0.00011[b]	0.26
Reilly for agricultural areas	-0.04552	-0.78
Reilly for greenhouse horticultural areas	-0.29144	-0.64
Reilly for industrial areas	0.01566***	3.06
Reilly for waste sites	-0.00015[b]	-0.87
City centre	0.04767***	8.74
Countryside	0.16564***	6.98
Busy road	-0.00510	-0.75
Distance to nearest highway (in km)	0.05461***	15.35
Distance to nearest highway exit (in km)	-0.05848***	-22.72
Distance to nearest railway (in km)	0.07007***	14.85
Distance to nearest railway station (in km)	-0.04125 ***	-10.34
Distance to the North Sea (in km)	-0.01024 ***	-18.98
Period of construction	0.02565***	20.65
Newly developed	0.03773**	2.21
Ground-floor apartment	0.03961***	5.17
Upstairs apartment	-0.05013***	-8.87
Ground floor and upstairs apartment	-0.00693	-0.34
Maisonette	-0.06880***	-8.30
Gallery apartment	-0.04622***	-7.39
Home for the elderly	-0.27271***	-4.58
Terraced house	0.10546***	13.80
Corner house	0.18909***	22.36
Semi-detached house	0.43316***	35.95
Semi-detached house, linked through garages	0.20768***	11.99

(Table continued on next page)

(Table continued)

Free standing	0.91307***	59.57
Surface of the house (in m^2)	0.00924***	185.68
Number of balconies	-0.00397	-1.28
Number of dormers	0.01133**	2.34
Number of roof terraces	0.07917***	14.43
Number of kitchens	0.00034	0.09
Number of sculleries	0.09239***	15.62
Storage in the attic	0.01921***	3.45
Practice inside	0.02391	1.40
Carport	0.12015***	11.18
Single car garage	0.18175***	29.99
Multi car garage	0.47465***	28.94
Maintenance of the house	0.05979***	39.35
Number of isolation materials used	0.00955***	8.55
Ground rent	-0.06244***	-12.72
Permanent	-0.08251***	-7.91
Partly rented	-0.25707***	-6.92
Population density within the neighborhood	0.00022	0.41
Percentage of non-western immigrants in the neighborhood	-0.00581***	-25.56
Average income within the neighborhood	0.00857***	14.88
Elevation level (in m)	-0.01242***	-6.13
Monthly trend	0.00547***	114.52
Constant	-0.16664***	-25.12
Rho	0.01037***	4.90
Lambda	0.51321***	9.77
R^2	0.8016	

*** indicates significance at the 1%, ** at the 5%, and * at the 10% critical levels. [b] For computational purposes, the Reilly for recreational water and waste sites were rescaled. The Reilly for recreational water is multiplied by 10,000 and the Reilly for waste sites by 1,000.

7.4.1 Spatial effects

The significance ($p<0.01$) of the spatial parameters rho and lambda indicates that the GS2SLS estimator is indeed the correct one. Therefore, we conclude that the moving average of prices of properties that were sold within the same 6-digit postal code areas influences sales prices directly. Moreover, we conclude that there are spatial influences not captured by the explanatory variables. To apply the GS2SLS estimator we had to rescale the Reillys for recreational water and waste sites to overcome singularity problems during the estimation procedure. Therefore, the Reilly for recreational water is multiplied by 10,000 and the Reilly for waste sites by 1,000.

Anselin (2003) indicated that we have to be careful with the interpretation of the coefficients if spatial lags are included in the model. The impact of changes in explanatory variables on sales prices is then given by the direct effect plus the indirect effect through changes in neighboring sales prices. However, our weighting matrix includes only impacts of past sales prices on the current sales prices. Therefore, we do not allow for indirect or feedback effects.

7.4.2 Externalities of different land use types

The adjacency measures of open space (forests, parks, water and other types of open space) are all highly significant ($p<0.01$) and have a positive impact on property prices. Waterfront properties have the highest added value, €15,289 on average per property. Adjacency of forests has an added value of €10,052, parks of €7,047 and other types of open space have an added value of €3,351. Although, gardens are in general not for public use and they are in general much smaller than public open space, they can also be viewed as providers of open space. The presence of a garden adds about €4,762 on average to the value of the house or apartment.

Other impacts of surrounding land uses are measured with Reilly indices. In this highly urban area, the Reilly for urban parks is significant ($p<0.01$) and positive. Therefore, we can conclude that urban parks have an added value for residents, the larger and more nearby the higher the added value. Rouwendal and Van der Straaten (2007) also found positive effects of parks and public gardens in the Dutch cities Amsterdam, The Hague and Rotterdam. Apparently the net effect of landscape services and other externalities provided by urban parks is positive. For larger nature areas we also find a positive effect, but this is not significant. This is almost opposite to the findings of Lutzenhiser and Netusil (2001). Although they found significant positive impacts of all types of open space, they found that natural areas provided the largest benefits and urban parks the smallest of all open space areas. They argue that urban parks are often associated with negative externalities. However, based on our findings we conclude that larger nature areas do not always serve the interests of the residents who live nearby. In Midden-Delfland these areas are often used for day-recreation and therefore, tourists and others are likely to benefit from and value these larger nature areas more than the residents who live nearby. Open space provided by farmland has a negative, but insignificant impact on nearby residential property values. The insignificance is likely caused by the fact that farmland (mainly pastures in the research area) provides both positive and negative externalities. Positive externalities being landscape and wildlife (e.g. meadow birds), negative externalities being smell and slow moving vehicles. Irwin and Bockstael (2001) found positive impacts of crop and pasture land on residential property prices. The Reilly indices for greenhouse horticulture, waste sites and recreational sites have the expected negative effect but are insignificant. An interesting finding, is the significant positive impact of industrial areas in this region. Since the harbor of Rotterdam is the largest industrial area in this region, this area seems to be appreciated by those who live nearby. The harbors are adjacent to the arm of a river 'Nieuwe waterweg'. Therefore, residents might appreciate the view of this large water mass and its incoming and leaving container ships. Another explanation might be the job opportunities provided in the harbor.

Other locational aspects of properties also matter. The model indicates that people are willing to pay a large premium for living in the countryside. Properties located in the countryside, sell on average for €16,564 more than properties somewhere in between the city centre and the countryside. The reason for this finding is that there is no information about lot size included in our model specification, and lot sizes of countryside properties are very likely to be larger than those of other properties. Including lot size in the model, will probably (at least partly) offset this finding. On the other hand the city / village centre also provides many types of benefits, therefore, we find an average premium of €4,767 for apartments and houses located within city or village centers.

Accessibility indicators such as the distance to the nearest train station and highway exit are also highly significant and negative. This means that people pay significantly more for more accessible properties. However, the presence of highways and railways themselves causes nuisances such as noise and highways also add to the pollution. This is according to our findings, because we find significant ($p<0.01$) positive coefficients for distances to the nearest highway and railway. On the other hand, the North Sea and its beaches provide positive landscape services and other externalities. Residents pay on average €1,024 more for each kilometer closer to the beach.

7.4.3 Other effects

With respect to the different apartment and housing types we have to compare the results to the base case of apartment buildings with closed entrances to the front doors. Ground-floor apartments sell for higher prices, and all other apartment types are priced lower than the base case. As expected, all housing types are priced higher than apartments, and free-standing houses are the most expensive, given the selection of housing types taken into account in this research.

The monthly trend is also highly significant ($p<0.01$) and positive. This indicates increasing real prices over time, as was already indicated by Figure 7.2.

With respect to neighborhood characteristics, we find insignificant effects of the population density. However, the percentage of non-western immigrants has a highly significant ($p<0.01$) and negative impact on the property prices. On the other hand, non-western immigrants might also search for cheap residences[9]. The average income within the district has a highly significant ($p<0.01$) positive impact on property prices. A reason for the insignificant effect of population density is that prices within very populated areas rise as a result of the high demand for residences. On the other hand, residents also impose externalities on each other and these might be negative in very populated areas. Another reason for the insignificant effect of this variable is that it is correlated with the percentage of non-western immigrants. Although the model as a whole doesn't suffer from multicollinearity, some variables are related. The elevation level has a significant ($p<0.01$) negative impact on property prices. Apparently residents are not afraid of higher flooding risks if they live below sea level.

7.5 Summary and discussion

The objective of this paper is to determine the impact of land use surrounding residential properties, and its externalities, on residential property prices in Midden-Delfland. According to the Reilly for urban parks, we find that the closer to urban parks and the larger these urban parks are, the higher the premium paid for residential properties. For larger nature areas and open space provided by farmland, we do not find significant impacts on property prices. This research also used adjacency

[9] If non-western immigrants search for cheap residences, endogeneity might be present in the model. However, we argue that this specific part of the model is not very likely to have a large influence on the estimates of the parameters of interest.

measures to investigate open space premiums. We find that residential properties adjacent to open space sell for a premium between €3,351 and €15,289 depending on the type of open space. And of all types of open space, waterfront properties sell for the highest premium. The North Sea and its beaches also provide positive landscape services and other externalities. Residents pay on average €1,024 more for each kilometer closer to the beach. Furthermore, the city / village centre also provides many types of benefits, goods and services, therefore, we find an average premium of €4,767 for apartments and houses located within city or village centers.

Therefore, from the Reilly indices we can conclude that although large nature areas might be important for preservation of wildlife and landscape residents pay no premium for living close to them. However, urban parks apparently provide the externalities residents appreciate such as green space people see from their window and the place where they can play with their kids. Also, the adjacency measures indicate a positive impact of adjacent open space. Note that the adjacency measures differ from the Reilly indices in the sense that they measure the view from the window and not the amount and distance to open space. E.g. a property with a high Reilly index can be very close to a nature area, but the Reilly indices do not indicate whether the property overlooks the nature area. Reilly indices for agricultural and large nature areas are not significant.

Greenhouse horticulture, waste sites and recreational sites have a negative but insignificant impact on the property prices. An interesting finding, is the significant positive impact of industrial areas in this region. Since the harbor of Rotterdam is the largest industrial area in this region, this area seems to be appreciated by those who live nearby. The harbors are adjacent to the arm of the river 'Nieuwe Waterweg'. Therefore, residents might appreciate the view of this large water mass and its incoming and leaving container ships. Another explanation might be the job opportunities provided by the harbor.

Furthermore, we find evidence for spatial lag and error dependence in the hedonic pricing model using a Generalized Spatial Two-Stage Least Squares procedure (Kelejian and Prucha, 1998). Therefore, we conclude that the moving average of prices of properties that were sold within the same 6-digit postal code areas influences sales prices directly. Moreover, we conclude that there are spatial influences not captured by the explanatory variables in the model.

In the current research we used Reilly indices to measure the impact of externalities. However, according to the Reilly indices, except for urban parks and industrial areas most types of land use do not impose externalities on residential properties. One explanation of the insignificance of the Reilly indices is provided by Smith, et al. (2002). They argued that insignificant effects of open space might be caused by the fact that there is a future potential for development of the open space, and therefore, the future value of the open space is not guaranteed. This argument might also hold for our highly urbanized research area, where conversions to urban land uses often take place. The current research only incorporates current land use and not government plans for land use changes. Including such plans might be an interesting for future research.

Appendix 7.1

The Reilly indices include all land uses within a radius of 50 km from the centroid of the 6 digit postal code area the residential property is located in. This has the advantage that land use outside the research area is also included in the Reilly measures if properties are located within 50 km of the boundary of the research area. Furthermore, the radius of 50 km is assumed to be large enough to capture all effect of externalities imposed on residential properties by surrounding land use. This is also an assumption of the Reilly indices, since distance squared is used in the denominator of the Reilly indices. Therefore, if a specific land use is located 50 km from the property, this has an effect of $size / 2.5*10^{-9}$ and the size of the area with that specific land use should be very large to show up in the Reilly index.

Because the centroid of postal code areas is not an exact indication of the location of properties, the centroid can be located within a certain land use area we are trying to measure the impact of. If this is the case the distance to that specific land use area is set to 1 instead of 0, indicating a distance of 1 meter between the residential property and the land use of interest.

The definition of areas with specific land uses is based on the Land Use Statistics database (*Bestand Bodemgebruik, BBG*). Because roads and waterways cross areas with the same land use, we specified buffer zones of 20 meters around each area with a specific land use. Land use areas with overlapping buffer zones were dissolved into one area if the land use was the same in each of these areas. The buffer zone was not subtracted afterwards, but since the extra 20 meters is included in each area, the deviation from the actual size of the areas is not assumed to affect the final estimation results.

Appendix 7.2

Table A7.1 Summary statistics dependent and explanatory variable(s), n = 74,959.

Variable	Mean	Std. dev.	Min	Max
Real sale amount (100,000 €)	1.4669	0.8213	0.11	20.63
Reilly for nature areas	0.0063	0.2482	1.24e-06	11.71
Reilly for urban parks	0.0361	0.4418	3.92e-07	70.96
Reilly for recreation (hotels, campsites etc)	0.0156	0.5802	7.14e-07	30.41
Reilly for recreational water	0.0002	0.0056	5.89e-08	0.47
Reilly for agricultural areas	2.2108	46.8537	7.11e-06	4721.51
Reilly for greenhouse horticultural areas	0.6005	5.7331	4.54e-07	56.20
Reilly for industrial areas	0.0243	0.5361	8.71e-07	40.37
Reilly for waste sites	3.93e-06	0.0008	8.00e-09	0.15
Adjacent to forest (=1 if located next to a forest)	0.0044	0.0661	0	1
Adjacent to water (=1 for waterfront properties)	0.0732	0.2605	0	1
Adjacent to park (=1 if located next to a park)	0.0289	0.1676	0	1
Adjacent to open space (=1 if located next to other open space areas)	0.1380	0.3449	0	1
Garden (=1 garden is present)	0.4747	0.4994	0	1
City centre (=1 property is located in the city centre)	0.1072	0.3094	0	1
Countryside (=1 property is located in the countryside)	0.0043	0.0654	0	1
Busy road (=1 property is located at a busy road)	0.0503	0.2186	0	1
Distance to nearest highway (in km)	1.4947	1.1344	0.00	6.92
Distance to nearest highway exit (in km)	3.0738	2.0807	0.13	13.97
Distance to nearest railway (in km)	1.3421	1.3084	0.00	7.88
Distance to nearest railway station (in km)	1.7906	1.4366	0.03	8.55
Distance to the North Sea (in km)	17.8132	7.2868	0.07	31.51
Period of construction (1=1500-1905, 2=1906-1930, 3=1931-1944, 4=1945-1959, 5=1960-1970, 6=1971-1980, 7=1981-1990, 8=1991-2000, 9>2000)	4.8070	2.1970	1	9
Newly developed (=1 property is recently developed)	0.0086	0.0921	0	1
Ground-floor apartment (=1 if apartment is on the ground floor)	0.0728	0.2599	0	1
Upstairs apartment (=1 if apartment is not on the ground floor)	0.1331	0.3397	0	1
Ground floor and upstairs apartment (= 1 if apartment includes the ground floor and other floors)	0.0049	0.0697	0	1
Maisonette (=1 if apartment is a maisonette)	0.0521	0.2222	0	1
Gallery apartment (=1 if apartment is situated on a gallery)	0.1117	0.3150	0	1
Home for the elderly (=1 if apartment is part of a home for the elderly)	0.0012	0.0340	0	1
Terraced house (= 1 if terraced house)	0.2895	0.4535	0	1
Corner house (=1 if corner house)	0.1072	0.3094	0	1
Semi-detached house 1 (=1 if semi-detached house)	0.0349	0.1835	0	1
Semi-detached house 2 (=1 if semi-detached house, linked through garages)	0.0083	0.0906	0	1

(Table continued on next page)

(Table continued)

Free standing (=1 if house is free-standing)	0.0158	0.1246	0	1
Surface of the house (in m^2)	108.8083	42.404	17	753
Number of balconies	0.4910	0.5732	0	3
Number of dormers	0.1013	0.3091	0	2
Number of roof terraces	0.0780	0.2748	0	3
Number of kitchens	0.8910	0.3678	0	4
Number of sculleries	0.0662	0.2495	0	2
Storage in the attic (=1 attic for storage is present)	0.0726	0.2595	0	1
Practice inside (=1 part of the property can be used for a practice at home)	0.0065	0.0801	0	1
Carport (=1 if carport is present)	0.0222	0.1473	0	1
Single car garage (=1 if single car garage is present)	0.0846	0.2782	0	1
Multi car garage (=1 if multi-car garage is present)	0.0072	0.0843	0	1
Maintenance of the house (1=bad, ….,9=excellent)	6.9747	0.9188	1	9
Number of isolation materials used	1.3043	1.5945	0	5
Ground rent (=1 if the land is not part of the property)	0.1947	0.3960	0	1
Permanent (=1 in case of permanent residence)	0.9851	0.1211	0	1
Partly rented (=1 if part of the house is rented out)	0.0013	0.0367	0	1
Population density within the neighborhood (in 1,000 per km^2)	7.1094	4.9077	0	24.45
Percentage of non-western immigrants in the neighborhood	15.8488	15.085	0	80
Average real disposable income per inhabitant per year within the neighborhood (in €1,000)	10.7163	3.0911	0.46	37.49
Elevation level (in meters)	-1.46577	1.6519	-6.20	7.30
Monthly trend (=1 January 1996,..., =132 December 2006)	75.8370	36.645	1	132

CHAPTER 8

DISCUSSION AND CONCLUSIONS

8.1 Introduction

The general objective of this research was to quantify the externalities that different types of land use impose on farmland and residential properties, and to evaluate the effect of existing policies regarding the preservation of agricultural land and open space, using GIS-based hedonic pricing models. The estimated impact of externalities on residential properties and farmland are specified as net effects that result from the nearness of each of these different types of land use. In this chapter, we review the main outcomes of this research. Section 8.2 discusses the effect of zoning and other policy measures on farms in the urban-rural fringe. A critique of the value of open space and related policy implications follows in section 8.3. Data and methodology are discussed in section 8.4. Some final remarks ensue in section 8.5. Moreover, where relevant we give some suggestions for future research.

8.2 Farmland

8.2.1 The effect of zoning policies on farmland

From Chapters 2, 3 and 4 we learn that both the Netherlands and British Columbia[1] use zoning policies to regulate land use. However, the aim of these zoning policies differs between the two jurisdictions. British Columbia actively preserves farmland in the Agricultural Land Reserve (ALR). Whereas the zoning system in the Netherlands, the Spatial Planning Act (*Wet op de Ruimtelijk Ordening, WRO*) zones all land in the Netherlands, implying that all land currently in agricultural production is zoned as farmland. Although there might be some local initiatives to preserve farmland, in general, policy measures to preserve open space in the Netherlands are more concerned with the preservation and extension of nature areas than they are with the preservation of agriculture and farmland.

Chapter 4 uses empirical results from hedonic pricing models of the farmland markets in the Netherlands and the Saanich Peninsula to examine what the impact is of zoning on farmers in the

[1]The Saanich Peninsula, our research area is part of the province of British Columbia, Canada. Provincial laws and regulations with respect to open space and farmland preservation apply to our research area.

urban-rural fringe. The answer seems to depend partly on how vigorous agricultural zoning is within those areas. If zoning plans change easily, zoning is less credible and speculation about the future ability to develop farmland increases (Blewett and Lane, 1988; Nickerson and Lynch, 2001; Shi et al., 1997). The reason for speculation is that zoning schemes lead to a segmented land market, with different price levels within segments. Prices in each submarket are related to the profitability of the related land use (Luijt and Van der Hamsvoort, 2002). For example, land prices in residential and industrial markets are much higher than those in the farmland market. Therefore, farmland prices in close proximity to urban areas are very likely to be higher than the agricultural value of the land. The agricultural value of the land refers to the economic return to the land, given that it would remain in agricultural use in perpetuity. See Plantinga, et al. (2002) for a theoretical model regarding economic returns of land.

This corresponds with findings from Chapters 2 and 4, where we conclude that the proximity to and the size of urban areas in the Netherlands primarily determine farmland prices in areas in close proximity to urban areas. Farmland prices increase with nearness to and the size of the urban area. Therefore, zoning does not seem to be credible in urban areas. In more remote rural areas in the Netherlands we did not find speculative effects. In fact, we even found the opposite in the form of negative externalities imposed on farmland by residential areas and highways. This implies that zoning in rural areas is credible. However, in these more rural areas, nature and recreational uses of farmland compete with agricultural use. Farmland prices of rural land that is zoned as future nature area is valued lower, because there is no longer an option value of future farm or urban use. In urban areas, land values are too high for future zoning of nature land to be credible, therefore, we did not find significant impacts of future nature zoning in urban areas.

The Saanich Peninsula is considered as a whole, since rural-urban and more (remote) rural areas cannot be distinguished, because the Saanich Peninsula is a relatively small area of about 30 × 10 km, and the whole area is within the shadow of the city of Victoria. In Chapter 3 we hypothesize that if the ALR would be credible, one would expect lower prices inside the ALR than outside it as land outside the ALR can more easily be developed. Moreover, farmland prices adjacent to urban areas should be lower due to the reduced productivity associated with negative urban externalities (Nelson, 1992). Alternatively, if landowners do not believe agricultural protection is permanent, these lands will have higher values in expectation that they will be sold to developers in the future. Based on findings from Chapters 3 and 4, we conclude that the ALR is at least partly credible since the estimated signs of the effects related to the ALR all support the hypothesis that the ALR is credible. For example, ALR land is sold for less than land outside the ALR, land at the ALR boundary sells for less, and farmland that is more fragmented and farther away from the heart of the ALR sells for less. However, in Chapters 3 and 4 we also find that there are some indications of speculation on the Saanich Peninsula. For example, prices closer to the city centre of Victoria are higher, hobby farmers pay higher prices than conventional farmers, and smaller farm lots sell for higher prices. Since the ALR regulations permit one building per lot, smaller lots are more attractive to hobby farmers and buyers who wish to live on a rural estate rather than on a smaller city lot that might be of comparable price.

In general we can conclude from Chapters 2, 3 and 4 that the degree of urban development pressure affects long term farm profitability as agricultural returns might not always be sufficient to cover higher land costs due to speculation.

8.2.2 Local farmland markets

In Chapter 2, we investigate how prices of farmland in the Netherlands are influenced by the market form and personal characteristics of buyers and sellers. We find there is not perfect competition in rural farmland markets, and prices deviate from competitive market prices. No evidence was found of market power in more urban farmland markets, since prices in these areas were mainly driven by speculation. We also investigate whether personal characteristics of sellers and buyers caused parallel shifts in hedonic pricing functions as was assumed by Harding, et al. (2003b). We only find some evidence of their influence in the price determination process. Either they have a direct effect on the willingness to pay of buyers or the willingness to accept of sellers, or they influence the bargaining power of the sellers and buyers.

Our findings with respect to market power also have important consequences for subsequent work that uses hedonic price techniques to model farmland prices. Ignoring local market power in rural farmland markets may lead to omitted variable bias on estimated shadow prices in hedonic price models.

8.2.3 Hobby farmers

In Chapters 3 and 4, we find evidence for speculation on smaller parcels on the Saanich Peninsula. Because the Agricultural Land Reserve permits one building per parcel, smaller parcels are very attractive for hobby farmers and those who prefer to live on a large rural estate as opposed to in the city. Therefore, in Chapter 5 we investigate whether the establishment of hobby farmers was detrimental to the goals of agricultural land preservation. We test whether hobby farmers affect prices inside and outside the ALR and identify what implications this has for the effectiveness of the ALR and other policy measures to protect agriculture in the urban shadow.

The findings from Chapter 5 indicate that the existence of hobby farms drive up prices of ALR land. Hobby farming can increase values by between \$61,700 and \$162,200 per ha. Outside the ALR there is no significant difference between parcels bought by hobby farmers and conventional farmers. Furthermore, from Chapter 5 we conclude that hobby farmers likely benefit from British Columbia's favorable property tax treatment of agricultural land, which sets a low threshold for obtaining tax benefits. Potential hobby farmers sought parcels that provided them the lowest threshold for qualifying for farm class status, avoiding parcels smaller than 0.8 ha that would place them in the category with the highest taxes and ones greater than 4.0 ha that would require them to become 'serious' farmers.

Nonetheless, it is not entirely clear whether hobby farming is something to be discouraged because of the amenity benefits that it is still capable of providing (open space, views, wildlife habitat) and the fact that hobby farmers are often located outside the ALR. On the other hand, hobby farming may simply lead to 'rurbanization' of the countryside with all pretence of farming disappearing as conventional farms rollover.

Up to now, the issue of hobby farms appearing in the urban-rural fringe has not received a lot of attention in the literature. In this research, we based our classification of hobby farmers on the Land Use Inventory of British Columbia. It would be interesting to develop a standard to define hobby farmers in order to distinguish them in a formal way from conventional farmers, and then to apply those standards to farmland markets in different research areas in the urban-rural fringe to investigate the impact of hobby farmers further.

8.2.4 Preservation of farmland

In British Columbia the protection of farmland receives relatively more attention than in the Netherlands. When surveyed, British Columbians indicated strong support for agricultural land protection; for instance, in 1997, 90 per cent said they favored limits to urban development to protect farmland (Quayle, 1998) and, in 2005, 94 per cent of Central Saanich residents said they felt agriculture contributed greatly to the community (Walker, 2005).

However, the efficiency of the policy regulations in place can be better judged after shedding light on the reasons to preserve farmland. Therefore, we raise the question why so many people favor protection of farmland as a matter of principle. Chapters 4 and 5 suggest that policies to protect farmland in British Columbia could possibly have a deleterious effect on farmers in the urban-rural fringe in the longer term. Since the ALR permits one building per lot and favorable tax regulations can be easily met by hobby farmers, one recommendation is that current policies need to be modified if agricultural production is to be protected in the long run.

A remaining thought from Chapter 5 questions whether it is maintenance of open space and prevention of urban sprawl and not local food provision that are the main reasons for preserving farmland. Moreover, it is questionable if farmland and nature are interchangeable open-space providers. Although they both provide open-space amenities, they also provide different externalities on surrounding land uses. If open space is most important, note that for governments it is cheaper to preserve open space in the form of agricultural land than in the form of nature, because farmers maintain the land instead of the government.

As argued in Chapter 5, from an economic perspective, food security and local food production cannot be a reason for government interference, because food production is not an externality but a primary product. If local food production and food security would be important enough, local food prices would increase in response, causing individuals to preserve land and production potential in response. Similarly, as a response to the increase in local food prices the demand and price of land in agriculture would also rise.

Since urban sprawl is a problem in the Netherlands (Van der Valk, 2002) and British Columbia (Garrish, 2002/2003), it would be interesting to know which externalities provided by farmers are worth preserving. A survey that compares the value of different types of externalities provided by regular farmland, and land use by hobby farmers versus use for nature purposes, would provide insights in the value associated with different types of open space. Until governments know exactly what it is about agricultural land that causes the public to support its protection, they cannot design the most appropriate policy instruments to address the problem of disappearing farmland near the urban fringe.

8.3 Residential properties

From Chapters 6 and 7, we conclude that the value residents attach to open space on the Saanich peninsula and in Midden-Delfland depends on a variety of factors related to the characteristics of open space. Open space in each capacity that was investigated (urban parks, larger nature areas, agricultural areas, and golf courses) imposes both positive and negative externalities on surrounding residential properties. On the Saanich Peninsula and in Midden-Delfland, properties close to small nature parks (mostly urban parks) sell for a premium. People seem to prefer urban parks over larger nature areas close to their homes. As argued in Chapter 6, the smaller parks can be used for short term recreation but do not cause the inconveniences that large parks do when people visit them by car. Urban parks provide the green space people see from their window and the place where they play with their children. Large nature areas and agricultural areas seem to serve other purposes, that are mostly attractive to non-residents. Both in Midden-Delfland and on the Saanich Peninsula, there are many waterfront properties for which people are willing to pay a large premium. We can also conclude that open space provided by agricultural land is not valued positively by residents, at least in terms of a positive impact on housing prices. The negative externalities associated with farmland (e.g., odors, dust, noise) seem to override the positive externalities, especially for animal farms. The uncertainty with respect to potential future urban development of farmland may also play a role in this finding.

From Chapter 6, we conclude that golf courses provide positive benefits for residents on the Saanich Peninsula. Residents pay higher prices for houses that are located close to (larger) golf courses, although having a house adjacent to a golf course does not increase its value, ceteris paribus. The effect of golf courses was not investigated for the Netherlands, but an interesting finding for Midden-Delfland was that nearness to larger industrial areas has a significant positive impact on property prices in this region. Since the harbor of Rotterdam is the largest industrial area in this region, this area seems to be appreciated by those who live nearby. The harbors are adjacent to the river 'Nieuwe Waterweg'. Therefore, residents might appreciate the view of this large water mass and its incoming and leaving container ships. Another explanation might be the job opportunities provided by the harbor.

Hedonic pricing studies can contribute to decision making regarding the question how to finance open space and the planning and reconstruction of landscapes. The development of open space is increasingly incorporated in urban development projects in the Netherlands. Development planning and spatial policy have recently become more market-oriented and land use policies are increasingly based on public-private partnerships (Louw et al., 2003). By creating a link between property values and surrounding open space, financial arrangements that take this link into account can be considered. So-called 'red-for-green' projects in the Netherlands are examples of public-private partnerships, where 'red' refers to the land in residential and industrial use, and 'green' to agriculture, nature, landscape, outdoor recreation and environmental uses. 'Red-for-green' refers to the investment by private organizations in public 'green' areas using revenues from the development of 'red' areas. Project developers should be aware of the fact that the creation of open space could potentially increase the revenues they receive because residential properties in close proximity to open space might become more attractive, with an increase in sales prices as a result. A similar argument holds for municipalities. While municipalities receive revenues from property taxes, they spend money on the development and maintenance of open space. With open space in close proximity to residential properties, the value of these properties increases as do revenues from property taxes. Awareness of this link can lead to more integral planning of the development of open space and urban uses of land.

8.4 Data and methods

8.4.1 Data

For the farmland models in the Netherlands and British Columbia we had about 1,000 observations for each of the hedonic pricing models. However, the residential property sales datasets for the Saanich Peninsula contained more than 10,000 observations and the residential sales database for Midden-Delfland even contained more than 70,000 observations. This led to very significant results regarding many explanatory variables in both models.

For each of the different chapters, we had to link different databases. Linkages between databases were either based on the identification numbers of parcels, addresses or spatial location in the Geographic Information System (GIS) model. Sometimes similar variables were defined in different databases and we had to choose between more than one definition. Sometimes the definition of variables was exactly the same, but observations differed between databases. Although in theory similar variables should have similar outcomes in different databases, in practice there are always differences between databases.

For this thesis the scripting language Python (Lutz and Ascher, 2004) was used to build models and standardize processes in GIS. Combining scripting in Python with GIS enabled us to develop better measures for the independent variables in the hedonic pricing model, such as the Reilly indices, fragmentation measures of farmland and market characteristics of farmland markets. Although ArcGIS, the software program that was used to process GIS data, includes some basic tools to perform tasks on spatial data, some processes involved many different tools and actions that had to be performed. These processes were standardized and computerized. Although the calculation of these variables was computerized, it was very demanding to perform these tasks in terms of computer time and space.

Time trends, time dummies and other macro-economic variables were included in different hedonic pricing models to correct for time effects. Our data cannot be viewed as traditional panel data (or even unbalanced panel data) and panel-estimation techniques could not be used, because observations at different points in time refer in most cases to different cross-sectional units. Further, data observations are not recorded in regular time intervals. Sometimes different observations succeed each other after a couple of days, and sometimes different observations are recorded on the same day. In addition, prices for both farmland and residential properties in the Netherlands and British Columbia increased faster than inflation, and therefore price corrections were not sufficient to cover the overall price increases over time.

8.4.2 Estimation methods

Because each specific dataset requires specific data-handling and methods, this thesis used different spatial econometric techniques. We incorporate many locational aspects of properties as explanatory variables in the models, therefore, sometimes (e.g. Chapter 2) we do not find evidence for additional spatial autocorrelation. However, in Chapters 3, 6 and 7, significant positive spatial lag and/or error dependence is found.

In Chapters 6 and 7 we incorporate spatial lag and error dependence in our residential sales models by using the spatial Method of Moments (MM) estimators developed by Kelejian and Prucha (1998; 1999; 2004). Chapter 6 includes spatial error dependence in a Seemingly Unrelated Regression (SUR) model by using the MM approach (Kelejian and Prucha, 2004). Chapter 7 uses the Generalized Spatial Two-Stage Least Squares (GS2SLS) estimator developed by Kelejian and Prucha (1998; 1999). This approach combines an instrumental variable approach to estimate spatial lag dependence and the MM approach to estimate spatial error dependence. These methods were used instead of maximum likelihood techniques because we had to handle datasets with respectively over 10,000 and 70,000 observations. Because of the large number of observations maximum likelihood techniques (unless programmed very efficiently) cannot be used to correct for spatial lag or error dependence. Maximum likelihood requires the calculation of either the eigenvalues of the spatial weighting matrix, reflecting the spatial dependence between observations or error terms, or the determinant of a similar sized matrix. Both matrices are $n \times n$, where n refers to the number of observations. Kelejian and Prucha (1999) could only do this reliably for spatial weighting matrices up to 400×400. Bell and Bockstael (2000) restricted their weighting matrices to be sparse and reported problems when dimensions were roughly $2{,}000 \times 2{,}000$, while Pace and Barry (1997) were able to work with matrices up to $20{,}000 \times 20{,}000$ by imposing additional restrictions. However, the methods we used were fast and convenient.

In Chapter 3 we a used a combination of Markov Chain Monte Carlo Model Composition (MC^3) and Bayesian Model Averaging (LeSage and Parent, 2007) to deal with specification uncertainty in the hedonic pricing model. Specification uncertainty arises because spatial weighting matrices and explanatory variables have to be specified a priori. The benefit of Bayesian Model Averaging is that it does not assume only one correct model specification; rather, final parameter estimates are weighted averages based on a whole range of possible model specifications, including different explanatory variables and different specifications of the weighting matrix. Furthermore, the MC^3 framework ensures that model specifications with high posterior probabilities are taken into account in the weighted averages. Although the combination of Bayesian model averaging and MC^3 is intuitively very attractive, in practice, these methods are rather time consuming if there is no closed form available for the marginal likelihood and posterior model probabilities. Similar to maximum likelihood techniques, they require the calculation of the determinant of an n × n matrix, which is only possible for relatively small datasets. Another disadvantage is that Bayesian models require the specification of priors for each of the coefficients in the model. If no such prior information is available, non-informative priors have to be used.

The current research uses Bayesian techniques to resolve specification uncertainty in hedonic pricing models. Therefore, we use these techniques more as a mechanical approach. Originally, the idea of Bayesian methods is to combine both prior and data information to draw conclusions about the parameter(s) of interest. Although, including prior information is a controversial aspect of Bayesian methods (Koop, 2003), in future research it would be interesting to develop an algorithm to include prior model probabilities in the Bayesian models used in Chapter 3 for specific variables that have proven to be important in the literature.

8.4.3 Measurement of externalities

In this research, we quantified externalities imposed on farmland and residential properties by different types of land use. This research assumes that the closer each of these land uses is to residential and farmland, the more externalities these land uses experience and the more they influence property prices. The introductory chapter pointed out that the effect of externalities on property prices can be measured using a distance or area metric. The problem with distance measures is that large and small areas with a specific land use are treated equally. The problem with area percentages is that arbitrary buffer zones around each property have to be specified and land use outside those boundaries is not taken into account. We address this issue of conflicting measures by explicitly combining the distance and area-percentage measures using Reilly indices, which include both the size and distance measures.

Note that each type of land use can impose both positive and negative externalities on other types of land use. Therefore, by measuring the presence of a certain type of land use, we measure only the net effect of the externalities caused by these types of land use. Future research needs to be concerned with the specification of externalities in hedonic pricing models. It might also be possible in future research to incorporate externalities more directly. The existence of data related to noise and smells for example is growing. But the downside of incorporating these externalities directly is that one might no longer be able to link these externalities to the activities that impose them.

8.4.4 The hedonic pricing method

Without government interference, the open space, cultural heritage, landscapes, animal and plant diversity, and recreational externalities of farmland and nature areas could be lost. Therefore, it is important to weigh the costs against the benefits of open space preservation. Hedonic pricing methods contribute to cost-benefit analyses by revealing the shadow prices residents attach to open space surrounding their properties. It does not take into account non-use amenity values and even many use values of open space. Non-use values refer to the willingness of people to pay for open space simply because it exists, or because of its bequest value (i.e., it should be available for future use by future generations) or altruistic motives (i.e., it should be available for others in this generation) (Bateman et al., 2002). Use values refer to the actual use of the open space. This includes visits of residents to the open space area and the visual amenities provided for those who drive by or near the open space. But also option values of future use of residents are incorporated. Also ignored in hedonic pricing models are the use values of people who do not live in the area. Because the value of open space revealed by hedonic pricing methods is only part of the total value, we cannot use values resulting from hedonic pricing models as the only value of open space in a cost-benefit analysis. Thus, if the value revealed from a hedonic pricing study is negative, we cannot conclude that the open space area should not be preserved.

8.4.5 Assessed versus sales values

Hedonic pricing models require actual property transaction data as inputs, because these values reflect property characteristics that can then be decomposed into their constituent parts. However, sales values are not always readily available; therefore, some researchers have employed approximations of sales values in hedonic pricing models. Chapter 6 investigates whether assessed values were good proxies for actual sales values in a hedonic pricing model that was used to estimate the value of open space on the Saanich Peninsula. In particular, open space provided by farmland, parkland and golf courses was examined, as was open space protected under the province's Agricultural Land Reserve. To construct a test statistic for the comparison of the parameters in the assessment and sales equations, we estimated a Seemingly Unrelated Regression (SUR) model with two equations, one with actual market values as the dependent variable and one with assessed property values. Furthermore, we took account of spatial autocorrelation and combined Method of Moment estimates of the spatial parameters in both equations (Kelejian and Prucha, 1999; 2004).

Although not all parameters in the assessment and sales equations were the same, we accepted the hypothesis that the impacts of open space on property values were valued in the same way in both equations. However, we did observe some differences between the distributions of assessed versus sales values. Specifically, we observed that average assessed values were lower than average sales values and the variation in assessed values was smaller than that of sales prices. These findings imply that assessed values may be used in place of market values as the dependent variable in hedonic pricing models if one is interested in the impact of open space on property values, although it may be necessary to scale the distribution of assessed values. It is important to note, however, that property assessment systems may be very different in other jurisdictions of North America or Europe, which could affect the validity of applying these results to other locations.

8.5 Final remarks

The overall research provides insights into the allocation of land and the externalities that different types of land use impose on each other. The combination of large databases, use of GIS, scripting in Python and spatial econometric techniques make that this research adds to the literature on property markets in the Netherlands and British Columbia, measurement of externalities of different types of land use, the preservation of open space and for the Netherlands local farmland markets were analyzed in more detail. Furthermore, issues such as variable specification in a hedonic pricing model and the definition of the spatial weighting matrix were investigated. Also, spatial techniques that can be used to analyze large databases were applied. Results from this research can be used to inform urban planners, geographers, policy makers and other stakeholders about issues related to zoning, and the preservation of open space.

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SUMMARY

The main reason for government intervention in land markets is market failure. One reason for market failure is the presence of externalities. Open space is a non-market output or externality of farmland and also nature areas and, although it might be important to people, there is no actual market for the good as such. The Netherlands and the Province of British Columbia in Canada both experience similar problems of expanding cities and pressure on open space, and they both use zoning to regulate land use and its externalities.

The objective of this research is to evaluate the effect of zoning on the preservation of open space in the urban-rural fringe and to quantify the externalities that different types of land use impose on farmland and residential properties. Therefore, agricultural and residential land uses are the focus of this thesis. Externalities between these two types of land use flow in both directions, with agriculture affecting urbanities, but also urban development impacting farmland. Although, agricultural and residential land use are the main focus, where relevant, externalities imposed by other types of land use are also incorporated in the current research. The estimated impact of externalities on residential properties and farmland are specified as net effects that result from the nearness of different types of land use. The research areas are the Netherlands, Midden-Delfland in the Western part of the Netherlands, and the Saanich Peninsula on Vancouver Island near the capital city of British Columbia (Victoria), Canada.

Given the broad research objective, Chapters 2-7 of this thesis investigate six more specific research questions using a combination of GIS-based hedonic pricing models and (spatial) econometric techniques.

Chapter 2 investigates if market power has an effect on farmland prices in rural and urban areas in the Netherlands as a whole. Evidence from this chapter suggests that market power is present in local rural farmland markets, and therefore, prices deviate from competitive market prices. No evidence was found of market power in more urban farmland markets. Probably because prices in urban farmland markets are mainly driven by speculation. Chapter 2 used a combination of hedonic pricing techniques and GIS-data. The model was tested for heteroscedasticity, and spatial lag and error dependence. Because we found evidence for heteroscedasticity, we corrected for it. No evidence was found for spatial lag and error dependence.

Chapter 3 investigates whether the Agricultural Land Reserve (ALR), the zoning scheme for farmland in British Columbia, has been effective in preserving farmland near Victoria. We hypothesize that, if zoning is credible, farmland prices adjacent to Victoria should be lower due to the reduced productivity associated with urban externalities. Alternatively, if agricultural landowners do not believe the ALR is permanent, these lands will have higher values in expectation that the land will be sold to developers in the future. We conclude that the ALR is at least partly credible, since ALR land is sold for lower prices than land outside the ALR, land at the ALR boundary sells for lower prices, and farmland that is more fragmented and farther away from the heart of the ALR sells

for lower prices. However, we find that there are also some indications of speculation on the Saanich Peninsula. For example, prices closer to the city centre of Victoria are higher, smaller lots sell for higher prices and hobby farmers pay higher prices than conventional farmers. We resolved uncertainty with respect to the model specification in Chapter 3 by using Bayesian Model Averaging in combination with Markov Chain Monte Carlo Model Composition (MC^3). The benefit of Bayesian Model Averaging is that it does not assume there is only one correct model specification; rather, final parameter estimates are weighted averages based on a whole range of possible model specifications where model specifications with high posterior probabilities receive higher weights.

Chapter 4 investigates how the institutions and laws in the Netherlands and the Saanich Peninsula contribute to agricultural land preservation. For the Netherlands we find that agricultural zoning is more credible in more rural areas than urban ones, as prices in urban areas are affected by speculation to a greater degree. Farmland in the Netherlands has to compete with urban development in urban areas and with nature preservation in more rural areas. Conclusions with respect to the credibility of the ALR and speculation on the Saanich Peninsula of British Columbia are similar to the findings of Chapter 3. A recommendation of Chapter 4 is that if the purpose of farm class status in British Columbia is to support a viable farm economy, the threshold to achieve farm class status should be raised or other hurdles should be implemented by the government. This would make it harder for hobby farmers to benefit from preferential property tax regulations.

In Chapter 5 we investigate whether the establishment of hobby farms is detrimental to the goal of agricultural land preservation. We do so by investigating the divergence between the price paid by conventional and hobby farmers in relation to the ALR. First, a hedonic pricing model is estimated allowing for divergence between the two farming types. Second, the propensity score method (PSM) is used to control for a potential endogeneity bias with respect to hobby farms in the hedonic pricing model. The findings from both the hedonic pricing model and PSM indicate that the existence of hobby farms drives up prices of ALR land. Outside the ALR hobby farms tend to be worth less per ha than conventional farms; although these findings are corroborated by PSM estimates, the difference in that model was statistically insignificant.

The objective of Chapter 6 is to test whether assessed values are good proxies for actual sales values in a hedonic pricing model that is used to estimate the value of open space on the Saanich Peninsula. The value of open space provided by farmland is compared to that provided by nature and golf courses. We found that although estimated parameters look rather similar in the assessed and market values equations, they are not similar enough to assume that all estimated parameters in both equations are the same. Yet for the parameters of interest (open space measures) the hypothesis that the estimated effects are the same is accepted. This result is obtained after scaling the assessed values. Scaling is necessary, because sales values are higher than assessed values on average. The impact of open space on property prices is rather mixed. The reason is that open space in all three capacities (nature, agriculture and golf courses) imposes both positive and negative externalities on surrounding residential properties. Properties adjacent to nature parks sell for a premium, but people seem to prefer smaller parks instead of larger parks. Furthermore, open space provided by agricultural land is not valued positively by residents. Finally, residents pay higher prices for houses that are located closer to (larger) golf courses, although having a house adjacent to a golf course does not increase its value ceteris paribus. We estimated a Seemingly Unrelated Regression (SUR) model with two equations, one with actual market values as the dependent variable and one with assessed property values, and compared the resulting estimates of shadow prices for open space amenities. Furthermore, we took account of spatial autocorrelation and combined Method of Moment estimates of the spatial parameters in both the sales and assessment equation.

Chapter 7 determines the impact of land use surrounding residential properties, and its externalities, on residential property prices in Midden-Delfland, the Netherlands. Results show that urban parks provide the externalities residents appreciate such as views on open space and the provision of playgrounds for children. Although large nature areas might be important for preservation of wildlife and landscape residents pay no premium for living close to them. An interesting finding is the significant positive impact of industrial areas on property prices. Since the harbor of Rotterdam is the largest industrial area in this region, this area seems to be appreciated by those who live nearby. Residents might appreciate the view of this large water mass and its incoming and leaving ships. Another explanation might be the job opportunities provided by the harbor. Furthermore, we find that residential properties adjacent to open space sell for a premium between €3,351 and €15,289 depending on the type of open space. And of all types of open space, waterfront properties sell for the highest premium. The North Sea and its beaches also provide positive landscape services and other externalities. Furthermore, we found evidence for spatial lag and error dependence in the hedonic pricing model using a Generalized Spatial Two-Stage Least Squares (GS2SLS) procedure. Therefore, we conclude that the moving average of prices of properties that were sold within the same 6-digit postal code areas influences sales prices directly. Moreover, we conclude that there are spatial influences not captured by the explanatory variables in the model.

Chapter 8 provides an integrated discussion of the findings from Chapters 2-7. Moreover it discusses data and methodological issues. The overall research provides insights into the effects of zoning and the externalities that different types of land use impose on each other. The combination of large databases, use of GIS, scripting in Python (the scripting language used to computerize calculations in GIS) and (spatial) econometric techniques make that this research adds to the literature on property markets in the Netherlands and British Columbia, measurement of externalities of different types of land use, the preservation of open space and market power in local farmland markets. Furthermore, issues such as variable specification in a hedonic pricing model and spatial techniques that can be used to analyze large databases were analyzed.

Finally, results from this research can be used to inform urban planners, geographers, policy makers and other stakeholders about issues related to zoning, and the preservation of open space.

SAMENVATTING

Een vrije grondmarkt houdt geen rekening met de positieve en negatieve externaliteiten die worden veroorzaakt door verschillende grondgebruikstypen. Door dit marktfalen grijpen overheden veelal in op de grondmarkt door het gebruik van de beschikbare ruimte vast te leggen middels ruimtelijkeordeningswetgeving. Nederland en British Columbia maken hiervan gebruik om natuurgebieden en agrarische gebieden te beschermen. Zonder overheidsingrijpen zouden woon- en industriegebieden een groter beslag leggen op de beschikbare ruimte. Positieve externaliteiten van natuur en landbouwgebieden zijn onder andere open ruimte en de beschikbaarheid van ruimte om te recreëren. Negatieve externaliteiten van industrie en woningbouw zijn de verrommeling van het landschap en lawaai en drukte.

Dit proefschrift bestudeert hoe externaliteiten van verschillende typen grondgebruik de prijzen van nabijgelegen huizen en landbouwgrond beïnvloeden. Ook wordt onderzoek gedaan naar de effectiviteit van de bestaande regelgeving die gericht is op het behoud van agrarische open ruimte. Bij het bestuderen van de externaliteiten wordt het netto effect van zowel positieve als negatieve externaliteiten gekwantificeerd. De gebieden waar dit proefschrift zich op richt zijn Nederland (voor agrarische grondprijzen), Midden-Delfland in het westen van Nederland (voor huizenprijzen) en het Saanich schiereiland nabij Victoria, de hoofdstad van British Columbia, Canada (voor prijzen van huizen en landbouwgrond). Gegeven de brede onderzoeksvragen van dit proefschrift, specificeren we in de hoofdstukken 2 tot 7 meer specifieke onderzoeksvragen. In elk van deze hoofdstukken wordt gebruik gemaakt van een combinatie van Geografische Informatie Systemen (GIS) en hedonische prijsmodellen. Daarnaast maakt ruimtelijke econometrie een belangrijk onderdeel uit van dit proefschrift.

Hoofdstuk 2 gaat na of de prijs van grond wordt beïnvloed door de lokale marktmacht van kopende of verkopende boeren in de agrarische grondmarkt in Nederland. Omdat boeren vooral lokaal grond aan- en verkopen kan er door het kleine aantal potentiële kopers of verkopers lokale marktmacht ontstaan. Resultaten uit dit hoofdstuk tonen aan dat lokale marktmacht in de meer landelijke gebieden inderdaad een effect heeft op de grondprijs. Nabij stedelijke gebieden worden agrarische grondprijzen vooral beïnvloed doordat marktpartijen speculeren dat landbouwgrond wordt omgezet in bouwgrond. We vinden daarom geen effect van lokale markmacht van boeren op de agrarische grondprijs in meer stedelijke gebieden. Hoofdstuk 2 maakt gebruik van een combinatie van hedonische prijsmethoden en GIS-data. Omdat er sprake was van heteroskedasticiteit is hiervoor gecorrigeerd. Er was echter geen aanleiding om te corrigeren voor ruimtelijke samenhang in de afhankelijke variabele of in de storingstermen.

In hoofdstuk 3 staat de vraag centraal of de landbouwsector in voldoende mate beschermd wordt door ruimtelijke ordening (*Agricultural Land Reserve, ALR*) op het Saanich schiereiland, British Columbia. Aan de hand van een hedonisch prijsmodel wordt getest of de agrarische bestemming in dit gebied geloofwaardig is. Of de agrarische bestemming geloofwaardig is, testen we met de hypothese dat prijzen van grond met een agrarische bestemming lager zijn wanneer deze grenst aan grond met een andere bestemming. Dit als gevolg van negatieve externaliteiten die veroorzaakt worden door niet-agrarisch grondgebruik. Als prijzen van grond met een agrarische bestemming echter hoger liggen, dan kunnen we concluderen dat de agrarische bestemming niet geloofwaardig is omdat er op deze agrarische gronden speculatie plaatsvindt in afwachting van, of middels een actieve lobby voor, eventuele bestemmingswijzigingen. De conclusie is dat de agrarische bestemming slechts gedeeltelijk geloofwaardig is. Geloofwaardig omdat agrarische grond met een agrarische bestemming lager geprijsd is dan agrarische grond zonder agrarische bestemming. Dit geldt ook voor grond grenzend aan grond gebruikt voor andere activiteiten. Niet geloofwaardig omdat de prijs hoger is naarmate de percelen dichter bij het centrum van Victoria liggen, kleinere percelen voor hogere prijzen worden verkocht en hobbyboeren meer betalen dan conventionele boeren. Omdat er sprake is van onzekerheid in de specificatie van het hedonische prijsmodel hebben we gebruik gemaakt van *Bayesian Model Averaging* (BMA) in combinatie met *Markov Chain Monte Carlo Model Composition* (MC^3). Het voordeel van BMA is dat deze methode ervan uitgaat dat er niet slechts één correct model bestaat, maar de uiteindelijke schattingen zijn gewogen gemiddelden over een hele reeks van potentiële modellen. Modelspecificaties met een grote waarschijnlijkheid het juiste model te zijn krijgen daarbij een groter gewicht mee.

Hoofdstuk 4 richt zich op de effectiviteit van regelgeving in Nederland en op het Saanich schiereiland met betrekking tot het behoud van agrarische gebieden. Voor Nederland vinden we dat de agrarische bestemming in ruimtelijkeordeningswetgeving geloofwaardiger is in landelijke dan in stedelijke gebieden. In de stedelijke gebieden speelt speculatie een grotere rol. Boeren moeten in stedelijke gebieden met nieuwbouwplannen en de ontwikkeling van bedrijventerreinen concurreren, in landelijke gebieden moeten zij concurreren met natuurbehoud en de ontwikkeling van nieuwe natuur. Voor het Saanich schiereiland zijn de resultaten vergelijkbaar met die van hoofdstuk 3, hoewel een andere schattingsmethode gebruikt is. Op het Saanich schiereiland komen boeren in aanmerking voor lagere belastingtarieven. Uit hoofdstuk 4 volgt de aanbeveling om de voorwaarden om als boer te worden aangemerkt aan te scherpen, zodat niet elke hobbyboer hieraan kan voldoen en daarmee kan profiteren van de lagere belastingtarieven.

Hoofdstuk 5 behandelt de aanwezigheid van hobbyboeren op het Saanich schiereiland en of hun aanwezigheid in strijd is met regelgeving die gericht is op het behoud van agrarische gebieden. Om dit te onderzoeken wordt nagegaan of hobbyboeren andere grondprijzen betalen dan reguliere boeren, zowel in als buiten de gebieden met agrarische bestemming. Hiervoor wordt gebruik gemaakt van twee verschillende methodes. Eerst wordt een hedonisch prijsmodel geschat en vervolgens worden de resultaten hiervan vergeleken met de resultaten van de *Propensity Score Method* (PSM). Problemen met betrekking tot de mogelijke endogeniteit van hobbyboeren in het hedonische prijsmodel worden door de PSM ondervangen. Beide modellen laten zien dat hobbyboeren de prijzen in gebieden met een agrarische bestemming opdrijven. Buiten de gebieden met een agrarische bestemming vinden we geen verschillen tussen de prijzen die hobbyboeren en conventionele boeren betalen.

In hoofdstuk 6 staat de vraag centraal of men taxatiewaarden van huizen kan gebruiken als benadering voor de marktwaarden bij het maken van een juiste inschatting van de waarde die bewoners hechten aan de open ruimte op het Saanich schiereiland. Hierbij wordt onderscheid gemaakt tussen open ruimte als gevolg van agrarisch grondgebruik, natuur en golfterreinen. Hoewel de modelparameters op basis van de marktwaarde en op basis van de taxatiewaarde niet veel van elkaar verschillen, zijn de verschillen toch te groot om ervan uit te gaan dat alle parameters in beide vergelijkingen hetzelfde zijn. Maar als we enkel de parameters die betrekking hebben op open ruimte met elkaar vergelijken dan vinden we geen significante verschillen. Hierbij dient te worden opgemerkt dat de taxatiewaarden zijn opgeschaald, omdat zij aanvankelijk gemiddeld lager waren dan de marktwaarden. Huizenkopers in de nabijheid van kleine parken betalen relatief hogere prijzen. Echter, hoe groter de parken in de omgeving van het huis, hoe minder de bereidheid om hogere prijzen te betalen voor de huizen. Voor huizen in de nabijheid van landbouwgrond worden ook geen hogere prijzen betaald. Voor huizen in de nabijheid van golfbanen wordt echter wel meer betaald, maar niet als het huis direct naast de golfbaan ligt. De schattingen in hoofdstuk 6 zijn gebaseerd op uitkomsten van een *Seemingly Unrelated Regression* (SUR) model met twee vergelijkingen, één op basis van marktwaarden en één op basis van taxatiewaarden. Verder is er gecorrigeerd voor ruimtelijke autocorrelatie door gebruik te maken van de *Method of Moments* (MM) schatter.

Hoofdstuk 7 is net als hoofdstuk 6 gericht op de effecten van omgevingsfactoren op huizenprijzen. Dit hoofdstuk richt zich op Midden-Delfland. In dit gebied betalen bewoners net als op het Saanich schiereiland meer voor hun huizen als deze nabij parken liggen. Hoewel grotere natuurgebieden belangrijk zijn voor het behoud van landschapswaarden, vinden we geen effect van de nabijheid van grotere natuurgebieden op huizenprijzen. Interessant is ook het positieve effect dat we in dit gebied vinden van de nabijheid van industriegebieden. Dit komt waarschijnlijk omdat het onderzoeksgebied de haven van Rotterdam bevat en ook de activiteiten rondom de Nieuwe Waterweg. Bewoners waarderen de nabijheid van deze activiteiten blijkbaar, wat verklaard kan worden door de potentiële werkgelegenheid in dit gebied en het zicht op schepen op de Nieuwe Waterweg. Andere resultaten geven aan dat bewoners het positief waarderen als hun huis uitkijkt over open ruimte. Uitzicht op water wordt van de verschillende vormen van open ruimte het meest gewaardeerd. Ook de nabijheid van de Noordzee leidt tot hogere huizenprijzen. Daarnaast is ruimtelijke afhankelijkheid gevonden tussen huizenprijzen. Prijzen van huizen die dicht bij elkaar liggen zijn gerelateerd. Dergelijke samenhang vinden we ook in de residuen van het hedonische prijsmodel. Omdat er meer dan 70.000 waarnemingen meegenomen zijn in het model, is er gebruik gemaakt van een *Generalized Spatial Two-Stage Least Squares* (GS2SLS) procedure.

Hoofdstuk 8 integreert de resultaten uit de verschillende hoofdstukken. Ook vindt een discussie plaats over de data en gebruikte methodologie. Het proefschrift als geheel biedt inzicht in de externaliteiten van grondgebruik én de effectiviteit van ruimtelijke ordening gericht op het behoud van open ruimte. De combinatie van grote datasets, gebruik van GIS, scripting in Python (de taal die gebruikt is om berekeningen in GIS te automatiseren) en ruimtelijke econometrie in dit proefschrift dragen bij aan de literatuur op het gebied van het meten van externaliteiten, het behoud van open ruimte en de invloed van marktmacht in lokale agrarische grondmarkten. Verder zijn ook de specificatie van verklarende variabelen in hedonische prijsmodellen en econometrische technieken voor grote datasets geanalyseerd. Resultaten van dit onderzoek kunnen gebruikt worden om politici, planologen en geografen te informeren over de effecten van het behoud en de ontwikkeling van open ruimte en de effecten van ruimtelijke ordening.

COMPLETED TRAINING AND SUPERVISION PLAN

Name of the course	Department/Institute	Year	ECTS[1]
I. General part			
Techniques for writing and presenting a scientific paper	WGS[2]	2006	1.2
Career orientation	WGS	2008	1.5
Subtotal part I			2.7
II. Mansholt-specific part			
Mansholt introduction course	MG3S[3]	2004	1.5
Mansholt multidisciplinary seminar (PhD-day)	MG3S	2006	1
Mansholt multidisciplinary seminar (PhD-day)	MG3S	2007	
Mansholt multidisciplinary seminar (PhD-day)	MG3S	2008	
Other oral presentations			
AAEA[4] annual meeting	Long Beach, CA, USA	2006	2
Farm level policy APRN[5] research meeting and workshop	Calgary, Canada	2006	
Workshop on understanding relations in nature and economy: an application to the rural countryside	Wageningen, The Netherlands	2007	
1st World conference of the spatial econometrics association	Cambridge, UK	2007	
European EAAE[6] PhD workshop	Rennes, France	2007	
NAKE[7]-day	Utrecht, The Netherlands	2007	
107th EAAE seminar	Seville, Spain	2008	
12th Congress of the EAAE	Ghent, Belgium	2008	
Subtotal part II			4.5
III. Discipline-specific part			
Macro I	University of Tilburg	2004	6

(Table continued on next page)

[1] 1 ECTS (European Credit Transfer System) represents 28 hours.

[2] WGS stands for Wageningen Graduate Schools.

[3] MG3S stands for Mansholt Graduate School of Social Sciences.

[4] AAEA stands for American Agricultural Economics Association.

[5] APRN stands for Agricultural Policy Research Network.

[6] EAAE stands for European Association of Agricultural Economists.

[7] NAKE stands for Netherlands Network of Economics.

(Table continued)

Economic models	MG3S	2005	6
Environmental and natural resource economics	NAKE (field course)	2004/ 2005	6
Simulation-based econometric methods	NAKE (topic course)	2005	3
Experimental economics	NAKE (topic course)	2005	3
Social choice theory: an introduction	NAKE (topic course)	2005	3
Behavioural economics	MG3S	2005	4
Generalized Method of Moments	MG3S	2005	3
Bayesian methods in theory and practice	MG3S	2006	4
Panel data analyses in theory and practice	MG3S	2007	1.5
Discrete choice modelling	MG3S	2007	1.5
NAKE workshop (Utrecht), with Badi Baltagi, Gioseppe Bertola, John D. Wilson and Eyal Winter	NAKE	2005	3
NAKE workshop (Rotterdam), with David Laibson, Adrian Pagan, Ariel Pakes and Randall Wrigth	NAKE	2006	3
NAKE workshop (Nijmegen), with Yacine Aït-Sahalia, Raquel Fernandez, John List and Eytan Sheshinski	NAKE	2007	3
Subtotal part III			50
IV. Teaching and supervising activities			
Rural economic analysis (assisting at practical, writing part of reader)	Wageningen University	2006	
Econometrics (assisting at practicals)	Wageningen University	2006	
Spatial econometrics (organizing course and assisting at practicals)	Mansholt Graduate School	2008	
Bayesian econometrics (organizing course)	Mansholt Graduate School	2008	
Supervising BSc Student	Wageningen University	2008	
Subtotal part IV			**3**
TOTAL			**60.2**

CURRICULUM VITAE

Geerte Cotteleer is geboren op 23 september 1977 te Utrecht. In 1995 haalde zij haar VWO diploma aan het Montessori Lyceum Herman Jordan te Zeist. Vervolgens is zij aan de Universiteit van Amsterdam begonnen aan de studie Econometrie. In 1998 en 1999 begeleide zij experimenten en analyseerde zij resultaten van experimenten als student assistent bij het Center for Research in Experimental Economics and Political Decision Making (CREED) aan de Universiteit van Amsterdam. Verder heeft zij in 1999 een semester onderwijs gevolgd aan Melbourne University in Australië. In 2000 is zij afgestudeerd in de richting empirisch-statistische econometrie. Haar afstudeerstage heeft zij gedaan bij KPN-Research in Leidschendam. Ook behaalde zij haar propedeuse informatica in 2000 aan de Universiteit van Amsterdam.

In de periode 2001 tot 2004 was zij werkzaam bij het Landbouw Economisch Instituut in Den Haag. Hier was zij onderzoeker bij de sectie Sector and performance van de afdeling Dier. Binnen onderzoeksteams van verschillende samenstelling voerde zij onderzoek uit in uiteenlopende richtingen. Van mestbeleid tot plattelandsontwikkelingsplannen. Ook was zij betrokken bij de steekproefopzet van het Bedrijven Informatienet van het LEI en de advisering van medewerkers op het gebied van statistiek. Tevens heeft zij enkele projecten geleid.

In 2004 begon zij als AIO aan een promotieonderzoek bij de vakgroep Agrarische Economie en Plattelandsbeleid. In deze hoedanigheid heeft zij practica begeleid voor verschillende vakken op BSc-, en PhD-niveau. Ook heeft zij een BSc student begeleid bij het schrijven van haar scriptie. Verder heeft zij in samenwerking met het LEI een project uitgevoerd in opdracht van het Milieu en Natuur Planbureau. Dit project resulteerde in een wetenschappelijke publicatie, een onderzoeksrapport en een artikel in een vakblad. In 2006 en 2007 heeft zij gedurende vijf maanden een deel van haar promotieonderzoek uitgevoerd aan de University of Victoria in Canada. In 2008 behaalde zij het diploma van het landelijke Netwerk Algemene Kwantitatieve Economie (NAKE).

Vanaf november 2008 zal zij gaan werken als universitair docent bij de vakgroep Milieu-economie en Natuurlijke hulpbronnen aan Wageningen Universiteit.

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