Externalities Imposed on Residential Properties in Highly Urbanized Areas

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*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.**

*Keywords***— Hedonic pricing, Spatial econometrics, Externalities**

I. 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 harbour of Rotterdam, one of the largest harbours in the world, with all its industrial activities. In 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 opportunities 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 brown fields 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 was 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 problems are experienced while applying hedonic pricing models. First, to be meaningful large amounts of 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 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, 1988). Corrections for spatial error dependence should be applied if non-observed property characteristics are the same for neighbouring 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 technique 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 2 presents the empirical model. Section 3 describes the data. Estimation results are discussed in section 4. Finally, section 5 concludes.

II. EMPIRICAL MODEL AND ESTIMATION

A. Measuring externalities

Hedonic pricing models reveal implicit prices of property characteristics from the overall property prices. These characteristics also incorporate measures of the presence of different types of land use. Implicitly, it is assumed 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 (Nicholls and Crompton, 2007; Spalatro and Provencher, 2001). This research extends the use of the Reilly index, as proposed by Cotteleer et al. (2008) 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.

B. 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 neighbouring 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:

$$P = X\beta + \lambda WP + \varepsilon, \quad |\lambda| < 1$$
$$\varepsilon = \rho M\varepsilon + u, \quad |\rho| < 1, \qquad [1]$$

Where P is the vector with property prices; X is the matrix of property characteristics; β the associated coefficient vector; λ the spatial lag parameter; W the spatial weighting matrix associated with the spatial lag in the model; ε the spatially correlated vector of residuals; ρ the spatial error parameter; M the spatial weighting matrix associated with the spatial error term; and u is the remaining error term, with 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 $Z = (X, Wy)$. Furthermore define $\delta = (\beta', \lambda)'$. In this procedure we use X, WX and W2X as instruments in H. The two-stage least squares estimator is then given by:

$$\tilde{\delta} = \left(\hat{Z}'\hat{Z}\right)^{-1}\hat{Z}'y\,, \qquad [2]$$

where $\hat{Z} = PZ = (X, \overline{Wy})$; $\overline{Wy} = PWy$; 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 $\overline{u} = Wu$, $\overline{\varepsilon} = W\varepsilon$, $\overline{\overline{\varepsilon}} = WW\varepsilon$, $u = \varepsilon - \rho\overline{\varepsilon}$, and $\overline{u} = \overline{\varepsilon} - \rho\overline{\overline{\varepsilon}}$. The following moments are used:

$$E\left[\frac{1}{N}u'u\right] = \sigma_u^2,$$
$$E\left[\frac{1}{N}\overline{u}'\overline{u}\right] = \sigma_u^2\frac{1}{N}Tr(W'W) \text{ and} \qquad [3]$$
$$E\left[\frac{1}{N}\overline{u}'u\right] = 0$$

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 $\tilde{\overline{\varepsilon}} = W\tilde{\varepsilon}$ and $\tilde{\overline{\overline{\varepsilon}}} = W\tilde{\overline{\varepsilon}}$. This leads to the following conditions for the sample moments:

$$G_N\left[\sigma^2, \rho, \rho^2\right]' - g_N = v_N(\sigma^2, \rho)\,; \qquad [4]$$

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

$$G_N = \begin{bmatrix} 1 & -\frac{2}{N}\tilde{\overline{\varepsilon}}'\tilde{\varepsilon} & \frac{1}{N}\tilde{\overline{\varepsilon}}'\tilde{\overline{\varepsilon}} \\ \frac{1}{N}Tr(W'W) & -\frac{2}{N}\tilde{\overline{\overline{\varepsilon}}}'\tilde{\overline{\varepsilon}} & \frac{1}{N}\tilde{\overline{\overline{\varepsilon}}}'\tilde{\overline{\overline{\varepsilon}}} \\ 0 & -\frac{1}{N}\left(\tilde{\overline{\overline{\varepsilon}}}'\tilde{\varepsilon} + \tilde{\overline{\varepsilon}}'\tilde{\overline{\varepsilon}}\right) & \frac{1}{N}\tilde{\overline{\overline{\varepsilon}}}'\tilde{\overline{\varepsilon}} \end{bmatrix}$$

and $g_N = \begin{bmatrix} -\frac{1}{N}\tilde{\varepsilon}'\tilde{\varepsilon} \\ -\frac{1}{N}\tilde{\overline{\varepsilon}}'\tilde{\overline{\varepsilon}} \\ -\frac{1}{N}\tilde{\overline{\varepsilon}}'\tilde{\varepsilon} \end{bmatrix}$.

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:

$$\left(\hat{\sigma}^2, \hat{\rho}\right) = \arg\min\left\{v_N\left(\sigma^2, \rho\right)' v_N\left(\sigma^2, \rho\right)\right\}. \qquad [5]$$

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:

$$y^* = Z^*\delta + u\,, \qquad [6]$$

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

$$\hat{\delta} = \left[\hat{Z}^*(\rho)'\hat{Z}^*(\rho)\right]^{-1}\hat{Z}^*(\rho)'y^*(\rho)\,, \qquad [7]$$

where $\hat{Z}^*(\rho) = PZ^*(\rho)$.

C. The specification of the weighting matrix

Because we include both a spatial lag and a spatial error term in our model (see equation [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 km2, with larger postal code areas in the more rural areas and smaller ones within city centres. 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 km2, and the average size of postal code areas within agricultural areas is 0.203 km2.

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

Fig. 1 Research area and land use

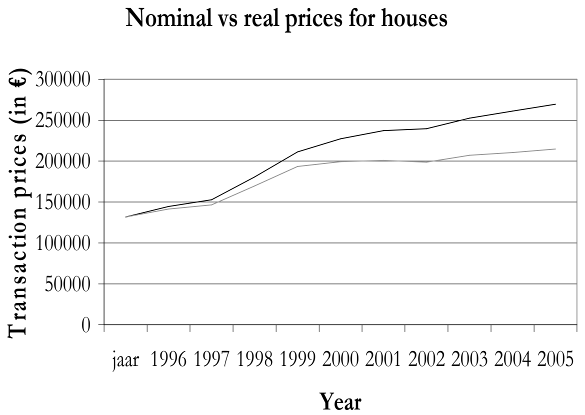
III. DATA AND RESEARCH AREA

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 houses1, corner houses, free standing houses and apartment buildings with closed entrances to the front doors are the base case.

Since the time horizon is 1996-2006, we have to take the time dimension of the data into account. Figure 2 shows the nominal versus real price changes of apartments and houses captured by the 74,959 transactions that we analyze.



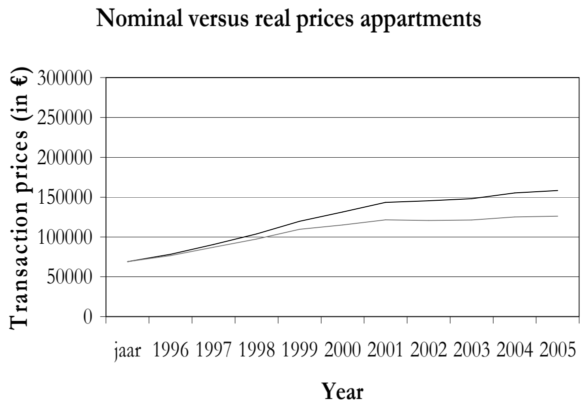


Fig. 2 Nominal versus real price changes of apartments and houses

To correct for inflation, we use real prices in the hedonic pricing model, but Figure 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.

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 Netherlands2. Based on this database, we calculated the Reilly indices for different types of land use surrounding each parcel. Reilly indices are given by:

$$R_i = \sum_{j=1}^{J} \left(S_j \big/ D_{ij}^2 \right), \qquad [8]$$

where R_i is the value 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 meters squared). 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 1. The overview statistics in Appendix 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[3]. We distinguished 465 neighborhoods within our research area. Data about elevation levels and distance to highway exits originated from the Land use scanner[4], and data about the distance to the highway, railways and railway stations originates from the Ministry of Transport, Public Works and Water Management[5]. It is apparent from Appendix 2. that elevation levels are sometimes negative indicating land that is located below sea level. Finally, we used 6 digit postal

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

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

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

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

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

code maps from Bridgis[6] 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 2.

IV. EMPIRICAL RESULTS

Estimates of the hedonic pricing model, including spatial lag and error dependence are shown in Table 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.

A. Spatial versus non-spatial approaches

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 1000.

LeSage and Fischer (2007) 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 neighbouring 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 effects.

Most explanatory variables have the expected sign and the sign is often the same as in the OLS specification. However, sometimes signs and significance differ between the spatial model represented in Table 1 and the OLS model. This is often the case for coefficients which are non-significant. For the parameters of interest, this means that the signs of the Reillys sometimes differ between an OLS specification and the spatial model in Table 1.

B. 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) has 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.

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

Table 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
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 neighbourhood	0.00022	0.41
Percentage of non-western immigrants in the neighbourhood	-0.00581***	-25.56
Average income within the neighbourhood	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-squared	0.8016	

***significant at 1%, **significant at 5%, *significant at 10%. [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 1000.

Since the harbour of Rotterdam is the largest industrial area in this region, this area seems to be appreciated by those who live nearby. The harbours 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 harbour.

Other locational aspects of properties also matter. 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. 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 centres. 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 €1024 more for each kilometre closer to the beach.

C. 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 2.

With respect to neighbourhood 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[7]. 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.

V. 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 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 €1024 more for each kilometre closer to the beach. People are also willing to pay a large premium for living in the countryside. Properties

[7] 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.

located in the countryside, sell on average for €16,564 more than properties somewhere in between the city centre and the countryside. On the other hand 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 centres.

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. Although the Reilly indices for agricultural and large nature areas are not significant, people seem to pay large premiums for living in the countryside. Living in the countryside can be associated with a more quiet atmosphere in general and there is no direct link with externalities associated with the Reilly indices for different types of land use.

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 harbour of Rotterdam is the largest industrial area in this region, this area seems to be appreciated by those who live nearby. The harbours 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 harbour.

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 impacts 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.

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REFERENCES

1. Anselin, L. 1988. Spatial Econometrics: Methods and Models. Dordrecht, NL: Kluwer Academic Publishers. pp. 284.
2. Cho, S.-H., J. M. Bowker and W. M. Park. 2006. Measuring the Contribution of Water and Green Space Amenities to Housing Values: An Application and Comparison of Spatially Weighted Hedonic Models, Journal of Agricultural and Resource Economics 31, no. 3. pp. 485-507.
3. Cotteleer, G., T. Stobbe and G. C. Van Kooten. 2008. Expert Opinion Versus Transaction Evidence: Using the Reilly Index to Measure Open Space Premiums in the Urban-Rural Fringe. Working paper, 2008-06.
4. Geoghegan, J. 2002. The Value of Open Spaces in Residential Land Use, Land Use Policy 19, no. 1. pp. 91-98.
5. Hill, R. C. and L. C. Adkins. 2001. Collinearity, in B. H. Baltagi (ed.), A Companion to Theoretical Econometrics. Oxford, UK: Blackwell Publishing Ltd. pp. 256-278.
6. Ihlanfeldt, K. R. and L. O. Taylor. 2004. Externality Effects of Small-Scale Hazardous Waste Sites: Evidence from Urban Commercial Property Markets, Journal of Environmental Economics and Management 47, no. 1. pp. 117-139.
7. Irwin, E. G. and N. E. Bockstael. 2001. The Problem of Indentifying Land Use Spillovers: Measuring the Effects of Open Space on Residential Property Values, American Journal of Agricultural Economics 83, no. 3. pp. 698-704.

8. Kaufman, D. A. and N. R. Cloutier. 2006. The Impact of Small Brownfields and Greenspaces on Residential Property Values, Journal of Real Estate Finance and Economics 33, pp. 19-30.
9. Kelejian, H. H. and I. R. Prucha. 1998. A Generalized Spatial Two-Stage Least Squares Procedure for Estimating a Sptatial Autoregressive Model with Autoregressive Disturbances, Journal of Real Estate Finance and Economics 17, no. 1. pp. 99-121.
10. Kelejian, H. H. and I. R. Prucha. 1999. A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model, International Economic Review 40, no. 2. pp. 509-533.
11. Kestens, Y., M. Theriault and F. Des Rosiers. 2004. The Impact of Surrounding Land Use and Vegetation on Single-Family House Prices, Environment and Planning B: Planning and design 31, no. 4. pp. 539-567.
12. LeSage, J. P. and M. M. Fischer. 2007. Spatial Growth Regressions: Model Specification, Estimation and Interpretation. Paper presented at The first world conference of the spatial econometrics association, Fitzwilliam college, Cambridge, UK, 11-14 July 2007.
13. Lutzenhiser, M. and N. R. Netusil. 2001. The Effect of Open Space on a Home's Sale Price, Contemporary Economic Policy 19, no. 3. pp. 291-298.
14. Nicholls, S. and J. L. Crompton. 2007. The Impact of a Golf Course on Residential Property Values, Journal of Sport Management 21, no. 4. pp. 555-570.
15. Rosen, S. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, Journal of Political Economy 82, no. 1. pp. 34-55.
16. Rouwendal, J. and W. Van der Straaten. 2007. The Cost and Benefit of Providing Open Space in Cities. Amsterdam. VU. pp. 25.
17. Smith, V. K., C. Poulos and H. Kim. 2002. Treating Open Space as an Urban Amenity, Resource and Energy Economics 24, no. 1-2. pp. 107-129.
18. Spalatro, F. and B. Provencher. 2001. An Analysis of Minimum Frontage Zoning to Preserve Lakefront Amenities, Land Economics 77, no. 4. pp. 469-481.
19. Taylor, L. O. 2003. The Hedonic Method, in P. A. Champ, K. J. Boyle and T. C. Brown (ed.), A Primer on Nonmarket Valuation. Dordrecht, NL: Kluwer Academic Publishers. pp. 331-394.
20. Wu, J. J. 2001. Environmental Amenities and the Spatial Pattern of Urban Sprawl, American Journal of Agricultural Econcomics 83, no. 3. pp. 691-697.
21. Wu, J. J., R. M. Adams and A. J. Plantinga. 2004. Amenities in an Urban Equilibrium Model: Residential Development in Portland, Oregon, Land Economics 80, no. 1. pp. 19-32.

APPENDIX 1 REILLY INDICES

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 at 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 distance2 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 / 4*10-10 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. If this is the case the distance 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 according to 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 on the final estimation results.

APPENDIX 2 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
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 1000 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 €1000)	10.7163	3.0911	0.46/37.49
Elevation level (in m)	-1.46577	1.6519	-6.20/7.30
Monthly trend (=1 January 1996,…., =132 December 2006)	75.8370	36.645	1/132

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