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Cultural Heritage and the Location Choice of Dutch Households in a Residential Sorting Model

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Abstract. Local amenities are an important factor in the location choice of households. Heterogeneity in preferences of households tends to sort households over different locations which satisfy best their preferences given their constraints. In this paper, we analyze the effect of cultural heritage on the location choice of households using a residential sorting model. Cultural heritage is often a determining factor of the specific atmosphere of a location and is valued as such by its residents. Since the attractiveness of a residential location may be affected by amenities in the surrounding locations, spatial econometrics is used to deal with these interdependencies. Our model accounts for unobserved characteristics of locations, heterogeneity of households and spatial correlation between the observed (and unobserved) attractiveness of locations. The results show, for instance, that the willingness to pay of highly educated households to reside in municipalities close to a high concentration of cultural heritage is higher than other types of households.

Key words: location choice, cultural heritage, equilibrium sorting models, discrete choice models, spatial dependence, unobserved characteristics, heterogeneous household preferences

JEL code: C31, J1, R2, Z1

1 Introduction

Household location choices in urban areas are determined to a large extent by accessibility to employment – as is stressed in the Alonso-Muth-Mills model. More recent literature acknowledges that such location choices can also be affected by other amenities than employment. For instance, Brueckner et al. (1999) develop a theory about the sorting of households in urban areas which recognizes the importance of urban amenities, particularly those typically found in downtown areas. Their theory is based on the assumption that the marginal valuation of these amenities rises sharply with income (Brueckner et al., 1999, p. 93). As a consequence, higher income households have a strong willingness to pay for central city locations if urban amenities are present (like in Paris), but prefer to consume more space in suburban locations otherwise (for instance in Detroit).

It is now widely acknowledged that consumer amenities are important for cities. Glaeser et al. (2001) have forcefully argued this on the basis of a wealth of empirical material. They showed, among other things, that US cities with many consumer amenities grow faster. This finding has been confirmed in other research. A recent example is Carlino and Saiz (2008) who concentrate on the attractiveness of particular urban areas for tourists. These authors show that especially the areas close to tourist offices have benefitted from the recent revival of city life in the US, which suggests that tourist attractions also attract high potentials to the residential areas in their proximity. Marlet and Poort (2005) have argued that the presence of cultural heritage attracts highly educated households in the Netherlands. Moreover, locations where highly educated households prefer to reside attract more industries and perform better economically (Florida, 2002; Marlet and Van Woerkens, 2005). If these statements are correct, investing in cultural heritage could be a powerful policy tool for municipalities to attract highly educated households and stimulate urban growth.

Many European cities have a historical background that provides a special identity to these areas that is generally considered as an important amenity for citizens living in those cities and their vicinity. The cultural heritage that is preserved in these areas often seems to function like an anchor point for flourishing neighborhoods with many shops, restaurants, theatres et cetera. The literature referenced above suggests strongly that urban amenities affect the location choice of households and attract the higher educated and more productive workers. In this paper we provide some empirical evidence for this phenomenon by developing a household location choice model and estimating it on Dutch data. The basic idea is that households choose among locations on the basis of the accessibility of employment as

well as urban and non-urban amenities. An ancient inner city is an example of the former category, whereas recreational areas in the vicinity exemplify the latter. The paper therefore attempts to overcome the difficulty of measuring the value people attach to cultural heritage (Throsby, 2003; Marlet et al., 2007; Navrud and Ready, 2002) by focusing on location choices. We use recently developed techniques for studying sorting in an equilibrium setting (Bayer et al., 2004; Bayer and Timmins, 2005; Bayer and Timmins, 2007). This approach allows us to estimate the willingness to pay of various types of households for ‘cultural embedded’ municipalities.

In this paper we also extend a residential sorting model and account for spatial dependence between municipalities. If a household chooses to locate in neighborhood A with few amenities, this does not mean it is restrained from consuming the amenities in neighborhood B. It could even be the case that the household preferred to locate in neighborhood B because of its amenities but could not afford to locate there because of the high house prices there. Hence, the household chooses to live as close as possible to the preferred neighborhood. This means that the characteristics of location A have an effect on the attractiveness of neighborhood B. In such cases B can be a ‘satellite’ of A. This happens quite often in the Netherlands which has a decentralized urban system with many small and medium sized towns located close to each other. Taking into account this spatial structure is therefore of potential importance. Our modeling approach therefore combines an equilibrium sorting model and spatial spillover effects.

We devote the next section to a discussion of the methodology used in our analysis. This includes the residential sorting model and the extensions to account for spatial dependence in various ways. Our data and some descriptive statistics are discussed in section 3. The results will be reported and discussed in section 4. Section 5 summarizes and concludes.

2 The location choice model

2.1 Methodology

This study focuses on the role of cultural heritage in household location decisions. By cultural heritage we mean all those amenities that relate the past to the present and are valued as such. Our primary interest is in the remnants of the past that contribute to the identity of a site or town. An example for

the Netherlands, to which our empirical work refers, are the historical inner cities of the towns that date back to seventeenth century – the Dutch Golden Age – or earlier. Cultural heritage contributes to the atmosphere in the neighborhood and its attractiveness for residents, firms and tourists (Marlet et al., 2007). The result may be that there will be more shops, cafés, restaurants and similar endogenous amenities in these areas, which further contribute to its attractiveness. Cultural heritage may therefore have a multiplier effect through its impact on endogenous amenities.

Currently, the most popular methods to value cultural heritage are the contingent valuation method and the hedonic price method. Throsby (2003) provides a detailed discussion on the contingent valuation method that exploits stated preference surveys to directly measure the willingness to pay of respondents. There is an ongoing debate about the reliability of this method, but aside from that, it is doubtful if it is more suitable to measure the direct impact of cultural heritage than its total effect on the attractiveness of particular locations. The hedonic price method links house prices to the presence of cultural heritage in the vicinity and interprets its marginal prices as an indicator of the average willingness to pay for this amenity.¹ Recent developments have shown that a more detailed picture of this measure may be obtained if house prices are linked to information of the residents (Kuminoff et al., 2010). Therefore, we will use a residential sorting model to study the role of cultural heritage in the location decisions of households. One advantage of this type of model is that it allows us to investigate differences in the willingness to pay for cultural heritage between groups of households. This is of some interest as it has been argued that this type of amenities is in particular attractive for high potentials (Carlino and Saiz, 2008). Our model follows the line of research initiated by Bayer et al. (2004). The equilibrium sorting model they develop has recently been applied in a variety of empirical studies (Timmins, 2005; Murdock, 2006; Van der Straaten and Rouwendal, 2010; Klaiber and Phaneuf, 2010).

2.2 Residential sorting model

We specify household utility as a function of the characteristics of the location (X_m), the price when choosing location m (p_m), and the distance from the location to the labor market and transport facilities (d_m). Household i chooses its location m in order to maximize its indirect utility (V_m^i):

$$V_m^i = \alpha_x^i X_m - \alpha_p^i p_m - \alpha_d^i d_m + \xi_m + \varepsilon_m^i \quad (2.1)$$

¹ For the seminal study on hedonic price methods, see Rosen (1974).

In the direct utility function we do not include information about amenities that are clearly endogenous like shops and restaurants. The idea is that the supply of these amenities will react to the more fundamental determinants of the attractiveness of cities that we do include. Apart from cultural heritage, we include labor market accessibility and connectivity to other locations as such basic determinants of attractiveness. The utility function (2.1) should therefore be interpreted as a reduced form equation of urban attractiveness. As a result, our estimates will indicate the total effects of the determinants of attractiveness, including their indirect effects and the number and variety of shops, restaurants, et cetera. The estimated coefficients of, for instance, indicators of cultural heritage will therefore refer to its total (direct plus indirect) effect on attractiveness.

It can be argued that cultural heritage is also endogenous, at least to some extent. Although it is clearly impossible for municipalities to create authentic cultural heritage, decisions with respect to maintenance, investments in the surrounding neighborhood and demolitions have a potentially important effect on the impact of cultural heritage on municipal attractiveness. Taking into account this potential endogeneity calls for a suitable instrument. This will be discussed in the next section.

The error structure of the model consists of a term that is equal among all households within a municipality (ξ_m) and an individual specific error term (ε_m^i). The ξ_m captures unobserved (by the researcher) quality aspects of the location. Heterogeneity among consumers is captured by allowing the parameters α_j^i for $j \in \{X, p, d\}$ of (2.1) to depend on the household characteristics (z^i) in the following way:

$$\alpha_j^i = \alpha_{0j} + \sum_{k=1}^K \alpha_{kj} z_k^i \quad (2.2)$$

It is convenient to demean the household characteristics, as this implies that the α_{0j} coefficients represent the mean utilities of the locations.

If we substitute (2.2) into (2.1) and assume that all ε 's are iid extreme value type I distributed, utility maximizing location choices are given by a logit model. The variability in the coefficients of this model introduced by (2.2) serves to mitigate the implications of the IIA property of this model (that is still present at the individual level) for the aggregate outcomes.

The equilibrium condition of the logit model is that the total number of individuals choosing a particular location m must in equilibrium be equal to the housing stock at m which is taken denoted as S_m :

$$S_m = \sum_{i=1}^I \text{Prob}(m|i) \quad (2.3)$$

In this equation $\text{Prob}(m|i)$ denotes the probability that household i chooses to locate in m , as given by the logit model. I is the total number of households in the economy. Prices adjust for the equilibrium condition to hold.

An important concern with this model is that equilibrium prices are a function of all arguments of the utility function, including the ξ_m 's. These variables are not observed by the researcher, but their effect on house prices is. The problems this causes were investigated thoroughly in Berry (1994) and Berry et al. (1995). Their solution was the use of a two stage procedure. The first stage requires the estimation of a conventional logit model that treats the mean utility of each location as an alternative-specific constant. In the second stage these mean utilities are further analyzed by instrumental variables techniques.

The utility function estimated in the first stage results from substitution of (2.2) into (2.1) and rewriting the resulting equation as:

$$V_m^i = \delta_m + \left(\sum_{k=1}^K \alpha_{kX} z_k^i \right) X_m - \left(\sum_{k=1}^K \alpha_{kp} z_k^i \right) p_m - \left(\sum_{k=1}^K \alpha_{kd} z_k^i \right) d_m + \varepsilon_m^i \quad (2.4)$$

where δ_m denotes the vector of mean indirect utilities:

$$\delta_m = \alpha_{0X} X_m - \alpha_{0p} p_m - \alpha_{0d} d_m + \xi_m \quad (2.5)$$

In the second stage of the estimation procedure the mean indirect utilities (δ_m) are treated as the dependent variables in a 2SLS procedure that deals with endogeneity of prices and, possibly, cultural heritage. Bayer et al. (2004) provide a suitable technique for constructing an instrument for prices and estimate the second stage via 2SLS. The exogenous characteristics of locations at a reasonable distance from that particular location are used as a suitable instrument for prices.²

² For an extensive explanation of the instrument strategy used for prices, see Klaiber and Phaneuf (2010).

2.3 Spatial extensions

Our basic unit of analysis is the municipality. Although this is an administrative rather than an economic unit, it has the advantage that many data are available at this level. There are almost 450 municipalities in the Netherlands and they differ substantially in area and population size. Urban amenities used by households do not necessarily have to be located in the municipality where they live. Many Dutch workers have a job that is located outside the municipality where they live, although employment accessibility is often an important issue in the choice of the residential location. Similarly, accessibility to the national highway system may be determined by a ramp outside one's municipality of residence.

The empirical work of this paper concentrates on the cultural heritage preserved in ancient inner cities and the impact of this amenity may also extend over municipal boundaries. The historical city centers are important for those living in the municipality in which they are located, but perhaps also for people living in the proximity who like to visit such a center for shopping, dining and recreational purposes. Casual evidence suggests that many people appreciate these inner cities, but choose not to live there, for instance because the available houses are either too small or too expensive. Choosing a location with more convenient housing in the proximity of such an old city center may be a strategy that offers the best of both worlds. These considerations suggest that we should take into account the possibility that the attractiveness of a municipality for residential purposes does not only depend on the cultural heritage in that municipality itself, but also in the surrounding municipalities, just as is the case with other amenities.³

The previous discussion strongly suggests that we should take into account the possibility that the attractiveness of a particular municipality is partially determined by the amenities in surrounding municipalities. We will do so by including not just a measure of the cultural heritage of the 'own' municipality in our model, but also a weighted average of the cultural heritage measures in the proximity. More specifically, we use the 'potential' formulation:

$$PCA_m = \sum_{n \in C_m} e^{-\beta d_{mn}} CA_n \quad (2.6)$$

³ These considerations are reinforced by the irregular shape of the Dutch municipalities. Amsterdam provides a good example of a municipality with an irregular boundary and some remote areas (like the Bijlmer) that are further from the city center than some locations in neighboring municipalities (like Amstelveen).

In this equation the potential PCA_m is a weighted average of the measure of cultural heritage CA_n in municipalities n in a set C_m of municipalities surrounding m , where the weights are defined as an exponential function of the distance d_{mn} between m and n . We include both CA_m and PCA_m as elements of X_m in (2.1). The potential in (2.6) can also be interpreted as a spatial lag, with exponential weights. It introduces a spatial element into the model. Since it relates only to exogenous variables, this has no significant consequences for estimating the model in itself.⁴

However, once we admit that the attractiveness of a particular municipality as a residential location is affected by amenities in surrounding places, we should be aware of the possibility that some of the relevant amenities are unobserved. In other words, it may be the case that the error term ξ_m is affected by unobserved characteristics of the surrounding municipalities. If this happens, the residuals of the mean utilities become spatially correlated.

A first step to deal with this concern is to use Moran's I to test for the presence of such spatial correlation between the ξ_m 's. If it is absent we can continue as before. If present, it is desirable to take this into account when estimating the model. A linear equation with spatially correlated error terms is known as a spatial error model and there exist standard techniques to deal with it (see, for instance, LeSage and Kelly, 2009). However, until recently, the spatial econometric literature did not pay much attention to endogeneity, which is an important issue in the present analysis. Fortunately, a recent paper by Drukker et al. (2010) fills this gap by providing a two-step GMM/IV procedure for estimating spatial econometric models in the presence of endogenous regressors.

For understanding this two-step GMM/IV procedure it is helpful to simplify the notation in formula (2.5) and to consider the following cross-sectional autoregressive spatial model with an autoregressive disturbance term:

$$\begin{aligned}\delta_m &= \beta Z_m + u_m \\ u_m &= \rho W_m u_m + \varepsilon_m\end{aligned}\tag{2.7}$$

⁴ The distance decay coefficient, β , is adjusted so that surrounding locations have a lower weight. The function is exponential decreasing where the weights are becoming close to zero when the distance is further than 30 km.

where $Z_m = (X_m, p_m, d_m)$. We also allow for the endogenous independent variable, the house price index (p_m) (Drukker et al., 2010).

The first step of the GMM/IV procedure proposed by Drukker et al. (2010) is to compute the 2SLS estimator of the first line in (2.7) where p_m is instrumented as before. Then use the disturbances term of the estimated equation to get an *initial* estimate of the autoregressive parameter ($\tilde{\rho}$). This procedure follows the work of Kelejian and Prucha (1998; 2010).

The second step of the procedure computes estimates from the Cochrane-Orcutt transformed model,

$$\delta_{m^*} = \beta Z_{m^*} + \varepsilon_m \quad (2.8)$$

where $\delta_{m^*} = (I_m - \tilde{\rho}W_m)\delta_m$, $Z_{m^*} = (I_m - \tilde{\rho}W_m)Z_m$ using again a 2SLS procedure where p_m is instrumented. The disturbance term of this estimated equation are then used to get an *efficient* estimate of the autoregressive parameter (ρ) accounting this time for both the autoregressive and the heteroskedastic nature of the disturbances. Finally, we compute estimates from the transformed model with the efficient autoregressive parameter.

Summarizing, our empirical model uses the methodology developed by Bayer et al. (2004) to deal with endogeneity of the house prices for owner occupiers and uses spatial econometric techniques within that framework. The two-step GMM/IV procedure is computationally simple, flexible to implement in equilibrium sorting models, and it is not based on the assumption that the disturbance term is normally distributed and homoskedastic. In section 4 we report the estimation results.

3 Data and descriptive analysis

We carry out a national analysis for the Netherlands using municipalities as our spatial units. The Netherlands is a small Western European country. Its urban system is very decentralized, although population density is highest in the so-called Randstad, located in the western part of the country with Amsterdam, The Hague, Rotterdam and Utrecht as its main cities. The central part of the Randstad is often referred to as The Green Heart because it is mainly agricultural. There is a lot of cross-commuting between the various parts of the country, which makes it difficult to define separate urban areas.

Estimation of the equilibrium sorting model needs essentially two types of data: household and locational characteristics. Household characteristics are provided by the 2009 Housing Survey.⁵ A housing needs survey is held every four years to investigate housing needs and current housing conditions of the population. The 2009 version provides detailed information on individual and household characteristics, housing attributes and location. This information is provided for approximately 70 000 households spread over 438 municipalities.

We want to investigate the heterogeneous preferences of different types of households. In particular, we are interested in highly educated households. It has been argued that highly educated households are attracted to locations with cultural heritage in the Netherlands (Marlet and Poort, 2005). We distinguish between highly educated singles and double earners because highly educated double earners face a different work-home relation than the highly educated singles. Therefore, the preferences between the highly educated singles and double earners are likely to be different.

The preferences of households are likely to be affected by the presence of children below the age of 18. The existing (predominantly Anglo-Saxon) literature mainly focuses on the provision of 'good' schools which is an important determinant of household location choices in the United States (Bénabou, 1996; Fernandez and Rogerson, 1996, 2003; Nechyba, 1999, 2000; Bayer, Ferreira and McMillan, 2005). In the Netherlands, the educational system is different from that in the US and the UK. There are no school districts (households can freely choose a school for their children) and denominational schools are more important than public schools.

Finally, we also take into account the age of the head of the households. The results could tell us something about the life-cycle preferences of households.

Table 3.1 reports some descriptives of the household types that we will use in the equilibrium sorting model. Highly educated singles were identified as single person households and the person should have at least an university degree. In our sample single person households represent 35% and the highly educated singles represent 10%. Highly educated double earners were identified as power couples (both partners have at least an university degree) who both have an income. Highly educated double earners form 10% of the households in our dataset. Around 34% of the Dutch households have children below the age of 18. The average age of the head of the household is 50 years.

⁵ *'WoonOnderzoek Nederland'* (WoON) in Dutch. The data includes household specific weighting factors, that ensure representativeness of the sample for the distribution of the Dutch population over the municipalities. This facilitates the use of equilibrium equation (2.3) and these weights were used in all estimations.

Table 3.1. Descriptives household characteristics

Variables	Mean	S.D.	Min.	Max.
Highly educated working single	0.098	0.297	0	1
Highly educated double earners	0.099	0.299	0	1
Household with children (-18)	0.342	0.474	0	1
Age head of household	49.97	17.27	18	107

Source: WoON 2009; No. of observations is 69 149.

These different types of households have specific preferences with respect to housing and urban and recreational amenities which are revealed in their location choice behavior. In this paper we take into account the important factors for the location choice of households, preferably exogenous factors. We include five types of municipality characteristics to be able to investigate the preferences for those characteristics by each type of household: (1) Cultural heritage, (2) Housing market, (3) Aesthetics, (4) Labor market, and (5) Accessibility to transport facilities.

Our main focus is on cultural heritage. The Netherlands has a rich historical background. It is therefore not surprising that in many locations in the Netherlands there is a wide variety of cultural heritage. There is not a single, generally accepted measure of cultural heritage but there exist a number of partial indicators.

We use information on national monuments, archaeological sites, and ‘historical city and village views’ that is made publicly available by the Netherlands Institute for Cultural Heritage.⁶ The dataset counts 61 172 national monuments, 13 031 archaeological sites and 459 historical city or village views. The latter are areas with many old houses or other real estate of cultural or scientific value arranged around a square or a canal or (parts of) a street that have been given an official protected status (Monumentenwet 1988). Such an area is appointed on the municipality level with the approval of the Ministry of Housing, Spatial Planning and the Environment. Many monuments are located within these areas. We deal with the historical city and village views as two separate variables. We do so because

⁶ ‘Rijksdienst voor het Cultureel Erfgoed’ in Dutch and this Service is part of the Ministry of Education, Culture and Science of the Netherlands. This dataset is processed in a geographic information systems (GIS). Hence we know the exact location of these monuments, sites and landscapes.

historical city views, which we will refer to as historical inner cities, has often more cultural heritage and therefore a higher cultural value than the historical village views, which we will refer to as historical sceneries. The latter often refer as much to the landscape as to real estate. For instance, the municipality Beemster, which is a former lake, is entirely a historical scenery. The historical inner cities, measured as the number of square kilometers of protected city views in a municipality, is our preferred indicator of cultural heritage. These areas represent a large share of the cultural heritage within a municipality. Moreover, the concentration of historical real estate provide the specific atmosphere of a location that presumably is the main attraction of cultural heritage for household location choice.

We will use information on monuments and museums to examine the robustness of the results we reach when using historical inner cities and sceneries as our indicators of cultural heritage. We noted in section 2 that it may be argued that cultural heritage is endogenous. To deal with this concern we will instrument cultural heritage with city rights. City rights were special rights and privileges ascribed to certain towns in the Netherlands during the Middle Ages. The towns that obtained these rights were usually protected by walls and the traditional definition of a city in Europe was indeed that of a town with city rights. All main urban centers in late medieval Europe had city rights. These cities often have a lot of cultural heritage, which ensures that there is a positive correlation between this instrument and our indicators of cultural heritage. But the variables that determined whether or not a medieval town could obtain city rights were considerably different from those that determined city growth in the 19th and 20th centuries, which suggests strongly that this variable is independent of the recent treatment of cultural heritage.

We capture the housing market by including a municipal price index for a standard house, which we interpret as the price of housing services. The price index is based on estimation of a standard hedonic price method with municipality fixed effects. The average price of the standard house is 190 041 euro. The lowest standard house price is in the municipality Reiderland, which is located in the north-east part of the Netherlands. The price index shows the expected pattern of high house prices in the western part of the country and in the larger cities. The highest standard house price is in the municipality Bloemendaal, which is located in the west part of the Netherlands.

We also take into account the percentage nature and water coverage. These give an indication about the natural landscapes of each municipality. In the Middle, East and South of the Netherlands and along the coastline nature is in abundance. The lowest coverage of nature is located in the centre of the Randstad, The Green Heart. These municipalities mostly contain agricultural land. A fifth of The

Netherlands consists of open water, rivers and lakes. This amenity is not only highly valued by its residents but along the coast the beaches also attract many tourists.

To deal with the labor market we need a measure that reflects the accessibility to jobs. We include the distance of a community to the nearest 100 000 jobs. These data is provided by Netherlands Environment Assessment Agency.⁷ The variable can be interpreted as when the Euclidean distance is low, the location is close to a large labor market. This variable is a good measure for the agglomeration economies in labor markets. In the last decade, there has not been major shifts of large labor markets in the Netherlands. The distance to the labor market is low in municipalities that are located within the Randstad area and around the larger cities, like Leeuwarden, Groningen, Enschede and Maastricht.

Accessibility to various modes of transport can also be of importance for households in their location decision. Individuals have to be able to travel to their work whether this is by car or by train. Therefore, we include the distance to the nearest intercity station and the distance to the nearest motorway ramp. The distance to the nearest intercity station does not only pick up the preferences of households for travel time, but probably also picks up some of the urban amenities, which are often close to intercity stations in the Netherlands.

Table 3.2 reports the descriptives of these municipality characteristics.

⁷ *Planbureau voor de Leefomgeving* in dutch and is the national institute for strategic policy analysis in the field of environment, nature and spatial planning. The distance to the nearest 100 000 jobs are given by a 500 by 500 meter cell. We combined the coordinates of these cells with the coordinates of the communities in the Netherlands and calculated the average distance for each community.

Table 3.2. Descriptives municipality characteristics

Variables	Data source	Mean	S.D.	Min.	Max.
Historical inner cities (km ²)	RCE(2008)	0.25	0.90	0	13.34
Historical sceneries (km ²)	RCE(2008)	0.43	2.18	0	28.24
Monuments	RCE(2008)	139	397	0	7442
Musea	ABF(2006)	3	5	0	74
Distance to labor market (km)	PBL(2000)	15.51	6.97	3.31	56.54
Distance to intercity station (km)	ABF(2005)	10.27	7.15	1.09	41.56
Distance to motorway ramp(km)	ABF(2000)	5.45	5.15	0.14	34.30
Nature (%)	CBS(2007)	12.23	14.23	0.01	94.03
Water (%)	CBS(2007)	10.60	16.83	0	93.55
Price of standard house (euros)	NVM(2007)	190041	44160	92179	366401

Note: We include 438 municipalities which covers most of the Netherlands. A few municipalities are left out because of the low number of household observations in the WoON 2009 dataset.

In this section we reported our data and descriptive statistics that we will use for the estimation of the sorting model. We will use different proxies of cultural heritage and keep the remaining factors constant. This allows us to look at the robustness of the estimation results.

4 Estimation results

This section reports and discusses the results of the first and the second stage of the residential sorting model for municipalities in the Netherlands. We provide an overview of the estimation results based on the basic residential sorting model. Furthermore, we report results of the spatial extensions of the equilibrium sorting model accounting for spatial dependence in various ways.

4.1 The basic residential sorting model

In the first stage of the residential sorting model developed by Bayer et al. (2004) we estimate a multinomial logit with the locational choice (municipality) of households as the dependent variable. In 2009, there were 438 municipalities in the Netherlands and we distinguish rental and owner-occupied housing. Apart from the mean utilities, which are estimated as alternative specific constants, we include

cross effects of household and municipality characteristics as described in section 2. We estimated two sets of coefficients: one for the rental sector and another for the owner-occupied sector. The reason is that the allocation mechanism in the rental sector is considerably different from that in the owner-occupied sector. More than 90% of the rental housing stock is rent controlled and waiting lists are often long, especially in the big cities.⁸ Priority is given to households that are judged to be especially in need of housing, but the rules used are not transparent. Given these large differences, we decided to include the rental sector in each municipality as an alternative for the owner-occupied sector, but to estimate a different set of coefficients for both.⁹

We are in particular interested in the heterogeneous preferences of households for cultural heritage. The basic version of the model uses the historical inner cities and historical sceneries as indicators of cultural heritage in a municipality. The coefficients of the first step estimation procedure are reported in Table 4.1. The results give an indication how the different types of households value municipality characteristics. They show, for instance, that highly educated households are less sensitive to high house prices than the average Dutch household, whereas the presence of children and being older tend to make people more sensitive to house prices. Appreciation of historical inner cities, which are of key interest in the present study, is higher than average among the higher educated, and less than average among households with children and the elderly. The historical sceneries have a much smaller impact on specific groups of households than the historical inner cities.

⁸ Rents are determined on the basis of quality points, which ignore location characteristics. This implies that houses with the same structural characteristics in Amsterdam and the periphery of the country have basically the same rents.

⁹ An alternative would be to assume that households first decide to rent or own, and then choose a residential location. This would suggest the development of a model for the owner-occupied sector only. A disadvantage of this approach would be that it does not take into account that the accessibility of rental housing differs substantially over the country, which suggests that the two tenure types are much better substitutes in some municipalities than in others.

Table 4.1. First stage procedure: Interaction parameter estimates

	<i>Household characteristics</i>			
	Highly educated single	Highly educated double earners	Households with children (-18)	Age
<i>Municipality characteristics</i>				
Standardized house price (ln euros)	3.1020 (0.0718)***	2.0653 (0.0731)***	-0.0786 (0.0494)	-0.0086 (0.0013)***
Historical inner cities (km2)	0.04925 (0.0049)***	0.01800 (0.0054)***	-0.02369 (0.0037)***	-8.61E-04 (0.00009)***
Historical sceneries (km2)	-0.0021 (0.0078)	0.0138 (0.0059)*	0.0163 (0.0055)	0.0011 (0.0002)***
Distance to labor market (km)	0.00169 (0.0044)	0.00292 (0.004)	0.01622 (0.0026)***	0.00055 (0.0001)***
Distance to intercity station (km)	-0.03814 (0.0038)***	-0.01688 (0.0033)***	0.01328 (0.002)***	0.00029 (0.0001)***
Distance to motorway ramp (km)	-0.0150 (0.005)***	-0.0092 (0.0042)**	-0.0070 (0.0026)***	1.40E-05 (0.00007)
Nature (%)	-0.00784 (0.0012)***	0.00068 (0.001)	0.00126 (0.0007)*	0.00025 (0.00002)***
Water (%)	0.0005 (0.0012)	-0.0056 (0.0011)***	-0.0015 (0.0007)*	-9.83E-05 (0.00002)***

Note: Parameter estimates reported with all variables normalized to have mean zero. These coefficients report the deviations from the mean indirect utility. Standard errors in parentheses. Significance at 90%, 95% and 99% level are, respectively, indicated as *, **, and ***. The regression results based on the other proxies can be obtained from the author.

The second stage of the residential sorting model consists of a 2SLS estimation. The dependent variable is the vector of mean indirect utilities – in other words that part of the utility that is equal for all households.¹⁰ We deal with endogeneity through instrumental variables. The instrument for house prices is computed as the equilibrium housing price that would prevail in the absence of unobserved heterogeneity.¹¹ The results of the second stage procedure can be found in Table 4.2 which reports the effect on municipality characteristics on the indirect utilities of the average household. Column 1 shows a highly significant negative effect of the house price and a highly significant positive effect of historical inner cities. The impact of historical sceneries is not significant, but labor market accessibility and natural amenities are. These results appear to be plausible and confirm our expectations. In column 2

¹⁰ The vector of mean indirect utilities was estimated in the first stage of the estimation procedure.

¹¹ For a deeper understanding of the instrumentation strategy, see Bayer et al. (2004) or Klaiber and Phaneuf (2010).

historical inner cities are instrumented with city rights. This results in a much higher and still significant coefficient for historical inner cities, while the changes in the coefficients of the other variables are modest. If municipalities with a small amount of cultural heritage tend to maintain it better and use it more intensively for city marketing purposes, the result may be a smaller coefficient for historical inner cities when it is not instrumented.

Table 4.2. Second stage procedure: Decompose the mean indirect utilities

Variables	(1)			(2)		
		2SLS (se)		2SLS - City rights (se)		
Standard house price (ln euros)	-7.703	(0.9726)	***	-7.768	(1.0575)	***
Historical inner cities (km ²)	0.299	(0.0824)	***	0.961	(0.2813)	***
Historical sceneries (km ²)	0.023	(0.0334)		0.033	(0.0364)	
Distance to labor market (km)	-0.161	(0.0255)	***	-0.147	(0.0271)	***
Distance to intercity station (km)	-0.026	(0.0141)	*	-0.019	(0.0155)	
Distance to motorway ramp (km)	-0.020	(0.0181)		-0.026	(0.0198)	
Nature (%)	0.038	(0.0074)	***	0.041	(0.0082)	***
Water (%)	0.020	(0.0057)	***	0.013	(0.0065)	**
Constant	96.507	(11.9893)	***	96.922	(12.9952)	***

Note: Standard errors in parentheses. Significance at 90%, 95% and 99% level are, respectively, indicated as *, **, and ***. Tests on the instruments are reported in Appendix A, Table A.1. The regression results based on the other proxies can be obtained from the author.

4.2 Spatial extensions

We now introduce some spatial extensions of the model. The first one is the inclusion of cultural heritage in surrounding municipalities among the explanatory variables. In the second extension we also account for spatial dependence of the disturbance term in the second stage procedure.

Table 4.3 reports the Moran's I and the (robust) Lagrange multipliers for the spatial error model. The Moran's I statistic clearly shows that the residuals face a spatial pattern. Both the Lagrange multiplier and the robust Lagrange multiplier tests for the spatial error model show significant values. The spatial error model should be flexible in the sense that it can be combined with the equilibrium sorting model

with endogenous regressors and is computationally simple. The two-step GMM/IV procedure by Drukker et al. (2010) gives us the opportunity to do so.

Table 4.3. Test statistics for spatial dependence

Test	Statistic	p-value
Moran's I	5.412	0.000
<u>Spatial error</u>		
Lagrange multiplier	20.117	0.000
Robust Lagrange multiplier	27.007	0.000

Note: These statistics are computed in GAUSS and STATA.
Source: Anselin (1988) and Anselin et al. (1996).

In the first extension we add a variable that represents the cultural heritage in surrounding municipalities through a distance decay function as described in Section 2.3.¹² Columns 1 and 2 of Table 4.4 report these results. The coefficient of the historical inner cities in surrounding municipalities is interpreted as an square kilometer increase in a surrounding municipality at a distance of around 20km (which is the average distance). The signs of the significant coefficients are similar to the corresponding columns in Table 4.2. A comparison makes clear that the introduction of cultural heritage in the surrounding municipalities has an enormous impact on the estimation results. The coefficients for the house price and a historical inner city in the own municipality increase substantially in absolute value, while the coefficient for historical inner cities in surrounding municipalities also gets a large and significant coefficient. This remains true if we instrument historical inner cities by city rights. The coefficient for historical sceneries in surrounding municipalities is surprisingly negative and statistically significant, however, the value is so small it is of no economic significance.

Columns 3 and 4 show that the results of taking into account spatial correlation in the unobserved heterogeneity through the GMM/IV procedure developed by Drukker et al. (2010) does not change the results much, although we find a relatively high value of the spatial error coefficient ρ .

¹² The distance decay function gives cultural heritage that are in the surrounding municipalities a lower weight. The average distance in this sample – measured from the core of a municipality to the cores of the surrounding municipalities within a radius of 30km – is 19.6 km.

In column 5 we remove the indicators for cultural heritage in the surrounding municipalities, but keep the spatial error. Now the estimation results are more similar to those reported in Table 4.2. In particular, we find a coefficient of the historical inner city that is comparable in magnitude to that in column 1 of that table. The coefficient for the house price is considerably higher.

Before ending this section, we briefly report the results of a sensitivity analysis, in which we included other proxies for cultural heritage: the number of monuments per municipality and the number of museums per municipality. We found comparable results. In particular, the indicator for cultural heritage was always significant. Using city rights as an instrument for these alternative proxies for cultural heritage did increase the coefficient in the same way as it did for the historical inner cities. This suggests that our results are reasonably robust.

Table 4.4. Second stage procedure: Spatial extensions

Variables	(1)			(2)			(3)			(4)			(5)		
	2SLS (se)			2SLS - City rights (se)			GMM/IV (se)			GMM/IV - City rights (se)			GMM/IV (se)		
Standard house price (ln euros)	-13.881	(2.5198)	***	-16.820	(4.7714)	***	-15.927	(2.4249)	***	-18.572	(4.6708)	***	-10.867	(0.9273)	***
Historical inner cities within (km2)	0.669	(0.1419)	***	1.343	(0.5422)	**	0.613	(0.1365)	***	1.312	(0.5308)	**	0.294	(0.0786)	***
Historical inner cities in surrounding (km2)	0.125	(0.0258)	***	0.164	(0.0531)	***	0.103	(0.0248)	***	0.155	(0.052)	***			
Historical sceneries within (km2)	-0.090	(0.0516)	*	-0.107	(0.067)		-0.043	(0.0496)		-0.078	(0.0656)		0.050	(0.0319)	
Historical sceneries in surrounding (km2)	-0.011	(0.0033)	***	-0.016	(0.0064)	**	-0.006	(0.0032)	*	-0.013	(0.0063)	**			
Distance to labor market (km)	-0.107	(0.0315)	***	-0.103	(0.0386)	***	-0.111	(0.0303)	***	-0.104	(0.0378)	***	-0.148	(0.0243)	***
Distance to intercity station (km)	-0.054	(0.0206)	***	-0.056	(0.0256)	**	-0.037	(0.0199)	*	-0.044	(0.0251)	*	-0.017	(0.0134)	
Distance to motorway ramp (km)	-0.013	(0.0256)		-0.017	(0.0315)		0.002	(0.0246)		-0.007	(0.0308)		-0.002	(0.0173)	
Nature (%)	0.086	(0.018)	***	0.108	(0.0338)	***	0.083	(0.0173)	***	0.106	(0.0331)	***	0.048	(0.007)	***
Water (%)	0.002	(0.0073)		-0.006	(0.0103)		0.006	(0.0071)		-0.003	(0.0101)		0.012	(0.0054)	**
ρ (spatial error)							0.676			0.503			0.765		
Constant	168.388	(30.2335)	***	203.106	(56.9481)	***	193.232	(29.095)	***	224.262	(55.7478)	***	134.365	(11.4301)	***

Note: Standard errors in parentheses. Significance at 90%, 95% and 99% level are, respectively, indicated as *, **, and ***. Tests on the instruments are reported in Appendix A, Table A.1. The regression results based on the other proxies can be obtained from the author.

5 Implications

In this section we consider some implications of our estimation results. We focus on the results reported in column (3) where spatial effects are taken into account. We choose this specification because it indicates a somewhat smaller effect of cultural heritage than the model in which we instrument this variable. With the estimation results in hand it is simple to compute the marginal willingness to pay of various households for municipality characteristics (see Appendix B for technical details). Table 5.1 reports the mean marginal willingness to pay for some municipality characteristics (in column 1) and the deviations from that mean of various household types (in the other columns).

The marginal willingness to pay – in terms of higher house prices – for historical inner cities is large and significant (7317 euros per km²), whereas that for historical sceneries is negative and insignificant (-511 euros per km²). The marginal willingness to pay for historical inner cities in surrounding municipalities is also positive and significant (1232 euros per km²), whereas that for historical sceneries in surrounding municipalities is negative (-70 euros per km²). The latter is so small it is of no economic significance. The interpretation of the marginal willingness to pay for historical inner cities in surrounding municipalities is that an extra square kilometer of historical inner cities in surrounding municipality B – where the distance between neighbouring municipalities A and B is around 20km (the mean distance between neighbouring municipalities in the Netherlands) – has an effect of 1232 euros on the mean marginal willingness to pay in terms of house prices in municipality A.

The deviations of the mean marginal willingness to pay of highly educated singles and double earners are reported in columns 2 and 3, respectively. Highly educated singles have a marginal willingness to pay for residing in municipalities with a large area of historical inner cities that is more than 25% as large as that of an average households, for power couples the deviation is still more than 10% of the average. This implies that municipalities with a large area of historical inner cities attract highly educated households. These highly educated households also appear to have a tendency to live in municipalities that give good accessibility to jobs, but the difference with the mean household is not significant. More important to highly educated households is the vicinity of transport facilities. Natural landscapes are somewhat of less importance for highly educated households.

Column 4 reports the results of the households with children under 18. We observe that those households do not prefer to reside in municipalities with a large area of historical inner cities. Their willingness to pay for historical sceneries, nature and water is not significantly different from the

average households. Households with children are rather identified by the fact that they prefer to reside further away from the labor market and intercity stations but instead they prefer to reside close to the motorway.

Column 5 shows that younger households are willing to pay more to live in municipalities with a larger area of protected historical inner cities. Older households are willing to pay more to live in municipalities with a larger area of protected historical sceneries. We also see that younger households prefer to live closer to the labor market, closer to intercity stations and in municipalities with a larger share of water compared to older households. On the other hand, older households prefer to live in municipalities with a larger share of nature. This implies that younger households tend to move to municipalities with a large area of historical inner cities where they also have a lot of job opportunities and live close to transport facilities whereas older households tend to move away from municipalities with a favorable business environment to municipalities with a large area of historical sceneries where they can enjoy more nature. This result is in line with the recent work of Chen and Rosenthal (2008).

Table 5.1. Marginal willingness to pay results from the two-step GMM/IV spatial error model

	(1)		(2)		(3)		(4)		(5)
	Mean		High educated working single		High educated double earners		Households with children (-18)		Age (+10 years)
Historical innercities within municipality (km ²)	7317.2		1994.6		1055.2	(ns)	-115.4	(ns)	-109.3
Historical innercities in surrounding municipality (km ²)	1232.1		180.2		127.6		46.6		16.5
Historical sceneries within municipality (km ²)	-511.3	(ns)	-6.3	(ns)	146.5		53.5	(ns)	101.5
Historical sceneries in surrounding municipality (km ²)	-69.9		-5.6		0.0		-2.3		0.1 (ns)
Distance to labor market (km)	-1330.0		-376.2	(ns)	-177.5	(ns)	213.6		112.1
Distance to intercity station (km)	-447.3	(ns)	-547.1		-255.0		83.0		26.6
Distance to motorway ramp (km)	20.9	(ns)	-259.4		-127.3		-37.2	(ns)	9.9 (ns)
Nature (%)	985.2		104.1		139.5	(ns)	11.0		26.0
Water (%)	69.2	(ns)	54.9		-43.6		-32.8		-21.5

Note: The values in this table are in euros. The first column reports the mean willingness to pay of a marginal change of the municipality characteristic. Columns 2 through 6 report the deviation from the mean willingness to pay for that type of household. (ns) means not significant at 5% level. The significant levels of columns 2 through 6 are based on the first stage of the residential sorting model.

The sorting model suggests that house prices react to differences in consumer amenities and we therefore expect that observed differences in house prices between municipalities can be explained by differences in the willingness to pay for the bundles of amenities offered by these cities. To illustrate this, we consider pairs of municipalities in the Netherlands that are related in the sense that one can be considered as a 'satellite' of the other. Dutch spatial planning is rather tight and attempts to mitigate the growth of the largest cities by concentrating new housing supply in growth centers at some distance from these mother cities. The growth centers thus become satellites of these larger cities and typically have more nature but less cultural amenities. Accessibility to jobs is typically less good in the satellites, and house prices are usually much lower than in the mother cities.

Table 5.2 provides information on two of such mother-satellite pairs, viz, Amsterdam - Almere and Utrecht - Nieuwegein. The housing price in Amsterdam is almost twice as high as in Almere (€ 313k vs € 162k); the difference between Utrecht and Nieuwegein is smaller (€ 250k vs € 206k), but still approximately 20%. The differences in the city characteristics are large. For instance, Amsterdam has more than 7 km² of historical inner city, more than 1 km² historical sceneries, and has good labor market accessibility, whereas Almere neither has a protected historical inner city nor sceneries and is further away from a large labor market. On the other hand, Almere has more nature and water. There are similar differences between Utrecht and Almere, but they are of a smaller size, as is true for the difference in house prices. Table 5.2 also reports the marginal willingness to pay for each characteristic in each municipality for the average Dutch household. The outcome of our computations is that the average Dutch household is willing to pay approximately 85 000 euros more for a standard house in Amsterdam than for a similar house in Almere and 15 000 more for a house in Utrecht than a similar one in Nieuwegein. The actual difference in house prices between Amsterdam and Almere is large because of the strong willingness to pay of particular groups for the cultural heritage that is abundantly available in the mother cities and absent in the satellites, and by differences in unobserved amenities.

We have also carried out a counterfactual simulation in which we compute the house prices that would prevail if there were no differences in the availability of cultural heritage among Dutch municipalities. Table 5.3 reports the computed equilibrium prices of standard houses in the four municipalities in the case there would be no cultural heritage in the Netherlands. We keep the mean price of standard houses in the Netherlands the same to compare the different prices. Our results show that the municipalities with cultural heritage in their municipality or in their vicinity are affected by a significant decrease in prices for a standard house. The standard house price in Amsterdam, for instance, would

decrease by 22%. This high percentage is expected to be around the upper boundary as Amsterdam has the most cultural heritage in the Netherlands. Municipalities with less cultural heritage than Amsterdam, like Utrecht, prices would decrease around 10%. Even the municipalities in the vicinity of rich areas of cultural heritage, like the satellite cities, would also decrease in prices for a standard house.

Another interesting observation is that the gap between the price of a standard house in Amsterdam and Utrecht will almost disappear. However, these municipalities still have a favorable characteristics regarding to the job market and the accessibility of transport facilities, hence the price of a standard house will still be larger than their satellite municipalities.

Table 5.2. Municipality characteristics and the marginal willingness to pay

	Amsterdam		Almere		Utrecht		Nieuwegein	
	Characteristics	MWTP	Characteristics	MWTP	Characteristics	MWTP	Characteristics	MWTP
Standardized house price (euros)	€ 312 539		€ 162 834		€ 250 317		€ 206 176	
Historical inner cities within (km2)	7.14	12034	0	6270	1.64	9638	0.00	7938
Historical inner cities in surrounding (km2)	3.69	2026	5.96	1056	6.06	7777	8.29	6406
Historical sceneries within (km2)	1.20	-841	0	-438	0.17	-674	0.13	-555
Historical sceneries in surrounding (km2)	8.96	-115	9.41	-60	9.50	-441	7.17	-363
Distance to labor market (km)	4.79	-2187	17.3	-1140	3.62	-1752	7.55	-1443
Distance to intercity station (km)	2.34	-736	2.17	-383	2.73	-589	6.80	-485
Distance to motorway ramp (km)	1.47	34	1.92	18	1.50	28	1.07	23
Nature (%)	2.16	1620	24.0	844	1.96	1298	3.26	1069
Water (%)	24.2	114	47.6	59	4.00	91	7.52	75

Note: The marginal willingness to pay (MWTP) values are in euros and municipality specific. Almere is a satellite town of Amsterdam and Nieuwegein is a satellite town of Utrecht.

Table 5.3. Counterfactual simulation: Eliminating cultural heritage using the GMM/IV procedure

	Amsterdam	Almere	Utrecht	Nieuwegein	
Standardized house price (euros)	€ 312 539	€ 162 834	€ 250 317	€ 206 176	
Adjusted equilibrium - No cultural heritage	€ 243 194	€ 156 458	€ 225 270	€ 183 769	
	Δ	-69345	-6376	-25047	-22407
	%	-22%	-4%	-10%	-11%

Note: The estimated house price regarding the adjusted equilibrium are reported for a counterfactual simulation that sets all preference parameters associated with cultural heritage to zero. Those newly estimated house prices are then compared to the standardized house price.

6 Conclusions

In this empirical paper we investigate whether cultural heritage affects the location choice of different households. We attempt to measure the value households attach to cultural heritage using a recent developed sorting model on Dutch data. While the existing literature on the valuation of cultural heritage has provided no conclusive evidence about the impact of cultural heritage on the attractiveness of cities, this paper focuses on that issue and suggests that the impact is large. The total impact is the sum of a direct effect – an ancient inner city makes a city more attractive – and an indirect effect – a city that is attractive because of its cultural heritage is a good location for shops, cafés, restaurants et cetera, and this contributes further to its attractiveness.

Households reveal their preferences for locational characteristics by choosing their location. Our analysis uses an equilibrium framework developed by Bayer et al. (2004) in which house prices equalize demand and supply for housing in each municipality. We find positive and significant values for the mean marginal willingness to pay for residential locations close to protected historical inner cities. The marginal willingness to pay for cultural heritage varies substantially between different types of households. Highly educated households have the highest marginal willingness to pay for this amenity and are therefore attracted to municipalities with a higher than average amount.

Our findings make clear that the success of a city does not only depend on job opportunities and transport facilities, but also on cultural heritage. Indeed, the impact of such amenities seems so large that our findings can be interpreted as empirically confirming Brueckner et al. (1999)'s contention that central Paris is rich and central Detroit is poor because of the huge difference in amenities.

Although it is clear that politicians cannot create (authentic) cultural heritage, there is a clear policy suggestion implied by our analysis: maintenance of cultural heritage and exposing it to visitors and residents can contribute substantially to the attractiveness of cities. Further research should try to look more carefully into the issues of maintenance and exposure than the data at our disposal allowed us to do.

In a geographical setting it is likely that the locational characteristics are spatially correlated between locations. This spatial dependence is present in our sample. This complicates the estimation procedure and the original estimates are then likely to be biased. We presented two possible extensions. The first extension has taken into account the spatial dependence of cultural heritage. The second extension uses

the two-step GMM/IV spatial error model to account for the spatial dependence in the disturbance term in a setting with endogenous regressors. Our model suggests that cultural heritage in surrounding municipalities are important for the location choice of households and that, in general, accounting for the unobserved characteristics of surrounding municipalities can help against the omitted variable bias caused by the attractiveness of surrounding municipalities. This improves the estimation of the model. The results report less biased and more efficient marginal willingness to pay results for cultural heritage. This gives us an idea what the impact of the spatial error model is in an empirical setting.

In our exercise we show that, if we account for the unobserved characteristics in surrounding municipalities in Amsterdam and there would be no cultural heritage, the price of a standard house would be decrease with 22%, which will be around the upper boundary since Amsterdam is one of the richest areas regarding cultural heritage. In Utrecht, this decrease is around 10%. Because of this decrease, the price discrepancies between Amsterdam and Utrecht decreases. The satellite municipalities do also suffer from a decrease since they are in the vicinity of areas with cultural heritage. The main municipality would, in this situation with no cultural heritage, still have a higher price of a standard house because of its favorable characteristics, regarding to the job market and the accessibility to transport facilities.

Combining the equilibrium sorting model with spatial econometrics gives us the opportunity to not only account for the heterogeneity of households, unobserved characteristics of locations, but also for the unobserved characteristics of surrounding locations. In our opinion it is important to think about spatial correlations when you do research in a locational setting. Future research on linking those streams of literature should be most interesting.

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Appendix A. Tests on the instruments used in the second stage procedure (2SLS)

Table A.1. Tests on the first step of the 2SLS procedure for specification (1) and (2) of Table 4.2.

(1)		(2)	
Underidentification test (Kleibergen-Paap rk LM statistic):	40.350	Underidentification test (Kleibergen-Paap rk LM statistic):	50.415
Chi-sq(1) P-val =	0.0000	Chi-sq(1) P-val =	0.0000
Weak identification test (Kleibergen-Paap rk Wald F statistic):	69.134	Weak identification test (Kleibergen-Paap rk Wald F statistic):	29.707
Stock-Yogo weak ID test critical values: 10% maximal IV size	16.38	Stock-Yogo weak ID test critical values: 10% maximal IV size	7.03
15% maximal IV size	8.96	15% maximal IV size	4.58
20% maximal IV size	6.66	20% maximal IV size	3.95
25% maximal IV size	5.53	25% maximal IV size	3.63
Source: Stock-Yogo (2005). Reproduced by permission.		Source: Stock-Yogo (2005). Reproduced by permission.	
NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.		NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.	
Hansen J statistic (overidentification test of all instruments):	0.000	Hansen J statistic (overidentification test of all instruments):	0.000
(equation exactly identified)		(equation exactly identified)	
Instrumented: price		Instrumented: price - historical inner city	
Excluded instruments: phat		Excluded instruments: phat - city rights	

Appendix B. Derivation of the marginal willingness to pay

The procedure to derive the marginal willingness to pay (MWTP) for locational characteristics is as follows. Equation (2.4) and (2.5) can be written as a hedonic price regression allowing for heterogeneity in household preferences.

$$P_{k,m} = \left(\frac{\alpha_{0X} + \alpha_{kX} z_k^i}{\alpha_{0p} + \alpha_{kp} z_k^i} \right) * X_m - \left(\frac{\alpha_{0d} + \alpha_{kd} z_k^i}{\alpha_{0p} + \alpha_{kp} z_k^i} \right) * d_m + \left(\frac{1}{\alpha_{0p} + \alpha_{kp} z_k^i} \right) * \xi_m + \left(\frac{1}{\alpha_{0p} + \alpha_{kp} z_k^i} \right) * \varepsilon_m^i - \left(\frac{1}{\alpha_{0p} + \alpha_{kp} z_k^i} \right) * V_m^i$$

Where $p_m = \ln(P_m)$ and k is the characteristic of household z . It is now simple to compute the MWTP of each k type of household for each locational characteristic (X_m).

$$\frac{\partial P_{k,m}}{\partial X_m} = \frac{(\alpha_{0X} + \alpha_{kX} z_k^i)}{(\alpha_{0p} + \alpha_{kp} z_k^i)} * P_m$$

When the household characteristics (z_k^i) are constructed to have mean zero, the MWTP of the average household is

$$\frac{\partial P_m}{\partial X_m} = \frac{\alpha_{0X}}{\alpha_{0p}} * P_m$$

The sorting model controls for the preferences of each type of household. As a result the MWTP of the average household can be substantially different from the MWTP of a particular type of household. This provides a household specific valuation of each locational characteristic.