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Abstract

This paper analyses hedonic pricing factors in the urban residential land market of Vienna. Considerable impacts of the underground network are to be found on residential land values. The accessibility of open space and shopping opportunities are among the major pricing factors of residential land markets. The socio-economic characteristics of the neighbourhood are also important. The connection between these characteristics and land price levels is, however, to some extent influenced by social housing and land politics in Vienna. Furthermore, analysis of submarkets shows that road-noise is the one characteristic which most distinguishes single family home owners from others. Disequilibria in housing markets seem to be of less importance for hedonic prices than underlying changes in the attributes of land parcels. An example is aircraft noise pollution, the hedonic price of which has risen considerably because of the rather strong increase in transport volume in the last decade. Finally, we find that announcements of new subway stations have positive effects on land values in newly developing areas but not so in already developed areas where redevelopment is prohibitive costly.

Keywords: Residential land prices, Hedonic pricing, Underground train stations, Amenities, Noise, Land price disequilibria, Developed and undeveloped urban residential areas, Housing submarkets

JEL Classifications: R14, R21, R31, R38, R4

Introduction

Traditional land price models predict a strong relationship between the value of urban residential property prices and distance to the central business district (CBD). In these models, travel costs are traded-off against rents (Alonso, 1964) and population densities (Muth, 1969). The main assumption is that properties distinguish themselves only by their distance to the core of a mono-centric city. Today, however, it is widely recognised that location is a much broader concept. In most of the larger cities, the CBD has lost its predominant place as the main location of employment and services, challenged by the emergence of peripheral centres of activity. Moreover, trips are made not only for employment and shopping activities; an increasing proportion of trips pertains to a broader range of consumption purposes, in particular, for recreation and other leisure activities. Thus, the linkage between accessibility, property values and land use patterns is more complex than assumed by the early theorists.

Relative accessibility, determined by both supply and demand side factors, constitutes a key aspect of location. On the supply side, accessibility depends on the presence, efficiency and effectiveness of transport modes. Changes in accessibility induced by new transport infrastructure investments lead to localised and more general changes in property values. Those value changes will eventually trigger off property investment and development decisions, resulting in the intensification of change in land use (Henneberry, 1998). On the demand side, changes in working conditions and people's preferences with respect to leisure and other activity patterns have an impact on the relative attractiveness of locations. Furthermore, long-term social, technological and economic trends may fundamentally change the physical and location attributes of properties and thereby influence values.

There is no single theoretical model which registers all of the factors influencing residential property prices in a satisfactory way. The reason is that properties are heterogeneous in consequence of a bulk of possible factors which determine their relative attractiveness of location. Moreover, the relative importance of those factors may change over time as a result of changes in both supply and demand conditions. It is also because of these difficulties that academic work in recent decades has increasingly concentrated on the empirical analysis of the determinants of residential property values. While theory still provides a hint on which factors may be relevant, the identification and functional relationship between factors and property values is totally empirical.

In this paper we use hedonic models to test for urban public transport infrastructure as well as amenity and dis-amenity effects in Viennese residential land markets. Application of the hedonic method delivers a range of estimates on the impacts of the attributes of land parcels on the metropolitan level, as well as for different submarkets. Submarkets are segmented by location (city centre/suburb) or by the type of housing (multi-storey/single family homes). Although a comment is made on all the major influencing factors which were identified in the empirical analysis, particular attention is drawn to the effects of the Vienna Underground System. Underground train stations have made a considerable impact on property prices in many other cities. The paper is organized as follows: Section 2 provides information on transport innovations and land use policy in Vienna. Section 3 delivers a short comprehensive review of literature mainly concerned with public transport and (dis)amenity effects on house prices.

Section 4 introduces the hedonic analysis and describes the data. Section 5 discusses the main results, and section 6 delivers conclusions.

Overview

Located on a plain surrounded by the Vienna Woods and the Carpathian foothills, the Austrian Capital Vienna is a cultural, industrial, commercial, and transport centre. The city is divided into 23 districts grouped roughly in two semicircles around the Inner City (the First District; CBD). It is the core of the Vienna functional urban region (FUR) which is defined to comprise the City of Vienna and the surrounding districts in Lower Austria. In 2001; the FUR had a population of 2.15 Mill which is about 27% of the total Austrian population. The FUR provides 33.6% of the total GNP in Austria, of which the City of Vienna provides 26.9% and the surrounding lower Austria districts the remaining 7.3%. Vienna´s GDP per head of 36.800 € was among the highest in Europe in 2001.

Vienna shows a similar pattern of suburbanisation as witnessed in many other major cities. There is a clear tendency of a declining core (districts 1-9 and 12-20) and at the same time a rising population in the outer ring (districts 10-11 and 21-23 and the Lower Austria districts). For the first time, in 2001, more people lived in the outer ring than in the core. The same pattern pertains in terms of employment and overall economic performance. While the outer ring of the FUR belongs to the most dynamic regions in Austria, the core of the city of Vienna has witnessed rather poor economic growth with rising unemployment since the 1970s.

Considering the size of the urban population Vienna has a well developed public transport network. The tram network is one of the largest in Europe (Taylor, 2005). The total length of the public transport system in Vienna is approximately 950 km. As all routes in the densely populated areas operate at only short intervals, even during off-peak hours, public transport is widely used. The network attracts approximately 740 million travellers a year. About half of all the journeys made by public transport in Vienna are carried out by the Vienna Underground Network. The construction of this network started in 1969 when the local council of Vienna decided to construct a basic network covering about 30 km with the lines U1, U2 and U4. The first line was opened in 1978 and construction of the basic network was completed in 1982. Today, about 66 km have been completed on five lines. In real terms more than 9 Billion € have been invested in lines, stations and facilities to date. The next openings are planned for 2009, resulting in a seventy-five-km network at the end of the so called third development phase.

Apart from the Vienna Woods, an area protected as early as 1905 by law as the "woods and green belt", the `Prater´ and the many large parks within the city boundaries, Vienna also boasts major new green spaces such as the `Danube Island´ and the `Lobau´. The Lobau is part of the `Donau Auen National Park´ which was founded in 1996 and internationally recognised by the IUCN (International Union of Conservation of Nature) in 1997. At present the total area of the national park is 9.300 hectares, of which 60% are forests and about 25% are covered with water. The Danube Island, of about 21 kilometres in length, was artificially created as a retreat for the urban population in the 1970s. It is earmarked exclusively for leisure and recreation and can be used free of charge. The Vienna Woods, the Prater, the Danube Island and the Lobau are the major recreation areas in Vienna.

The Vienna Building Code is the central legislative instrument regulating all land use and construction activity in Vienna. It has been in force since 1930 and also amended several times since. The building code comprises planning law (issues of land use, zoning and development plans) as well as building law including the regulations on granting building permits (Blaas and Oppolzer, 2003). Since 1984, Vienna has a more comprehensive land and city development management, mainly based on principles derived from public-private partnership models. Every ten years a comprehensive urban development plan (*Stadtentwicklungsplan, STEP*) is filed which sets the guidelines for the major developments planned for the next years. The plan is a general tool, defining principles and land use patterns, transport axes and development areas for the entire city. The Development Plan was newly issued in 2005. Another planning tool is the Strategy Plan for Vienna. According to the editors, this is "a modern planning tool designed by the Vienna city government to provide guidance for future developments. It formulates objectives for an ideal development of the city, which transcend the traditional development concepts". The plan does not focus on spatial development, but defines "strategic priorities" such as cross-border co-operation, business and employment policy, promotion of technology and education, and the improvement of ecological quality.

Those broad guidelines are supported by two institutions which are both the instruments of the City´s real estate property management and large-scale participants on the Vienna land markets. The Vienna Land Procurement and Urban Renewal Fund (*Wohnfonds Wien*) was founded in 1984 based on a resolution of Vienna's City Council. Its primary tasks are land procurement for social housing, preparation and development of projects, ensurement of quality and realization of measures for urban renewal, especially consultation, co-ordination and control of subsidised housing improvement. The Vienna Business Agency (*Wirtschaftsförderungsfonds Wien*) is the City´s primary business promotion vehicle. Its mission is to boost the competitiveness of the Vienna business community. At the same time, it is one of the City´s largest property owners, with around 3.5 million square metres in holdings.

Literature Review – public transport and (dis)amenity effects on housing prices

Public transport infrastructure and property prices

The extent to which public transport systems affect the value of properties in the vicinity has been studied in many large cities. Most of the studies have confirmed that public transport systems have an impact on property values. Some earlier investigations were provided by Dewees (1976), Bajic (1983), Giuliano (1986), JSUMR (1987), Voith (1991) and Gatzlaff and Smith (1993). In a study for Toronto, Dewees (1976) found that land value changes are steeper around underground train stations than around the underground train lines themselves. The study by Bajic (1983) combined modal choice and hedonic pricing models to examine the impact of the Spadina Corridor in Toronto between 1971 and 1978. He found that residential values were $2,237 higher near light-

rail lines than elsewhere. In Philadelphia, a study by the Joint Center for Urban Mobility Research (1987) on the effect of the Lindenwold Line, which runs 14.5 miles from Philadelphia to the New Jersey suburbs, shows that nearby housing values increased by 7%, or $4,500, on average. Voith (1991) finds that accessibility to train service resulted in a $5.714 average premium throughout Philadelphia. Gatzlaff and Smith (1993) find evidence, although weak, of increases in house values proximate to Miami Metrorail stations. Studies of the San Francisco Bay Area Rapid Transit (BART) show that the overall impact on land values has been modest but significant as property prices and rents have increased in certain station areas (Giuliano, 1986).
More recent studies are provided by So, Tse and Ganesan (1997), Chen, Rufolo and Dueker (1997), Bowes and Ihlanfeldt (2001), Bea, Jun and Park (2003), Gibbons and Machin (2004) and McMillen and McDonald (2004). So, Tse and Ganesan (1997) stress the high dependency on public transport in Hong Kong. About 90 per cent of all persons are carried by public transport. In their study the accessibility to minibuses emerges as the most influential determinant of house prices in a large residential area of the middle-income class in Hong Kong. Chen, Rufolo and Dueker (1997) deliver a replication and extension of Al-Mosaid et al. (1993), who examined the impact of proximity to Portlands light-rail stations on residential property values. They recognize that proximity to light rail may have two different effects: accessibility, which may increase property values, and nuisance effects, which may decrease property values. They measure accessibility by proximity to the LRT station, while nuisance is measured by proximity to the LRT line. They find, that the positive effect dominates over the negative effect, which implies a declining price gradient as one moves away from LRT stations for several hundred metres. In the same vain, Bowes and Ihlanfeldt (2001) notice that prior empirical studies have not fully investigated the factors that may account for the impacts of rail station proximity. On the one hand, stations may raise the value of nearby properties by reducing commuting costs or by attracting retail activity to the neighbourhood. On the other hand, negative externalities emitted by stations and the access to neighbourhoods that stations provide to criminals may counter these effects. They estimate hedonic pricing models and auxiliary models for neighbourhood crime and retail activity and find that all four effects play a role, but the relative importance of the effects varies with distance from downtown and the median income of the neighbourhood.

Open Space, Noise and Property Prices

Open spaces provide a range of benefits to the citizens of a community. Parks and natural areas can be used for recreation, and farms and forests provide aesthetic benefits to surrounding residents. Last but not least, any preserved land can offer relief from congestion and other negative impacts of urban development in rapidly growing urban and suburban areas. As is the case for public transport improvements, there are now a host of studies which have tried to place a monetary value on open spaces in general and parks, natural areas and other amenities in particular. McConnel and Walls (2005) provide an extensive review of approximately 40 studies investigating open space effects on property prices between 1967 and 2003. Although these studies cover a wide range of types of open space and a variety of ways to measure open space, the authors draw conclusions concerning the direction of particular effects, how values vary by location and other influences, and the differences among the methodologies used to estimate values. According to McConnel and Walls, open space values in terms of distance (being 200 metres closer) range from negative to 2.8 percent of the average house price. Interestingly, estimates from models that use dummy variables, rather than continuous distance or percentage of surrounding land variables, tend to be higher. In a study by Lutzenhiser and Netusil (2000), being near to open space, raises average house prices by as much as 16.8 percent.

Hedonic pricing has also been employed to estimate the economic value of changes in environmental hazards (such as noise levels). Hedonic price studies provide values in terms of the Noise Sensitivity Depreciation Index (NSDI), defined as the average percentage change in property prices per decibel. Among others, Nelson (1980), Gillen and Levesque (1989) DETR (1999), Bateman et al. (2000), and Navrud (2002) summarize results from studies on road traffic and aircraft noise. NSDIs for road traffic noise have been reported which range from 0.08% to 2.22%, i.e. a ten decibel reduction in road traffic noise raises property prices by between 0.8% and 22.2%. According to Navrud (2002), a simple mean of the studies suggests a NSDI of about 0.55%. Gillen and Levesque (1989) reviewed 15 studies on aircraft noise in mainly U.S. cities and found NSDI in the range of 0.4 to 1.1%, with a median of 0.5 – 0.6%. In another review, Bateman (2000) found NSDIs ranging from 0.29% to 2.3%. Schipper (1996) using meta-analysis finds that the implicit price of aircraft noise pollution is influenced by a number of factors such as timing, country and specification of the original noise studies. He finds an average NSDI of around 0.33% in the whole sample, whilst for the U.S. this rises to 0.65%. As Navrud (2002) notes, the variety of NSDI values should not come as any surprise, as from a theoretical point of view, we would not expect different housing markets to have the same hedonic price function and, therefore, we should not expect applications of the hedonic pricing technique in different cities in different years to return identical results. This remark is more general as it applies to almost all hedonic estimates not only those with regard to different kinds of noise pollution.

Methods and data

Hedonic Pricing

Hedonic analysis is a well-established technique which assumes that a property is sold as a package of inherent attributes. Each of the attributes contributes to the full enjoyment of the accommodation. Consumers are assumed to evaluate a bundle of attributes and the price paid for a particular property is the sum of the implicit prices that the market ascribes to the various attributes contained in the bundle (Rosen, 1974). With information on the prices of properties and their varying attributes, it is possible to derive the implicit equilibrium market price – the hedonic price – of each attribute.

As described by Palmquist (1989), it is assumed that there is a perfectly competitive market for the tract of land with characteristics

$$\mathbf{z} = (z_1, z_2, \ldots\ldots, z_k) \ . \qquad (1)$$

Each characteristic is valued in market equilibrium values. The price for the differentiated product is related to the characteristics and is given by the hedonic price equation:

$$P = P(\mathbf{z}) \qquad (2)$$

where P denotes property value, and z_i is the i^{th} attribute of the property. This function describes how the quantity and quality of a property´s characteristics determine its price in a particular market. It is important to realize that the hedonic price function for any particular market will be unique to that market reflecting the specific conditions of supply and demand that exist at that locality. For example, properties in peaceful locations will command relatively higher prices than in a generally noisy urban area.

If we are able to estimate (2) from available data, then the coefficients of the models can be used to determine the implicit price associated with each characteristic of a tract of land, assuming all other things are constant. The implicit price of characteristic z_i is the partial derivative of Equation (2) with respect to characteristic z_i,

$$p_{z_i}(z_i; \mathbf{z}_{-i}) = \frac{\partial P(\mathbf{z})}{\partial z_i} \qquad (3)$$

where z_{-i} denotes a vector of all the other attributes. In most applications it is assumed that these other characteristics are held constant at some given levels; that is, we are not considering the interaction of different characteristics. Furthermore, as in standard micro-economic theory it is assumed that although \`more is better´ for \`goods´ (i.e. garden size) as against for \`bads´ (i.e. noise), marginal utility of consumption of each individual characteristic is decreasing. For example, the bigger the garden of a property, the higher the price that property will command in the market. The marginal price of extra garden space, however, is not constant. This sort of relationship reflects a sort of satiation, which results in non-linear prices for the property´s characteristics.

As noted by Malpezzi (2002) and many others, the non-linearity stems ultimately from the cost of adjustment. In fact, if housing units could be re-formed instantly and without cost, then such repackaging free of charge would imply a linear structure of implicit prices. Repackaging, however, is expensive and consumers are forced to choose both, a quantity of some characteristic and, implicitly, its price. In hedonic pricing models, prices and quantities are correlated by construction, and the resulting non-linearity constitutes a unique sort of identification problem which goes beyond those found in garden-variety supply and demand models. This non-linearity, however, poses a number of problems for the empirical researcher. Among the main theoretical assumptions and implications of the hedonic pricing framework are (Day, 2001):

(1) Implicit hedonic prices depend on the particular conditions of supply and demand existing in the market. These prices are generally interpreted as equilibrium prices, although it is recognized that disequilibria in housing markets may have an impact on hedonic estimates.

(2) There is no theoretical basis for transferring implicit hedonic prices between different hedonic markets. Hedonic housing markets may be defined in spatial as well as in socio-economic dimensions. We should expect the analysis of different property markets to return different values of the implicit price function for characteristic z_i.

(3) As long as changes in characteristic z_i are marginal, the implicit price function for a particular market will also trace out the willingness to pay of households in that market for extra z_i. In this case, the implicit price function allows researchers to determine the welfare impact of marginal changes in a housing attribute.

(4) When changes in characteristics are non-marginal, welfare calculations based on the implicit price function are inaccurate. However, careful inspection of changes in demand and supply conditions allows one to infer at least the direction of the likely welfare impacts. For example, if preferences are dynamically stable over time, changes in implicit prices may reflect welfare impacts changes on the supply side. On the other hand, if the supply of a characteristic is totally elastic or totally inelastic, changes in implicit prices may reflect shifts in demand (preferences) of households. Under certain

assumptions, it is therefore possible to derive welfare implications from the underlying implicit price schedules alone. Although it is clear that a quantification of welfare impacts under a full cost-benefit analysis requires the estimation of demand curves from several hedonic markets. Demand functions for housing characteristics cannot be estimated from data collected in a single hedonic property market without the imposition of non-testable assumptions concerning the nature of household preferences.

In empirical applications, the hedonic price function of equation (2) is estimated by collecting data on the selling price of houses in a particular property market and then regressing these on the characteristics of those properties. Researchers most often use a very simple functional form for the hedonic price function. Typically, the natural log of sales `prices´ is regressed against a linear specification of the housing characteristics (semi-log form). Many other forms of relationships are imaginable. Unfortunately, theory provides little guidance on the specification of hedonic models. *A priori* it is little known about how to choose the right dependent variable (selection bias, truncation bias), how to select the right independent variables, which functional form to choose, or how to define markets and submarkets. Experience from the many studies now available suggests that a full dataset would include as independent variables the structural characteristics of the property as well as tenant characteristics, neighbourhood variables (quality of schools, socio-economic characteristics of the neighbourhood), distance to the central business district, and perhaps sub-centres of employment, environmental variables (noise and air pollution, distance to parks and recreation areas), and data on the surrounding structures. Choice of the semi-log form has a number of advantages over a simple linear form. Among them are a simple and appealing interpretation[i], often a mitigation of the common statistical problems associated with changing variances of the error term (heteroskedasticity), and specification flexibility on the right-hand side (i.e. using dummy variables). Market and submarket definitions depend predominantly on the research question. Within metropolitan areas, submarkets are usually segmented by location (city centre vs. suburbs), or by housing quality level, or by socio-economic neighbourhood (such as ethnic origins, nationality, income, or education).

The data

The data used in this study refer to vacant land zoned for single-family homes as well as for multi-story residential buildings and row-houses in the Austrian City of Vienna. The sample includes about 3,900 transactions which took place from 1987 to 2004. Vacant land sales are recorded in a public register called *Kaufpreissammlung*, which is administered by a local government body (*Magistratsabteilung 69-Zentrale Liegenschaftsevidenz*)[ii]. It is electronically available since 1987. Amongst other information, the register records the grid reference of each property and the price at which the property was sold. Given the grid preference, it is possible to employ GIS to link each property sale observation to features reflecting its location with respect to (dis)amenities such as shops, schools, parks, industrial sites or waste incinerators. For schools, instead of measuring straight line distances to the next primary school, the number of schools within corridors of 250, 500 and 750 metres, respectively, are counted. This should, besides accounting for the quantitative availability, at least partially also account for the qualitative aspects as well. When considering the accessibility of shops, the straight line distance to the next major shopping centre or shopping mall is measured. By employing GIS it is, of course, possible to calculate straight line distances to underground train stations and the CBD.

The major risk involved in hedonic price regressions is the presence of multicollinearity between property attributes and the consequent instability of estimates. To overcome problems of multicollinearity, particularly with a measure of central district effects, we measure the distance from underground train stations in discrete steps. This is done by inspecting the continuous distance measure after setup regressions by submarkets with non-parametric methods (kernel regressions)[iii]. These deliver non-linear correspondences of underground train effects. We limit the discrete ranges to three, where the last range includes the greatest distance where underground train effects are still at least marginally observable. The coefficients of these discrete (dummy) variables then estimate the hedonic price of the underground train effect relative to the no-effect case.

Data on land uses (zoning types) and the location and orientation of each property were combined with information on the landscape topology and building heights to calculate the indices of the views available from the property. Road traffic and light rail noise was calculated as the straight line distance to the next road and tram line, respectively, where the average noise level by day exceeds 50dB. Aircraft noise was classified into three categories. Category 0 is comprised of land parcels outside the noise corridors, while category 1 encompasses those land parcels within a corridor burdened with the highest noise levels. Category 2 comprises land parcels within a corridor of an intermediate noise level. The three categories are measured via two dummy variables.

Neighbourhood characteristics came from the Vienna population and housing censuses of 1991 and 2001. They can be constructed from the smallest unit of the census or averaged over larger spatial scales to provide indicators of attributes of the wider neighbourhood. The smallest area over which census data is provided is a *Baublock* (BB). Vienna is divided into more than 10,650 BBs, with each BB containing an average of 68 households (142 inhabitants). BBs are gathered into larger scale political units known as enumeration units (*Zählsprengel*, ZS), which again are gathered into the larger enumeration districts (*Zählbezirke*, ZB). Vienna contains 1,364 ZSs and 250 ZBs. On average, one ZB contains 8 ZSs and 42 BBs, and one ZS contains 5 BBs. Each ZS comprises an average of 550 households (1,130 residents which amount to an average of 2,990 households (6,160 inhabitants) in the larger ZBs.

The censuses provide a lot of information on the socio-economic characteristics of the population living in each BB. Following Day et al. (2004), a factor analysis was employed which identified five major dimensions in the socio-economic composition of the households inhabiting each BB. The scores of the factors were included as regressors in the empirical applications that follow. These scores can be interpreted as registering (1) an increasing proportion of married people over 40 years of age ("the New Beginners"), (2) those representing the increasing age of the population (proportion of those older than 65), (3) an increasing proportion of families, (4) an increasing proportion of younger people with good salaries (Yuppies) and, (5) those inhabitants (defined by educational levels) with increasing levels of skills. As separate regressors we use the proportion of inhabitants who are foreigners within the EU-14 and the proportion of people from outside the EU-15.

Table 1 lists data items and statistics from some of the more important variables investigated here. All in all, four types of independent variables were considered. The *Structural characteristics* of the urban land transactions which include area in square metres, zoning type, shape of area, type of transactors (private, state or state affiliated) and the year of transaction. The *Topographical characteristics* include slope and aspect of land. The *Accessibility attributes* include distance to the next subway station, distance to the CBD, and distances to other public facilities and amenities as well as dis-amenities (roads, greenbelts, schools, shopping centres/malls, etc.). Finally, the *Neighbourhood characteristics* include socio-economic factors (information on education levels, age structure, family status, percent of foreigners, etc.) and environmental attributes (road traffic noise, aircraft noise, garbage incinerator, heights of surrounding structures (headways)).

Table 1 Data Statistics

Variable (Unit) - the whole market (3, 896 obs.)	Mean	Med.	Std. dev.	Min.	Max.
per square meter price of residential land (in nominal terms)	346	220	383	5.4	5,505
per square meter price of residential land (in real terms; 2003 prices)	404	258	448	7.4	6,386
per square meter size of residential land	1,447	643	2,884	20	62,835
year of transaction	1994	1994		1987	2004
Distance from the next metro station (in meters)	2,547	2,377	1,837	12.2	8,841
Distance from the next tram station (in meters)	1,148	695	1,269	1	6,614
Distance from the next bus station (in meters)	379	160	771	0	6,042
Distance from the CBD (in meters)	7,736	7,883	2,773	740	13,823
Distance from the next major park (in meters)	1,770	443	1,577	0	7,289
Distance from the next major shopping center/mall (in meters)	3,983	3,856	2,303	2	12,089
Number of primary schools within 750 meters	1.86	1	2.16	0	12
Road noise (in dB)	53.3	50	6.6	50	81

Estimation Results

This section comprises three sub-sections. First of all an analysis is made of property price determinants in the whole sample covering all types of residential land all over the city area. In sub-section two, hedonic models of sub-markets are examined. In the third sub-section it is tested whether house price disequilibria or changes in attributes supply have stronger impacts on the hedonic estimates. Finally, the last sub-section provides a dynamic analysis of subway effects on land values and tries to evaluate the connection between transport infrastructure planning and the timing and character of urban development in two different situations.

Regression Analysis of the whole sample

Appendix A1 lists the results of a hedonic model of all samples (the basic model) calibrated with the generalized least squares (GLS). Most of the signs of coefficients are consistent with expectations, and most of them have values significantly different from zero. The model fit is acceptable owing to its R^2 = 0.726. All of the VIF values are below 8, while the mean VIF is 2.24 which is greater than one, though not considerably so. Since most of the coefficients are significant we can be quite confident that no harmful co-linearity exists among the independent variables.

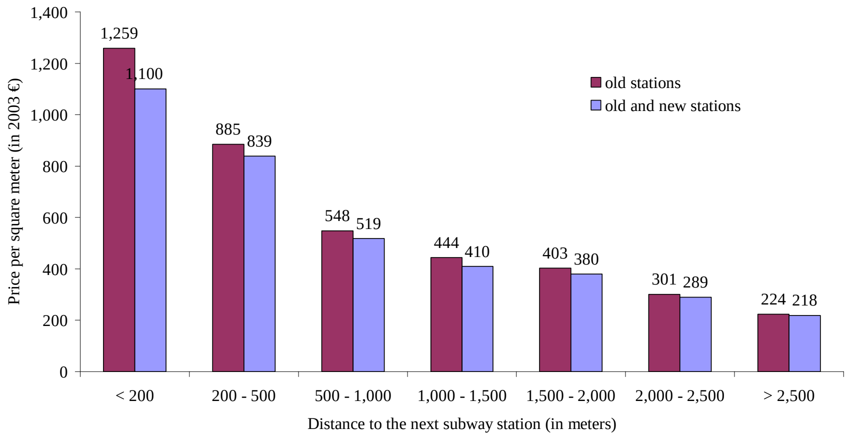
The first comment to be made is on the relationship between land prices and the structural characteristics of the land parcels. Under `s*tructural characteristics*´ all the information which was extracted from the land transactions dataset and the associated topographical information is to be understood. Attributes include permissible building height, land area, surface of land, slope and aspect of land, and percentage of main zoning permits. Further information on whether the respective land parcel is undeveloped or a building site (i.e after demolition), and whether the land parcel has been divided into plots or not is at hand. With the exception of the aspects variable, all the variables are highly significant with the signs expected. The aspects variable is a dummy set to 1 if the land parcel is located in hilly areas aligned to south, south-east or south-west. The lack of significance of the coefficients is likely to be due to the data sample which is, to a larger extent, comprised of transactions on land parcels in the greater north-eastern flat areas as against the more hilly areas in the western and south-western parts of the city. The results for the other variables show that land prices rise with the increase in permissible building height, that prices are higher for undeveloped objects compared to the sites of demolished buildings, that they are higher when the land parcels are divided into plots and that they decrease with the slope of the land parcel.

Important variables are the size and surface of the parcels. The result obtained in this study, that land prices are nonlinear in parcel size, confirms the findings of other studies made elsewhere. Taking into consideration the parcel size has profound implications for hedonic estimates, particularly for the rate at which land prices decline with distance to the CBD. Because land area increases with distance to the CBD, increased parcel sizes would falsely be associated with lower unit prices as a result of the non-linearity of the land prices function (Colwell and Munneke, 1997). On the other hand, the parcel surface may also be a function of urban space. There may be natural physical constraints on land parcelling in more hilly city areas. As they are not randomly distributed across the total urban space, control of the surface-type is important too.

One main hypothesis states that, all else equal, prices of properties near underground train stations are on average higher than prices elsewhere. According to Bowes and Ihlanfeldt (2001) four factors account for the total effect of subway station proximity on property values, two of them causing higher property values, and the other two resulting in lower property values. The positive factors are the access advantage and the possible attraction of neighbourhood commercial services. Countering the positive impacts are negative externalities emitted by the stations (noise, pollution and unsightliness) as well as crime, which may be higher in station areas. Thus, it is a priori unclear, whether subway effects on property values are positive or negative on average. Typically a single (distance) variable is used to measure the impact of subway stations on property values. The coefficient of this variable then measures the net benefits from station proximity by netting out positive and negative factors. Bowes and Ihlanfeldt criticise that attributes like station characteristics, type of neighbourhood and opportunities for shopping are typically excluded from the property value equation. We use distance (corridors) to subway stations to measure the effects of the subway system on residential land values. We account for the different factors in our study by controlling for neighbourhood characteristics as well as for shopping opportunities and other amenity and disamenities near the railway stations. Furthermore, we estimate subway effects for different housing submarkets, particularly for single family homes and for multi family storeys.

We first begin with some descriptive statistics. Construction of the Vienna subway system began in 1969, while the earliest observations in our dataset on property prices are from 1987. Figure 1 shows average real vacant land prices dependent on the distance to the next subway station. We differentiate old stations from new stations, where the latter are those stations construction of which was announced after 1987[iv]. For both, old and new stations, the relationship between the real prices of the properties and distance to the station seems to be non-linear, with prices within 200 meters about five times higher then prices of properties outside a corridor of 2,500 meters. Furthermore, real prices of properties near old stations are on average higher than prices of properties near the new stations. There are at least three explanations for this observation: Firstly, most of the old stations are near the CBD, where prices are generally higher because of classical central district effects. Secondly, zoning headways of the properties are higher near the CBD and land prices are increasing with permissible headways. The new stations were built into the periphery where zoning is mainly restricted to single family homes. Thirdly, it is very probable that the willingness to pay for better accessibility through public transport is higher in the central regions where a combination of high population density, the local concentration of economic activities and limited road space combined with strict parking regulations discourage extensive use of private cars. The situation in the suburbs is quite different. There single family homes dominate with a more extensive use of private cars.

Figure 1 Average real prices of vacant residential land as a function of the distance to the nearest subway-station



The descriptive analysis, however, shows a rather crude picture of the subway effects. Controlling for structural, locational, environmental and neighbourhood characteristics in our basic regression model, we find strong evidence for independent subway effects on vacant residential land values in Vienna. We use distance (corridors) to underground stations to measure the effects of the underground network on residential land values. Underground effects are estimated for different housing submarkets, particularly for single family homes and for multi-family storeys. By carrying out controls on structural, location, environmental and neighbourhood characteristics in the basic regression model, strong evidence is found for independent underground effects on vacant residential land values in Vienna. There seems to be a non-linear correspondence between distance to the underground station and property prices. Moreover, underground effects can be proven up to a distance of 5,000 metres, which seems to be quite large. There are two possible explanations for this rather broad corridor. One is that Vienna still shows strong characteristics of a mono-centric city with a single main city centre where a lot of people from the suburbs are working. Furthermore, most of the inner districts are constrained with regard to parking facilities, which makes job travel by car not very attractive, to say the least. The second explanation comes from the public transport system as a whole. The secondary net is far developed, meaning that even people living in the outer suburbs can easily reach the underground train stations by bus or by tram. Above all, the bus system in Vienna is extensive enough to provide a service even to those locations which lie outside the City of Vienna. It is therefore not surprising that a bus station near properties does not have a significant impact on the prices of those properties (the coefficient on the distance-to-bus-station variable is not significant; see Appendices A1 to A3).

Besides the formal evidence on underground effects, the basic regression model delivers some further interesting results: Firstly, most of the location controls are significant at least at the 5% level. A 1,000 metre reduction in distance to the city centre would add 5 per cent to the value of residential land, while one additional school within 250 metres from the property raises the price by 3.3 per cent. As suggested above, the variable for primary schools combines distance and school quality into a single index. The possibility to choose between a higher number of schools (per inhabitant) should exert some pressure on school headmasters to stand up for quality against their competitors. Even if most of the schools are public, competition should be quality enhancing and be manifested in higher neighbourhood land prices, at least in the long run. Of course, there is again some kind of *endogenity* as school quality (and quantity as well) may be a function of neighbourhood characteristics which may themselves be price enhancing. The distance to the city centre is an important variable for itself and will be commented on it in the course of an investigation based on housing submarkets in the next section.

The two other important location controls are access to major shopping centres/shopping malls as well as accessibility of parks, greenbelts and other major recreation areas. There is, however, a major difference in the functional form of the relationship between land prices and distance to the amenity, because of both different demand and supply conditions. From a demand perspective, living near an open space provides a range of benefits. Parks and natural areas can be used for recreation and they provide aesthetic benefits to surrounding residents. It is very likely that most of the parcels which are very close to the areas are not affected by congestion or noise. On the other hand, living near major shopping centres is not very attractive. Because of negative externalities, we should expect price discounts for parcels which are too close. From the supply side, there is another major difference. While shopping centres may be subject to relocation or restructuring, major recreation areas are seldom affected by such kinds of supply shocks. Of course, regulatory measures might change the conditions of usage, but such measures are normally long lasting. That means that supply conditions of open space are usually quite stable.

Secondly, the coefficients of the buyer and seller dummies clearly reveal the direction of land politics in Vienna. **Table 2** shows the proportions of the different buyers and sellers in the Vienna land market. Private persons as buyers count for more than 60 per cent of all transactions, whereas at the seller side they count for nearly ¾ of all transactions. The next most important transactors are private housing developers, followed by the housing associations on the buyer side and by the Vienna Land Procurement and Urban Renewal Fund on the seller side. These are the four main types of agents in this sample of land transactions on the Vienna residential land market. The estimates show that the average selling price obtained by the city and its two authorities (the Vienna Business Agency and the Land Procurement and Urban Renewal Fund) was between 9 per cent and 22 per cent lower than the selling price obtained by private individuals. On the other hand, while the city paid 26 per cent less compared to private individuals, the Vienna Business Agency paid 35 per cent more. Only private housing agencies pay higher prices on the Vienna residential land market.

Table 2 Type of buyers and sellers in per cent of all transactions (N = 3,896)

Seller / Buyer	City	Public Utilities	housing associations	Austrian republic	Vienna Business Agency (WWFF)	land procurement and urban renewal fund (WBSF)	other public association	other private association	Private persons	
City	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.4	0.7
Public Utilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
housing associations	0.3	0.0	0.3	0.0	0.2	2.7	0.0	2.1	4.6	10.3
Austrian republic	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6
Vienna Business Agency (WWFF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
land procurement and urban renewal fund (WBSF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.2	1.4
other public association	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
other private association	0.2	0.1	0.2	0.1	0.5	0.6	0.1	8.4	16.7	26.8
Private persons	0.5	0.1	0.3	0.1	0.2	0.1	0.0	8.6	50.3	60.1
	1.1	0.2	1.0	0.2	0.8	3.5	0.2	19.4	73.6	100.0

Thirdly, the variables measuring environmental characteristics show the expected signs, with the exception of the variable measuring the average height of surrounding buildings (sightlines). Proximity of a garbage incinerator reduces land prices by 22.3 per cent. Road noise is measured as the average dB-level of the nearest road (and tram route) during the day, with the lowest dB-level being 50. The estimate shows a semi-elasticity of price with respect to road noise of -0.3, that is a one dB increase in road noise reduces land prices by 0.3 per cent. Thus, all else equal, a property suffering from road noise at the 70 dB level has a price discount of 6 per cent compared to a property registering a baseline level of noise pollution at 50 dB. This is a rather low figure compared to results found elsewhere. As the next section will show, however, road-noise is heavily punished by single family home owners in the suburbs.

We measure aircraft noise with dummy variables representing the location of a property with respect to two aircraft noise zones. A property located within zone 1 has a price discount of 13.5 per cent, while a property in zone 2 suffers from a price reduction at a value of 5.7 per cent compared to a similar property outside the two zones.

Finally, many researchers suggest that the characteristics of the local neighbourhood are essential to a property estimation model. Indeed, as found by many others, the variables describing the socio-economic characteristics of the neighbourhoods (most of them constructed in a factor analysis) are important in explaining the variation in property prices in Vienna too. Higher property prices are associated with higher skill levels, and with the yuppy (singles) and age factors. Lower property prices are seen in association with attributes reflecting family factors. There is generally a strong correlation between skills and levels of income, it is therefore not surprising that increasing skills of the inhabitants of an area tend to manifest themselves in higher property prices. Of course, there is the issue of direction of causality in this relationship, which will not be further discussed here. From the highly significant estimates, however, it should be clear that there is a strong form of segregation along the neighbourhood factors, at least if the whole city area is taken into consideration. On the other hand, it is interesting to observe, that the proportion of other foreigners has no statistically significant impact on vacant residential land values in Vienna. These are mainly residents which stem from Turkey and from the former Yugoslavian States. The great majority of all Turkish and former Yugoslavian households live in dwellings built before 1919, which are characteristic of the private rental segment. This is the only segment without regulatory barriers, whereas, until fairly recently there was no access to the social housing segment for non-Austrians. However, the statistically insignificant estimate here does not mean that there is no segregation of Turks and Yugoslavian groups in Vienna. On the contrary, there is evidence that spatial segregation of these groups is to be found at the more disaggregated levels (Giffinger, 1998), and that segregation is increasing in recent years (Fassmann et al., 2007).

Another interesting observation concerns the relationships between the age factor and the family factor on the one hand, and the level of property prices on the other hand. These relationships reveal a second, characteristic feature of the Viennese housing markets. Older people tend to live in areas near the city centre mainly in older multi-storey buildings. Rent regulation has, for a long time, protected inhabitants in those submarkets from increasing rents. It is only a few years ago that changes in rent regulation (liberalisation) took place. Existing rent regulation did not have a depressing effect on recent land transactions in the area, because there was the expectation that these changes would lead to increases in rents in the older housing stock.[v]

On the other hand, the negative association between family attributes and land prices is a consequence of at least two factors. One is that, generally families do not belong to the upper income level. The second factor develops out of the Viennese housing policy. Social (subsidised) housing is mainly directed towards younger families and social housing construction is directly affected by land policy. The city government and its associated authorities make land available for social housing at prices which are sometimes significantly below the market level (see above).

In order to get a better understanding of the impacts of underground rail innovations and amenities on the Viennese housing markets, two directions were taken. The next section analyses static effects in three submarkets: the market for multi-storey buildings, the market for single family homes and the market as a whole. It is of interest to consider the functional form of the relationship between the distance to the amenity and the land prices in the submarkets. Section 5.3 is concerned with the impacts of disequilibrium effects on the estimates. It is a fact that land prices have risen strongly in the first half of the observation period. It took several years until price increases began to level out. One may wonder, whether this period of prices, which were obviously out of equilibrium, had significant effects on the interesting coefficients.

Submarket Analysis

There is both theoretical and empirical reasoning why accounting for market segmentation is both a desirable and necessary step in hedonic analysis. In particular, if our land price data set contains data from more than one market segment, it is likely that the hedonic price functions for each segment will be quite different. The identification of submarkets, however, is not an easy task. Previous studies have applied different rules by which properties in an urban area are allotted to a particular submarket. Criteria include spatial location or political boundaries, characteristics of households and property types and classifications based upon the judgement of estate agents. All these approaches make *a priori* assumptions with regard to the criteria defining submarkets. An alternative procedure presented by Day et al. (2003) uses information from the data itself and is based on cluster analysis.

Figure 2 Submarket 1: Single family homes (SFHO)

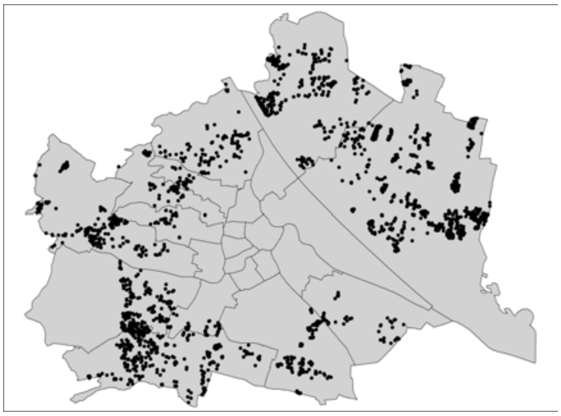
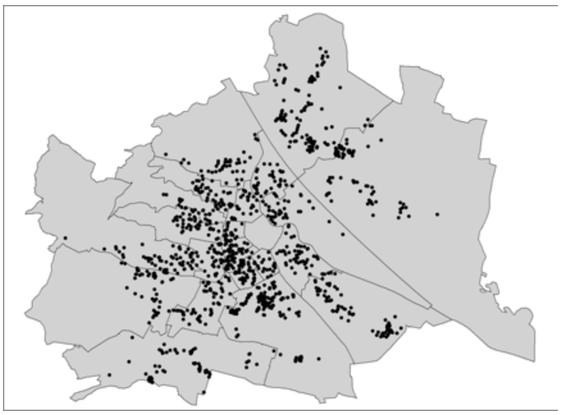


Figure 3 Submarket 2: Multi-storey buildings (MSB)



Following Basu and Thibodeau (1998) and others, the dataset at hand was divided according to the structure type. The idea is that households may wish to purchase or rent a property of a certain type. They have to decide whether to purchase or rent a house with garden, or to purchase or rent a flat or maisonette. It is therefore necessary to distinguish between single family homes and multi-storey residential buildings. To this purpose, the information on the zoning type of the property and the buyer and seller structure are utilized. The dataset distinguishes between properties according to their permissible building height. We assume that properties with a permissible building height of at the most 9 metres are designated for the construction of single family homes if the land parcel was purchased by a private person. The remaining parcels of land are designated for the construction of multi-storey residential buildings. Figures 2 and 3 plot the spatial location of land parcels in the two submarkets.

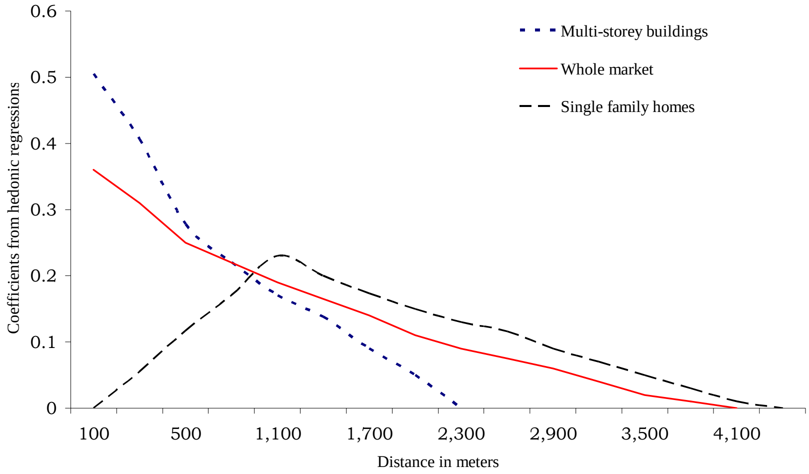
Table 3 Data statistics per submarket

Variable (Unit) - submarket 1 (Single family homes; SFHO) - (2,176 obs.)	Mean	Med.	Std. dev.	Min.	Max.
per square meter price of residential land (in nominal terms)	199	167	152	5.4	1,564
per square meter price of residential land (in real terms; 2003 prices)	231	193	167	7.4	1,951
per square meter size of residential land	682	564	475	20	6,703
year of transaction	1994	1993		1987	2004
Distance from the next metro station (in meters)	3,177	2,915	1,793	80	8,841
Distance from the next tram station (in meters)	1,551	1,046	1,386	14	6,614
Distance from the next bus station (in meters)	478	172	952	1	6,042
Distance from the CBD (in meters)	8,919	8,909	2,046	3,749	13,823
Distance from the next major park (in meters)	744	432	875	0	5,156
Distance from the next major shopping center/mall (in meters)	4,768	4,605	2,129	308	12,072
Number of primary schools within 750 meters	0.98	1	1.16	0	5
Road noise (in dB)	52.0	50	4.96	50	73.8
Variable (Unit) - submarket 2 (Multi-storey buildings, MSB) - (1,720 obs.)	**Mean**	**Med.**	**Std. dev.**	**Min.**	**Max.**
per square meter price of residential land (in nominal terms)	529	374	490	19.7	5,505
per square meter price of residential land (in real terms; 2003 prices)	619	445	576	25.3	6,386
per square meter size of residential land	2,433	962	4,102	26	62,835
year of transaction	1994	1994		1987	2004
Distance from the next metro station (in meters)	1,752	1,156	1,572	12	8,748
Distance from the next tram station (in meters)	647	292	879	1	6,490
Distance from the next bus station (in meters)	255	144	424	0	5,864
Distance from the CBD (in meters)	6,247	6,160	2,848	740	13,808
Distance from the next major park (in meters)	566	459	478	0	5,049
Distance from the next major shopping center/mall (in meters)	3,004	2,720	2,134	2	12,089
Number of primary schools within 750 meters	2.95	2	2.57	0	12
Road noise (in dB)	54.9	50	7.89	50	81

Properties in submarket 1 (single family home owners; SFHO) are located in the outer districts of Vienna, while properties in submarket 2 (multi-storey buildings, MSB) are spread over the whole city area, although most of the transactions took place within the boundaries of the more central districts. Table 3 summarizes the characteristics of the two sub-markets according to some of the more interesting housing market attributes. It reveals that prices in the MSB-market are more than twice as high as those in the SFHO-market. This is due to a combination of different effects. Parcels of land designated for MSB have permission to build higher, are more centrally located, and they have better accessibility to public transport. For example, according to the medians, the distance to the next underground train station is about 2/3rds shorter for properties designated for multi-storey buildings. Properties in the second submarket have also better accessibility to major shopping opportunities and they are better supplied with primary schools. On the other hand, there is virtually no difference in terms of access to major recreation areas and the average level of road noise near the properties in these two submarkets.

In two separate regressions, it was tested whether accessibility effects are different in the two submarkets. The results presented in the Appendices A2 and A3 suggest some interesting interpretations. First, centrality seems to be more important for inhabitants living in multi-storey buildings near the CBD. The coefficient on the CBD-variable is two times higher than in the case of the single-family homes. A 1000 metre reduction in distance to the CBD brings about a price discount of 6 per cent compared to a 3 per cent discount in the suburbs. The distance to the next tram stop brings about a similar result, while the distance to bus stops have no effects on the prices. The latter result suggests that, at least on average, the bus system in Vienna has already reached a high density level.

Figure 4 Metro effects in the submarkets



On the other hand, accessibility to the underground train network is also quite differently valued in the submarkets. Although accessibility to the underground train network is highly valued in both markets, the ranges and magnitudes of the effects differ considerably. While inhabitants living in single family homes in the suburbs value accessibility up to a distance of almost 5,000 metres, proximity ends within a distance of 2,000 metres for people living in multi-storey buildings. Moreover, for single family home owners, property value is a non-linear (concave) function of proximity, where the highest valuation accrues to properties within a distance between 800 metres and 1,400 metres from the station. Therefore, home owners like to be near an underground train station, but not too close. On the other hand, value is a linear function of accessibility to the underground train network in the MSB-market with very high valuations near the stations. Being close to an underground station raises the average prices in this submarket by more than 50 per cent. This means that rents are about 10 per cent higher compared to otherwise similar properties which are more than 2,000 metres away from the underground station[vi].

Apart from differences in transport accessibility effects, there are other distinguishing features in the two submarkets. For instance, the presence of an additional school seems to be relatively more valued by single family home owners in the suburbs, probably because of the poor supply. Residents living in districts near the CBD have more opportunities to select from the supply of primary schools. At the extreme, there are 5 schools to choose from within a corridor of 250 metres, whereas in submarket 1 there are 2 schools at the most. Although, the coefficient is not significant at the 10 per cent level, a closer inspection might reveal that the supply (both in quality as well as quantity) of schools in the suburbs is insufficient.

Furthermore, road noise seems to be valued very differently between the two submarkets. The coefficient on the road-noise variable, which is high and significant in the SFHO-market, is insignificant in the MSB-market. A 10dB higher noise level from the next road reduces prices by more than 8 per cent in the single family land parcels in the suburbs. This is maybe the one variable which registers the differences in preferences between the two submarkets best of all. According to Schnare and Struyk (1976), housing market segmentation will occur when the households´ demand for a particular structural or neighbourhood characteristic is highly inelastic and when this preference is shared by a relatively large number of households. In the dataset at hand, it is not the neighbourhood characteristics[vii] or the accessibility of open spaces, where the coefficients on the latter variable are of comparable magnitudes. What distinguishes single family home owners from others is the relatively high (marginal) utility a quiet location provides.

Disequilibrium effects vs. changes in attributes supply

Costly adjustment processes are among the features of housing markets which make the usual simplifying assumption that markets are in equilibrium, quite untenable. As Malpezzi (2002) notes, disequilibria are a recurring theme of housing markets. In this regard, the Viennese housing markets are no different. After a decade of modest housing starts, land prices began to rise strongly at the end of the 1980s. It took several years until housing completions were able to absorb all of the extra housing demand, which emerged mainly as a result of the baby-boom generation and the fall of the Iron Curtain. From 1993 onwards, changes in vacant residential land prices have been less significant than in the years before. However, yearly changes in the average real prices seem to be very erratic after 1993. In order to identify periods of more stable prices, it was necessary to extract the coefficients of the year dummies from the basic model for the full sample period (Appendix A1). The resulting hedonic price index is much smoother than observable average prices. Apart from two relatively minor up and down swings between 1993 and 2003, the period after 1993 seems to have been one of relatively stable prices. In real terms, the prices in 2002 have been very close to the level of those in 1993.

If markets are in disequilibrium, hedonic estimates may be biased. In order to get rid of disequilibrium effects, individual models for the three sub-markets have been estimated.

Time periods for the restricted samples have been chosen by eliminating all transactions which took place in years with a significant year dummy in set-up regressions. After elimination, a new set of restricted samples were obtained in which all the year dummies are insignificant. Through this procedure the following years remained which were supposedly almost free of disequilibrium effects in the housing submarkets: 1994 to 2002 for submarket 1 (single family homes), 1992 to 2004 (without 2003) for submarket 2 (multi-storey buildings), and 1993 to 2002 for the market as a whole. If there are noticeable differences in estimated coefficients between the full sample and the restricted sample, this could be a hint on impacts of general housing market disequilibria on the hedonic estimates. There is, however, another possible interpretation which rests on a kind of comparative static analysis of equilibria in the more disaggregated markets for the housing characteristics. That means that the changes in preferences of the people and/or changes in attribute supply may be decisive for changing hedonic prices.

Figure 5 A hedonic price index for vacant residential land in Vienna – estimated from the whole sample (3,896 observations; 1987 = 100)

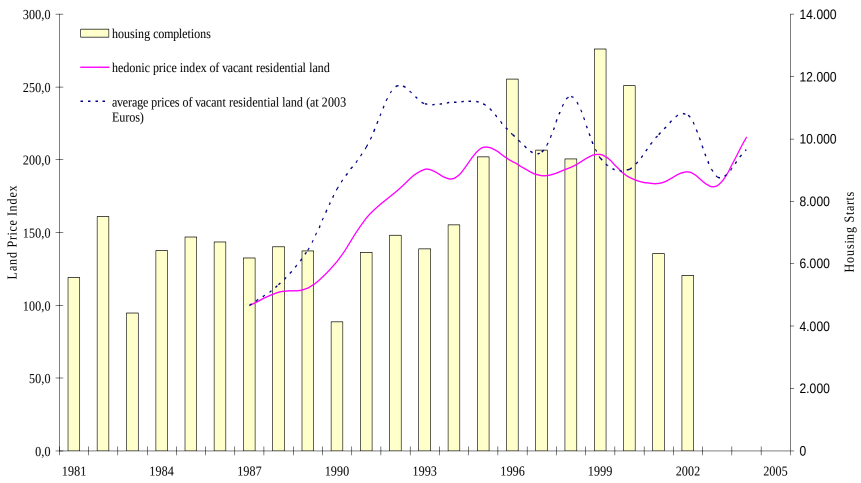


Table 4 shows the estimated coefficients for some of the more interesting controls in the basic model. With regard to the underground station variables as compared with the full samples, estimates have risen in all three submarkets. The lower estimates in the full samples could be the result of the disequilibria in the early years of the period here under investigation. If this be so, the effects of the underground train network are underestimated systematically in periods of strong price increases. However, the view taken here is that, in this case, supply effects might be more important. There have been new underground train openings and the announcement of two new underground lines in the second half of the 1990s. The completion of the underground train line U3 in 1998 has considerably improved accessibility in the more centrally located 1st, 3rd, 6th, 7th districts as well as in the 11th , 15th and 16th districts. These are districts where multi-storey buildings predominate. On the other hand, it was announced that two new lines were to be constructed in 1997 and 1999, respectively. These lines should eventually have an important impact on urban formation in the north-eastern parts of the city. Along the line U2, where single family homes comprise a large part of the housing market, modal split will eventually change as a consequence of the new lines. The higher coefficients in the restricted samples might be a result of an enlargement of the market for the underground attribute. Better accessibility increases the attractiveness of public transit versus the use of private cars in those submarkets. Because there are now more (potential) consumers, marginal evaluation of better underground train accessibility might have increased.

Another kind of interpretation refers to the hedonic evaluation of higher order shopping opportunities. It is a matter of fact that several trends, such as changing consumer habits, increasing individual mobility and new organisational forms of retailing, have dramatically changed the spatial pattern as well as the hierarchy of urban sub-centres in the city. In recent years, Vienna´s traditional retail structure, characterised by a city-wide network of local shopping streets, has witnessed a dramatic transformation. Traditional (more centrally located) local centres are losing more and more of their economic power to major shopping malls and shopping centres. Most of them are now located on the outskirts of the city, exploiting all the cost advantages proffered by the environs of peripheral locations, such as lower real estate prices, increased floor space and almost unlimited parking facilities. Urban planning measures, such as the redesigning of streets and re-organisation of transport have been taken to prevent an outflow of purchasing power from the city. These measures, however, have been mainly directed towards top locations within the city, and have thereby contributed to a devaluation of the less attractive lower ranked shopping streets. As a result, the supply of attractive higher order shopping opportunities in the more centrally located areas has been reduced by both commercially enhanced retail restructuring and urban planning (Fassmann et al., 2002).

The changing pattern of retailing activities in Vienna in recent years may be one, if not the most important, factor to explain the different directional changes of the hedonic estimates of the shopping centre variables in the regressions carried out in this study. Compared to the full samples, the estimate in the restricted sample has fallen considerably in the SFHO-market, while it has increased to a large extent in the MSB-market. Thus, the decrease in the supply of higher order shopping opportunities for the more centrally located multi-storey lots might have increased the marginal evaluation for better accessibility. On the other hand, the relocation of retail activities to the outskirts has improved the shopping opportunities for the single-family home owners there and, as a consequence, privileged access is, comparatively, now of less value.

A third observation, which lends support to our tentative appraisal that the effects of disaggregated attributes overrule the major housing price trends, is connected with the aircraft noise effects. Sensitivity to aircraft noise in Vienna has risen dramatically in recent years. Between 1980 and 2004, flight movements on the Vienna International Airport have increased by more than 230 per cent. In each of the last few years, the airport reported growth rates of about 5 to 6 per cent. Although there have been considerable attempts to restrict the noise pollution from the aircraft fleet, about 10 per cent of all noise affected people in Vienna cited air craft as being the main source of noise. Disturbance by aircraft noise is greatest for citizens in the 22nd District (particularly in Essling) as well as in the southern and western districts (10th to 15th and 23rd). There are only two districts from the inner circle (5th and 6th) which seem to be affected. According to the estimates made, the hedonic price of aircraft noise remains largely unaffected by the sample restriction in the more centrally located areas, whereas there is a strong increase in the estimate for the submarkets in the outer areas. This is interpreted as being consistent with a supply effect predominantly restricted to the outer districts. Obviously, regulatory constraints and fleet improvements have not been sufficient to compensate for the great increase in flight movements (take-offs and landings) on the Vienna International Airport.

Table 4 Aggregate house price disequilibria vs. attribute supply changes

The whole market	Full sample (1987 to 2004)		Restricted sample (1993 - 2002)	
Independent variable	Coeff.	t-stat	Coeff.	t-stat
Metro station corridor < 1,000 m	.291	5.98	.363	4.38
Metro station corridor 1,000 - 2,000 m	.265	5.93	.304	3.88
Metro station corridor 2,000 - 5,000 m	.161	4.55	.222	3.13
Distance to next Tram station	-.00004	-2.41	.000003	-0.08
Distance to City Center (in meters)	-.00005	-6.72	-.00005	-4.91
Major shopping centers/malls within 6,000 to 10,000 m	.184	6.56	.107	2.67
Primary schools within 250 m	.032	1.89	.020	0.95
Major recreation area within 4,000 m	.064	3.00	.078	2.71
Road Traffic Noise (measured in dB over day)	-.003	-1.97	-.001	-0.62
Aircraft Noise Level 1	-.142	-3.49	-.194	-3.33
Aricraft Noise Level 2	-.057	-1.47	-.096	-1.89
	N = 3,896 F(82, 3,812) = 122.60 Prob > F = 0.0000 Adj R-squared=0.7215		N = 2,060 F(73, 1,984) = 53.78 Prob > F = 0.0000 Adj R-squared=0.6797	

Submarket 1 (single family homes)	Full sample (1987 to 2004)		Restricted sample (1994 - 2002)	
Independent variable	Coeff.	t-stat	Coeff.	t-stat
Metro station corridor < 1,000 m	.136	2.13	.199	2.45
Metro station corridor 1,000 - 2,000 m	.236	4.00	.305	3.20
Metro station corridor 2,000 - 5,000 m	.127	2.99	.210	2.54
Distance to next Tram station	-.00003	-1.64	.00003	1.05
Distance to City Center (in meters)	-.00003	-2.77	-.00002	-1.32
Major shopping centers/malls within 6,000 to 10,000 m	.181	5.07	.113	2.02
Primary schools within 250 m	.048	1.63	.024	0.54
Major recreation area within 4,000 m	.067	2.39	.079	1.84
Road Traffic Noise (measured in dB over day)	-.008	-3.35	-.007	-2.53
Aircraft Noise Level 1	-.079	-1.43	-.227	-2.59
Aricraft Noise Level 2	.055	0.87	-.040	-0.41
	N = 2,176 F(64, 2,108) = 46.17 Prob > F = 0.0000 Adj R-squared=0.5818		N = 985 F(54, 927) = 17.19 Prob > F = 0.0000 Adj R-squared=0.4840	

Submarket 2 (multi-storey flats)	Full sample (1987 to 2004)		Restricted sample (1992 - 2004; without 2003)	
Independent variable	Coeff.	t-stat	Coeff.	t-stat
Metro station corridor < 200 m	.341	4.95	.474	3.25
Metro station corridor 200 - 800 m	.253	4.73	.349	2.52
Metro station corridor 800 - 2,000 m	.130	2.89	.226	1.76
Distance to next Tram station	-.00006	-2.59	-.00005	-1.87
Distance to City Center (in meters)	-.00006	-4.83	-.00007	-4.69
Major shopping centers/malls within 6,000 to 10,000 m	.129	2.16	.189	3.05
Primary schools within 250 m	.024	1.26	.027	1.16
Major recreation area within 4,000 m	.056	1.68	.043	1.34
Road Traffic Noise (measured in dB over day)	.0003	0.22	.003	1.46
Aircraft Noise Level 1	-.178	-2.79	-.162	-2.12
Aricraft Noise Level 2	-.104	-2.03	-.099	-1.76
	N = 1,720 F(82, 1,636) = 52.87 Prob > F = 0.0000 Adj R-squared=0.7147		N = 1,133 F(74, 1,055) = 36.64 Prob > F = 0.0000 Adj R-squared=0.7068	

Assuming dominance of attributes as factors over aggregate housing market disequilibria on hedonic estimates in this section has important consequences on the overall assessments of house price factors derived from hedonic analysis. From a methodological point of view, estimates out of purely cross sectional regressions should be interpreted with caution. They are generally interpreted as delivering long term impacts of housing attributes on house prices. However, as this analysis suggests, the dynamics of urban development prevent those estimates from being totally reliable. At least for those factors, which are subject to ongoing changes, estimates based on observations from one moment in time are hard to interpret. A full analysis should take into consideration different time periods and thoroughly analyse the attributes supply and demand conditions.

Another qualification pertains to the often read interpretation of hedonic estimates as representing the demand side of the market. Firstly, from a theoretical point of view, it should be clear that hedonic estimates should be given a reduced-form model interpretation. They are results from both demand and supply side factors. Of course, there may be characteristics, the hedonic prices of which are predominantly determined, at least short or medium term, by the demand side. Two examples would be open space or CBD accessibility because of an inelastic supply. On the other hand, the analysis above suggests that supply side considerations play a significant role in dynamic urban environments. Changes on the supply side may be the consequences of both, commercial intentions or urban planning initiatives.

Anticipatory subway effects in developed and undeveloped urban areas

The analysis so far has been purely static or comparative static. We have estimated the impacts of the Vienna metro system on residential land prices across the whole city area, and the delivered estimates (cross-sectional in nature) can be interpreted as measuring the long run impacts. We can, however, also exploit the time series dimension in our data set. One question which is particularly attractive from a planning perspective is, whether the announcement of a new metro line has positive effects on land values in the proposed station areas. Or stated otherwise, do plans for metro investments affect land values even before such investments have been made? This is a question which has been investigated among others by Damm et al. (1980) for the Washington D.C. Metro and by Knaap et al. (2001) for light rail investments in Washington County, Oregon. Again, most studies found that the announcement of plans influences the value of developed land. However, as Knaap et al. (2001) recognize, the announcement in these situations has no explicit purpose. Plan announcements for fully developed areas have at most a sorting effect with no impact on timing and character of urban development. The primary reason is that redevelopment is costly, whereas in undeveloped areas announcement is intended to affect both timing and character of development. Moreover, in this case, both city planners and operators are interested to increase the awareness of planned lines. While city planners intend to push a particular development, the operators expect increased revenues through increased ridership.

Based on the work of Intriligator and Sheshinski (1986) and Spence (1973), Knaap et al. (1997) analyse in a formal model how plans as a means by which governments signal their intended actions to developers, can influence urban development. In the case of a new metro line, land market participants informed by the plans will bid up land prices due to the expected increases in accessibility and prospected area developments. Increases in land prices around the planned stations will at the same time discourage development at other sites (particularly with low densities), encourage land owners to delay development until the new line begins operation, and encourage high-density development around the new stations. Thus, increasing land prices following the announcements of transportation plans act as a means to coordinate government investments in transportation infrastructure with private investments in urban form.

Fortunately, our dataset covers a period in which both kinds of urban development took place in Vienna. Two new metro line segments were announced by the city authorities in 1997 and 1999, respectively. In 1997 the city informed the public of an extension of metro line „U1“ towards the northern outer suburbs, connecting five new stations to the currently outer satellite station “Kagran”. While there are already some high developed areas near the proposed new stations, the share of affected low density undeveloped land was relatively high at the time of announcement. Among the explicitly mentioned functional reasons, operation of the new line segment should on the one hand enhance existing urban development in certain areas (Rennbahnweg, Großfeldsiedlung) and on the other hand should make new developments possible in other areas (north-eastern of Kagraner Platz and the surrounding areas of the new Station “Aderklaaer Straße”). Thus, in this case, city planning takes definitively a pro-active role directed towards new urban developments. Operation of the new line segment will start in fall 2006.

In 1999, extension of another metro line “U2” was announced. The proposed investment consists of 11 new stations. However, the route of the elongated line goes through relatively far developed areas with little prospects for new developments. In their argumentation the city planning authorities notice three main functions of the new line: a) raising public transport accessibility in order to transfer as large a portion of the Danube-crossing individual car traffic as possible on the new line; b) raising accessibility along the whole line, and c) discharge of subway line “U1” which at the moment pulls the majority of public transit from the north-eastern suburbs into the city centres on it. Overall, the aforementioned arguments can rather be classified as re-active, which is sharply in contrast with the argumentation for the extension of line “U1”. The empirical question is, whether those different kinds of transport planning manifest themselves in different kinds of land price reactions.

Empirical Approach

As Knaap et al. (2001) note, the effects of plans to build a new transport infrastructure are likely to vary by location and over time. Furthermore, it is uncertain how rapidly the value of proximity diminishes with distance to the stations. Last but not least, it is also uncertain when effects on land value are likely to appear. Bearing in mind those qualifications, we decided to proceed in more steps. First we had do decide which land transactions are to include in our analysis. From the arguments above it is clear that we had to impose restrictions on our land transaction dataset in both the space and the time dimension. In order to exclude impacts of the other existing subway stations we selected only those transactions on land which were close enough to the new stations and at the same time far enough from the already existing subway system. In the time dimension we restricted both samples to periods of stable prices. Those periods were identified by separate regressions for the two submarkets including year dummys as explanatory variables. Interestingly, although both markets are located in the north-eastern parts of Vienna, we identified two different periods with stable (hedonic) price levels: 1993 to 2003 for the submarket along the new U1-line, and 1995 to 2003 along the U2-line. After all we are equipped with two samples which are comparable in size: 483 observations in submarket U1, and 514 observations in submarket U2[viii]. These two samples had to be divided again in the spatial and in the time dimension. As for the spatial effects of the new stations on land values we chose to focus on property values within half a km, one km and two km of planned stations compared to properties farther away. In the time dimension we assumed that announced infrastructure changes manifest itself in land prices one year after announcement[ix].

Table 5 Data Statistics – Average real prices of pre- and post-announcement land transactions along the planned new line segments of subway lines U1 and U2

Submarket U1 (457 obs.) - announcement 1997; before: 1993 - 1997; after: 1998 - 2003	Obs.	Mean	Med.	Std. dev.	Min.	Max.
before announcement, within 500 meters	16	236	208	122	101	609
after announcement, within 500 meters	13	291	297	91	112	450
before announcement, within 1,000 meters	36	219	208	93	101	609
after announcement, within 1,000 meters	27	297	262	118	112	707
before announcement, within 1,800 meters	72	238	211	110	101	644
after announcement, within 1,800 meters	51	310	262	155	112	917
before announcement, total	217	261	224	142	101	959
after announcement, total	240	280	244	144	100	942
Submarket U2 (515 obs.) - announcement 1999; before: 1995 - 1999; after: 2000 - 2003	**Obs.**	**Mean**	**Med.**	**Std. dev.**	**Min.**	**Max.**
before announcement, within 500 meters	15	430	272	355	123	1,328
after announcement, within 500 meters	11	278	387	374	218	1,227
before announcement, within 1,000 meters	43	437	213	431	123	1,766
after announcement, within 1,000 meters	29	479	271	406	122	1,584
before announcement, within 2,000 meters	79	336	207	339	105	1,766
after announcement, within 2,000 meters	44	433	240	382	112	1,584
before announcement, total	308	270	209	218	105	1,766
after announcement, total	206	290	215	226	101	1,584

Table 5 lists the number of transactions and the average real prices before and after announcement in the two submarkets dependent on the distance to the new (announced) metro stations. Comparing average real prices before and after announcement of the new stations, it seems to be clear, that prices are consistently higher after announcements in both submarkets. The only exception being average prices within 500 meters of the new stations along subway line U2, though the median is considerably higher. The statistics, however, are misleading insofar, as the samples are comprised of parcels with different zoning types and there is different involvement of city authorities in land transactions.

To conduct a more rigorous empirical analysis, we use for each submarket two forms of hedonic regression equations, both including the same set of control variables. The controls differ, however, by submarket. Equation 4 separates the effects of distance to a planned station into two periods, before and after the station locations were announced:

$$\ln P = \beta_0 + \beta_i X_i + \beta_{db} (Dist * Before) + \beta d_a (Dist * After) , \qquad (4)$$

where *lnP* = logarithm of per square meter price of vacant land, X_i = the set of control variables, and Dist = Distance to the new announced station. *Dist* is measured as a dummy variable for three distinct distances from the stations: 500 meters, 1,000 meters and 2,000 meters. For example, if the parcel is located within 500 meters from the station, the dummy variable is set to 1 otherwise the variable is set to 0. *Before* is a dummy variable set to 1 if the parcel was sold before the station locations were announced, and *After* is a dummy variable set to 1 if the parcel was sold after the station locations were announced. The interaction terms *Dist*Before* and *Dist*After* capture the value of proximity to a planned station before and after announcement. If proximity to a planned station had no value before the station locations were announced, then the coefficient on this variable should be insignificant. If proximity raises the value after the station locations were announced, then the coefficient on this variable should be positive and significant.

Equation 5 captures the increment in value of the station location announcement:

$$\ln P = \beta_0 + \beta_i X_i + \beta_d (Dist) + \beta_{da} (Dist * After) \qquad (5)$$

Now the variable *Dist* captures the value of proximity to the planned station before and after the station was announced. The interactive term *Dist*After* captures any increase in the value of proximity that followed the announcement. If the coefficient on this term is positive and significant, then the announcement of the station locations increases the value of parcels located within the proposed distance.

Table 6 presents the results for the two models separated by submarket. We have estimated six equations, three for each submarket. The equations within submarkets differ only in the definition of the *Dist*-Variable. The controls are slightly differently measured between submarkets. Observation of the results in Table 6 delivers some interesting results. First, the overall fit is much better in the regressions for submarket U2. This could indeed be a result of the different development stages of the two areas. As mentioned above, the areas surrounding the new stations along the line U1 were to a greater extent undeveloped, whereas those along the new segments in line U2 are already highly developed areas. The better fit supports our view that land transactions in undeveloped areas provide more opportunities to developers. In this case, the controls from a basic city wide model, even if adapted to the new situation do not work as well. Second, estimation results from both models for submarket U1 give additional support.

As shown by the coefficients on the interactive variables *Dist*Before*, the value of parcels near announced stations was slightly but not significantly lower than others in the study area before the stations were announced. But as shown by the coefficient on the *Dist_2,000*After* variable, the prices of parcels located within those corridors were significantly higher than elsewhere in the study area if they were sold after the new stations were announced. It is very likely that this observation would also be true for parcels located nearer to the announced station. The coefficient on the variable *Dist_1,000*After* is close to significance[x].

Table 6 Price effects of the announcements of the new subway stations

Submarket U1 (455 obs.)	Coeff.	t-stat.	Adj. R^2	Prob(F)
Model I				
Dist_500*Before	-.049	-0.61	0.5755	0.0000
Dist_500*After	-.001	-0.01		
Dist_1,000*Before	-.057	-1.02	0.5755	0.0000
Dist_1,000*After	.092	1.47		
Dist_2,000*Before	.001	0.02	0.5809	0.0000
Dist_2,000*After	.121**	2.26		
Model II				
Dist_500*After	.049	0.42	0.5755	0.0000
Dist_500	-.049	-0.61		
Dist_1,000*After	.149*	1.90	0.5788	0.0000
Dist_1,000	-.057	-1.02		
Dist_2,000*After	.120**	2.05	0.5809	0.0000
Dist_2,000	.001	0.02		

Submarket U2 (513 obs.)	Coeff.	t-stat.	Adj. R^2	Prob(F)
Model I				
Dist_500*Before	.081	1.08	0.7468	0.0000
Dist_500*After	-.184**	-2.01		
Dist_1,000*Before	.025	.049	0.7452	0.0000
Dist_1,000*After	-.087	-1.41		
Dist_2,000*Before	-.079*	-1.65	0.7477	0.0000
Dist_2,000*After	-.166***	-2.79		
Model II				
Dist_500*After	-.265**	-2.42	0.7468	0.0000
Dist_500	.081	1.08		
Dist_1,000*After	-.111*	-1.70	0.7452	0.0000
Dist_1,000	.025	0.49		
Dist_2,000*After	-.087*	-1.67	0.7477	0.0000
Dist_2,000	-.079*	-1.65		

Results for Model II deliver further evidence in favour of our hypothesis. As shown by the coefficients on the variables *Dist_500, Dist_1,000 and Dist_2,000,* the value of parcels located within half a km, one km and two km were not consistently higher than parcels located elsewhere in the study area. However, the coefficients on the variables *Dist_1,000*After* and *Dist_2,000*After* reveal that values were 15 percent higher for parcels located within 1,000 meters, and 12 Percent higher for parcels located within

2,000 meters after the locations were announced. Thus, from the regression results, we can be quite confident that the announcement of the construction of five new subway stations along the new segment of line U1 increased the value of vacant residential land located within a corridor of 2,000 meters of the planned stations.

The average effects of the announcement of the eleven new stations along the prospected route of line U2 are totally different from the results presented above. All the coefficients of the interesting proximity variables in the regressions of the models I and II show the wrong sign, in most regressions even significantly. That means that the announcement has decreased the values near the new stations compared to the values elsewhere in the study area. Actually, we expected to find insignificant results at most, which would have supported our hypothesis that the announcement of new subway stations in already highly developed areas does not significantly impact on land values. The strong and significant negative effects, however, need further explanation. One explanation comes from the rather low density housing along the new stations. Most of the area is characterised by a high share of single family homes, garden settlements or agricultural use. Prospects for higher densification are limited due to the potentially high costs of redevelopment. The second explanation rests on the submarket analysis from section 5.2. There we have shown that spatial subway effects differ according to the tenure type. In particular, we have found evidence that single family home owners like to live near a subway station but not too close. The estimates again seem to support this observation, as the negative price effects are strongly diminishing with distance. Actually, we think that both explanations are applicable. It was the primary aim of the planning authorities to increase the accessibility of the areas surrounding the new stations of the line U2 in the third development phase. In the next development phase, a further extension of the line U2 is intended to bring about a comprehensive re-organisation of urban form in a currently almost completely undeveloped area. Dwellings for more than 8,000 residents and more than 25,000 high level service jobs are planned in the new area. Two new stations are necessary to connect the area to the then completed phase-3 stations of line U2. From a cost-benefit view, it will to a large extent depend on whether the planning authorities succeed to reach the planned defaults in the future. Based on present conditions any analysis confronting benefits with costs of the new stations of line U2 would very probably lead to a painful result.

Summary and conclusions

Using data on vacant land sales in Vienna, the impacts of public transport infrastructure as well as amenity, dis-amenity and neighbourhood effects on land values were investigated. The analysis provides a rich set of tentative conclusions and hypotheses for further work.

The analysis of the whole sample, as well as of submarkets, shows that accessibility to underground train stations has a considerable impact on vacant land values in Vienna. All else being equal, parcels of land in dense areas located within 200 metres from an underground station have a surcharge of more than 50 percent compared to similar land parcels which are more than 2,000 metres away. The analysis of submarkets reveals that the underground train effects are different for single family home owners (SFHO). For them, the implicit price of underground station accessibility is a non-linear (concave) function of proximity. SFHO like to be near the stations, but not too close. The analysis of each submarket further shows that the main characteristic distinguishing SFHO from residents in multi-storey buildings is the sensitivity to road noise. Although the residents in dense areas are more affected by road noise (as revealed by the higher average road noise level per day), the hedonic price of road noise is not statistically different from zero in the MSB-market. On the contrary, single family home owners seem to highly evaluate quietness. A 10dB higher noise level from the next road reduces vacant land prices by more than 8 percent in the SFHO-market. On the other hand, socio-economic characteristics and accessibility to open spaces seem to have rather similar evaluations in both submarkets. However, the estimates on the socio-economic factors suggest a more homogenous population composition in the suburbs.

An investigation of disequilibrium impacts on hedonic prices reveals interesting, if tentative, conclusions. Because of a rather long time series component in the data, which shows a couple of years with price increases in the first half of the sample period, one may speculate whether disequilibrium effects impact on the hedonic estimates. It seems, however, that disequilibrium effects are of less importance for implicit hedonic prices than underlying changes in the supply of attributes. An example is that of aircraft noise, the hedonic price of which has risen considerably in the SFHO-market because of the great increase in transport volume in the last decade. Other examples of supply side changes, which may impact on the implicit hedonic prices, have been found for the underground effects and effects on shopping centre accessibility. It appears that in both cases changes in attributes supply are to be blamed for the changes in hedonic prices. Whereas new underground openings have had similar impacts on the estimates in both submarkets, the relocation of major shopping centres to the outskirts had different impacts. Support for the alternative interpretation in terms of demand and supply side factors at the attribute level, in this study, comes from observations on other estimates. In particular, the hedonic prices of distance to a major recreation area and the hedonic price of distance to the CBD seem to be rather stable because the supply of both factors is dynamically quite stable.

A third major result from our study pertains to the anticipatory effects of new subway openings. We find that these effects are to a high degree context specific. Whether the announcement of new subway openings has positive impacts on land values depends critically on the development stage of the areas. In undeveloped areas around the proposed new stations along the line U1, the announcement caused statistically significant price increases near the new stations. Contrary to that, announcement of the new stations had statistically negative price effects around the new stations along the new line U2. We ascribe the negative effects on a combination of the low residential densification with little perspectives for redevelopment at least on nearby properties, and the non-linearity of subway effects in the SFHO-market.

References

Al-Mosaid, M.A., Duecker, K.J., and Strathman, G. (1993), Light Rail Transit Stations and Property Values, Transportation Research Record, No. 1400.

Alonso, W. (1964), Location and Land Use: Toward a General Theory of Land Rent, Harvard University Press, Cambridge, Massachussets.

Bae, Ch.-H., Jun M.-J. and Park, H. (2003), The impact of Seoul´s subway line 5 on residential property values, Transport Policy, Vol. 10, pp. 85-94.

Basu, S. and Thibodeau, T.G. (1998), Analysis of spatial autocorrelation in house prices, The Journal of Real Estate Finance and Economics, Vol. 17, No. 1, pp. 61-85.

Bateman, I.J., Day, B., Lake, I. and Lovett, A.A. (2000), The Effect of Road Traffic on Residential Property Values: A Literature Review and Hedonic Pricing Study, Report (March 2000) to the Scottish Office, Development Department, Edinburgh, School of Environmental Sciences, University of East Anglia, Norwich.

Bajic, V. (1983), The effects of a new subway line on house prices in Metropolitan Toronto, Urban Studies, Vol. 20, pp. 147-158.

Beschorner, B., Deußner, R., Oppolzer, G., Schönbäck, W., Wieser, R. (2005), Regionalwirtschaftliche und Stadtstrukturelle Wirkungen des U-Bahn-Ausbaus in Wien, Forschungsbericht, W. Schönbäck (Projektleitung), Dezember 2005.

Blaas, W. and Oppolzer, G. (2003), Socioeconommic dynamics and property rights regulation as driving forces of urban spatial development: the case of Vienna, Scienze Regionali – Italien Journal of Regional Science, Nr. 2/2004; S. 25 - 48.

Bowes, D.R. and Ihlanfeldt, K.R. (2001), Identifying the impacts of rail transit stations on residential property Values, Journal of Urban Economics, Vol. 50, pp. 1-25.

Chen, H., Rufolo, A. and Dueker, K.J. (1997), Measuring the impact of light rail systems on single family home values: A hedonic approach with GIS application, Center for Urban Studies Discussion Paper 97-3, Portland, Oregon.

Colwell, P.F. and Munneke, H.J. (1997), The Structure of Urban Land Prices, Journal of Urban Economics, Vol. 41, pp. 321-336.

Day, B. (2003), Submarket identification in property markets: A hedonic housing price model for Glasgow, CSERGE Working Paper EDM 03-09.

Day, B., Bateman, I. and Lake, I. (2004), Nonlinearity in hedonic price equations: An estimation strategy using model-based clustering ,CSERGE Working Paper EDM 04-02.

DETR (1999), Review of studies on external costs of noise, prepared by Rhian Hawkins, Environment Protection Economics Division, DETR (now DEFRA).

Dewees, D.N. (1976), The effects of a subway on residential property values in Toronto, Journal of Urban Economics, Vol. 3, pp. 357-369.

Fassmann, H., Hansal, M. and Hatz, G. (2002), Einkaufen in Wien, in Fassmann, H. and Hatz, G. (eds.), Wien. Stadtgeographische Exkursionen, Ed. Hölzel GmbH, pp. 183-204.

Fassmann, H., Hatz, G. (2004), Fragmentierte Stadt? Sozialräumliche Struktur und Wandel in Wien 1991-2001, Mitteilungen der Österreichischen Geographischen Gesellschaft, 146. Jg. (Jahresband), Vienna 2004, pp. 61-92.

Fassmann H. Kohlbacherm j. und Reger, U. (2007), Ghettoisierungsprozesse in Wien?, Studie der Österreichischen Akademie der Wissenschaften, Wien.

Gatzlaff, D.H. and Smith, M.T. (1993), The Impact of the Miami Metrorail on the Value of Residence Near Station Locations, Land Economics, Vol. 69, No. 1, pp. 54-66.

Formatiert: Englisch (Großbritannien)

Gibbons, St. and Machin, St. (2004), Valuing rail access Using transport innovations, Centre for Economic Performance, London Scholl of Economics and Political Sciences, Discussion Paper.

Giffinger, R. (1998), Segregation in Vienna: Impacts of market barriers and rent regulations, Urban Studies, Vol. 35, No. 10, 1791-1812.

Gillen, D.W. and Levesque, T.J. (1989), Alternative methodologies for determining and valuation of aviation noise: A survey of the applications, Technical report 89/02.

Giuliano (1986), Land-Use Impacts of Transportation Investments: Highway and Transit, in Hanson, S. (ed.), The Geography of Urban Transportation, Guildford.

Henneberry, J. (1998), Transport investment and house prices, Journal of Property Valuation & Investment, Vol. 16, No. 2, pp. 144-158.

Intriligator, M. and Sheshinski, E. (1986), Toward a theory of planning, in: Social choice and public decision making, Heller, W., Starr, R. and Starrett, D. (Ed.), Cambridge, UK: Cambridge University Press.

JSMUR (Joint Center for Urban Mobility Research) (1987), Assessment of Changes in Property Values in Transit Areas. Prepared for UMTA. Houston, Rice University, Rice Center for Urban Mobility Research.

Knaap, G.J., Hopkins, L.D. and Donaghy, K. (1997), Does planning matter? A framework for examining the logic and effects of land use planning, Journal of Planning Education and Research, Vol. 18, No. 1, pp. 25-34.

Knaap, G.J., Ding, C. and Hopkins, L.D. (2001), Do plans matter? The effects of light rail plans on land values in station areas, Journal of Planning Education and Research, vol. 21, No. 1, pp. 32-39.

Lengauer, L. (2004), Sozioökonomische Veränderungen in der Vienna Region 1971 – 2001, Ausgewählte Ergebnisse, SRE-Discussion Paper 2004/06.

Lin, J.-J. and Hwang, C.-H. (2004), Analysis of property prices before and after the opening of the Taipei subway system, The Annals of Regional Science, Vol. 38, 687-704.

Lutzenhiser, M. and Netusil, N.R. (2001), The Effect of Open Space on a Home´s Sale Price, Contemporary Economic Policy, Vol. 19, No. 3, pp. 291-298.

Malpezzi, St. (2002), Hedonic Pricing Models: A selective and applied review, Wisconsin-Madison CULER working papers 02-05, University of Wisconsin Center for Urban Land Economic Research.

McConnel, V.D. and Walls, M.A. (2005), The value of open space: Evidence from studies of nonmarket benefits, FRR-Report, Washington, DC.

McDonald, J. and Osuji, C.I. (1995), The effect of anticipated transportation improvements on residential land values, Regional Science and Urban Economics, Vol 25, No. 3, pp. 261-278.

McMillen, D. P. and McDonald, J. (2004), Reaction of house prices to a new rapid transit line: Chicago´s Midway Line, 1983-1999, Real Estate Economics, Vol. 32, pp. 463-486.

Muth, R. (1969), Cities and Housing, University of Chicago Press, Chicago, Illinois.

Navrud, S. (2002), The State-Of-The-Art on Economic Valuation of Noise, Final Report to European Commission DG Environment, April 14th, 2002.

Nelson, J.P. (1980), Airports and property values: A survey of recent evidence, Journal of Transport Economics and Policy, Vol. 14, No. 1, pp. 37-52.

Palmquist, R.B. (1989), Land as a differentiated factor of production: A hedonic model and its implications for welfare measurement, Land Ecnomics, Vol. 65, No. 1, pp. 23-28.

Rosen, S. (1974), Hedonic prices and implicit markets: product differentiation in pure competition, Journal of Political Economy, Vol. 82, No. 1, pp. 34-55.

Schipper, Y.J.J. (1996), On the valuation of aircraft noise: A meta-analysis, Tinbergen Institute, Free University of Amsterdam, unpublished paper.

Schnare, A. and Struyk, R. (1976), Segmentation in Urban Housing Markets, Journal of Urban Economics, Vol. 3, pp. 146-166.

So, H.M., Tse, R.Y.C. and Ganesan, S. (1997), Estimating the influence of transport on house prices: evidence from Hong Kong, Journal of Property Valuation & Investment, Vol. 15, No. 1, 40-47.

Spence, M. (1973), Job market signalling, Quarterly Journal of Economics, Vol. 87, No. 3, pp. 355-374.

Taylor, N. (2005), The Urban Transport Benchmarking Initiative – Year two final report, prepared for the European Commission Directorate General for Energy and Transport, July 2005.

Voith, R. (1991), Transportation, sorting, and house values, Journal of the American Real Estate and Urban Economics Association, Vol. 19, pp. 117-137.

Walsh, R.P. (2003), Endogenous Open Space Amenities in a Locational Equilibrium, University of Colorado working paper.

Wieser, R. (2006), Wirkungen der U-Bahn auf den Bodenmarkt, IFIP Working Paper 1/2006.

Appendix A1 - Basic model of all samples by GLS (The whole market) – Dependent variable: Natural Log of per square meter price

Indep. Var.	Description	Coeff.	t-stat.	p-value	Level of Sig.	VIF
Constant		5.213	28.76	0.000	***	
Locational Characteristics						
SC1	Dummy for Metro station corridor < 1,000 m	0.291	5.98	0.000	***	7.67
SC2	Dummy for Metro station corridor 1,000 - 2,000 m	0.265	5.93	0.000	***	4.79
SC3	Dummy for Metro station corridor 2,000 - 5,000 m	0.161	4.55	0.000	***	5.34
SC4	Metro station corridor > 5,000 m	b	b	b	b	b
DLR	Distance to next Tram route (in meters)	-0.00004	-2.41	0.016	**	6.27
DBUS	Distance to next Bus route (in meters)	0.000006	-0.20	0.845		3.01
DCBD	Distance to City Center (in meters)	-0.00005	-6.72	0.000	***	7.96
DR1	Distance to major roads of category 1 (in meters)	0.00001	1.76	0.078	*	3.50
DR2	Distance to major roads of category 2 (in meters)	0.00003	3.23	0.001	***	4.04
DR3	Distance to major roads of category 3 (in meters)	0.00009	5.39	0.000	***	1.62
DMSC	Dummy for major shopping centers/malls within 6,000 to 10,000 m	0.184	6.56	0.000	***	2.43
SCHOOLS	Number of primary schools within 250 m	0.032	1.89	0.058	*	1.36
DRECR	Dummy for major recreation area within 4,000 m	0.064	3.00	0.003	***	1.28
PIP1	Percent of area devoted to A-type industrial processes within 1,000 m	-0.002	-3.75	0.003	***	1.72
PIP2	Percent of area devoted to B-type industrial processes within 1,000 m	-0.001	-3.11	0.002	***	1.29
SBATH	Dummy for Summer bath within 500 to 2,500 m	0.049	2.56	0.010	***	1.51
FMARKET	Dummy for Farmer Market within 750 m	0.091	2.04	0.041	**	1.64
POP	Population in enumeration unit	0.00002	2.31	0.021	**	2.49
WP	Number of Working places in enumeration unit	-0.0006	-2.21	0.027	**	2.54
PES	Persons employed in services	0.00003	1.96	0.051	*	1.65
Structural characteristics						
ZP1	permissible building height: 2.5 m < x < 9 m	b	b	b	b	b
ZP2	Dummy for permissible building height: 4.5 m < x < 12 m	0.207	6.17	0.000	***	1.45
ZP3	Dummy for permissible building height: 10 m < x < 16 m	0.517	11.43	0.000	***	3.13
ZP4	Dummy for permissible building height: 16 m < x < 21 m	0.792	14.72	0.000	***	3.27
ZP5	Dummy for permissible building height: 21 m < x < 26 m	1.073	5.60	0.000	***	1.41
ZP6	Dummy for permissible building height: x > 26 m	0.660	3.17	0.002	***	1.17
LNA	Natural Log of lot area (in square meter)	-0.095	-7.02	0.000	***	1.98
SURF	Surface of Lot (Area/Perimeter)	-0.049	-3.29	0.001	***	1.27
MZP	Percent of main zoning permissions	0.002	3.12	0.002	***	1.37
DAO	Dummy for aborted objects	-0.071	-2.69	0.007	***	1.29
PLOT	Dummy for plotted lots	0.109	4.89	0.000	***	1.24
SLOPE	Slope of land	-0.001	-2.17	0.030	**	3.76
ASPECT	Dummy for south aligned parcels	0.022	0.82	0.415		1.67
Year of transaction						
Y1987	Sales year 1987	b	b	b	b	b
Y1988	Dummy for 1988	0.086	2.13	0.033	**	2.27
Y1989	Dummy for 1989	0.112	2.44	0.015	**	
Y1990	Dummy for 1990	0.263	5.95	0.000	***	2.22
Y1991	Dummy for 1991	0.470	10.55	0.000	***	2.09
Y1992	Dummy for 1992	0.576	12.35	0.000	***	2.13
Y1993	Dummy for 1993	0.659	14.25	0.000	***	2.18
Y1994	Dummy for 1994	0.627	13.45	0.000	***	1.91
Y1995	Dummy for 1995	0.735	16.01	0.000	***	1.91
Y1996	Dummy for 1996	0.686	15.05	0.000	***	1.96
Y1997	Dummy for 1997	0.637	14.73	0.000	***	1.76
Y1998	Dummy for 1998	0.667	13.26	0.000	***	1.96
Y1999	Dummy for 1999	0.711	16.41	0.000	***	1.94
Y2000	Dummy for 2000	0.630	14.32	0.000	***	1.96
Y2001	Dummy for 2001	0.609	13.67	0.000	***	1.91
Y2002	Dummy for 2002	0.651	13.84	0.000	***	1.76
Y2003	Dummy for 2003	0.599	12.28	0.000	***	1.64
Y2004	Dummy for 2004	0.767	10.89	0.000	***	1.33

N = 3,896
F(82, 3,812) = 122.60
Prob > F = 0.0000
Adj R-squared=0.7215

*p = 0.1, **p = 0.05, ***p = 0.01
b = basis

Appendix A1 - Basic model of all samples by GLS (The whole market) - continued

Indep. Var.	Description	Coeff.	t-stat.	p-value	Level of Sig.	VIF
Type of Seller-Dummys						
ST1	City	-0,200	-3.08	0.002	***	1.11
ST2	Public Utilities	-0.024	-0.15	0.884		1.05
ST3	housing associations	-0.058	-0.57	0.570		1.09
ST4	Austrian republic	-0.169	-1.53	0.126		1.02
ST5	Vienna Business Agency (WWFF)	-0.243	-2.90	0.004	***	1.11
ST6	land procurement and urban renewal fund (WBSF)	-0.091	-2.04	0.041	**	1.64
ST7	other public association	-0.855	-2.23	0.026	**	1.23
ST8	other private association	0.028	1.23	0.217		1.18
ST9	Private persons	b	b	b	b	b
Type of Buyer-Dummys						
BT1	City	-0.300	-3.05	0.002	***	1.13
BT2	Public Utilities	1.135	13.59	0.000	***	1.04
BT3	housing associations	0.238	7.10	0.000	***	1.94
BT4	Austrian republic	-0.198	-1.29	0.199		1.12
BT5	Vienna Business Agency (WWFF)	0.300	3.69	0.000	***	1.05
BT6	land procurement and urban renewal fund (WBSF)	-0.004	-0.05	0.963		1.38
BT7	other public association	-0.496	-1.95	0.051	*	1.02
BT8	other private association	0.345	14.88	0.000	***	1.74
BT8	Private persons	b	b	b	b	b
Environmental characteristics						
DWI	Dummy for Garbage incinerator within 1,500 m	-0.287	-4.70	0.000	***	1.21
RTN	Road Traffic Noice (measured in dB over day)	-0.003	-1.97	0.049	**	1.16
AN0	no Aircraft Noice	b	b	b	b	b
AN1	Dummy for Aircraft Noise Level 1	-0.142	-3.49	0.000	***	3.11
AN2	Dummy for Aricraft Noice Level 2	-0.057	-1.47	0.142		1.54
BH	Height of sourroundig buildings (sightliness)	0.007	1.78	0.075	*	2.59
Neighbourhood Characteristics						
FNB	Newbeginner Factor	-0.042	-2.65	0.008	***	2.21
FE	Skills Factor	0.048	4.08	0.000	***	2.33
FF	Family Factor	-0.175	-10.08	0.000	***	4.98
FY	Yuppy Factor	0.034	1.99	0.047	**	2.67
FO	Age Factor	0.067	6.02	0.000	***	1.84
EU-14	Percent of people from the EU-14	0.020	1.97	0.049	**	2.55
OF	Percent of people from other countries	-0.002	-1.16	0.246		3.07
Important sides						
SBRUNN	Schönbrunn within 10,000 m	0.135	2.48	0.013	**	3.40
DWW	Distance to Wienerwald (in meters)	-0.00001	-2.72	0.007	***	6.00
PRATER	Prater within 3,000 to 14,000 m	0.165	4.79	0.000	***	1.73
DOINSEL	Donauinsel within 1,800 to 7,000 m	0.055	2.40	0.016	**	2.45
NASCHMARKT	Naschmarkt within 750 m	-0.422	-2.29	0.022	**	1.16
TRANSDANUBIEN	Dummy for districts 21 and 22	-0.155	-3.10	0.002	***	5.36

N = 3,896
F(82, 3,812) = 122.60
Prob > F = 0.0000
Adj R-squared=0.7215

*p = 0.1, **p = 0.05, ***p = 0.01
b = basis

Appendix A2 – Basic model of submarket 1(Single family homes; Suburbs) – Dependent Variable: Natural Log of per square meter price

Indep. Var.	Description	Coeff.	t-stat.	p-value	Level of Sig.
Constant		4.690	12.12	0.000	***
Locational Characteristics					
SC1	Dummy for Metro station corridor < 1,000 m	.136	2.13	0.034	**
SC2	Dummy for Metro station corridor 1,000 - 2,000 m	.236	4.00	0.000	***
SC3	Dummy for Metro station corridor 2,000 - 5,000 m	.127	2.99	0.003	***
SC4	Metro station corridor > 5,000 m	b	b	b	b
DLR	Distance to next Tram route (in meters)	-.00003	-1.64	0.101	
DBUS	Distance to next Bus route (in meters)	-.00002	-0.92	0.357	
DCBD	Distance to City Center (in meters)	-.00003	-2.77	0.006	***
DR1	Distance to major roads of category 1 (in meters)	-000003	-0.23	0.822	
DR2	Distance to major roads of category 2 (in meters)	.00002	1.41	0.157	
DR3	Distance to major roads of category 3 (in meters)	.00008	3.99	0.000	***
DMSC	Dummy for major shopping centers/malls within 6,000 to 10,000 m	.181	5.07	0.000	***
SCHOOLS	Number of primary schools within 250 m	.048	1.63	0.103	
DRECR	Dummy for major recreation area within 4,000 m	.067	2.39	0.017	**
PIP1	Percent of area devoted to A-type industrial processes within 1,000 m	-.002	-1.77	0.078	*
PIP2	Percent of area devoted to B-type industrial processes within 1,000 m	-.001	-2.22	0.027	**
SBATH	Dummy for Summer bath within 500 to 2,500 m	.046	1.68	0.093	*
POP	Population in enumeration unit	.00005	3.67	0.000	***
WP	Number of Working places in enumeration unit	-.001	-3.13	0.002	***
PES	Persons employed in services	.00002	0.52	0.604	
Structural characteristics					
LNA	Natural Log of lot area (in square meter)	-.110	-3.78	0.000	***
SURF	Surface of Lot (Area/Perimeter)	-.049	-2.79	0.005	***
MZP	Percent of main zoning permissions	.010	4.11	0.000	***
DAO	Dummy for aborted objects	-.066	-1.93	0.054	*
PLOT	Dummy for plotted lots	.086	2.91	0.004	***
SLOPE	Slope of land	-.002	-2.25	0.025	**
ASPECT	Dummy for south aligned parcels	.027	0.76	0.449	
Year of transaction					
Y1987	Sales year 1987	b	b	b	b
Y1988	Dummy for 1988	.079	1.69	0.091	*
Y1989	Dummy for 1989	.057	1.01	0.312	
Y1990	Dummy for 1990	.199	3.73	0.000	***
Y1991	Dummy for 1991	.353	6.27	0.000	***
Y1992	Dummy for 1992	.435	6.89	0.000	***
Y1993	Dummy for 1993	.567	9.50	0.000	***
Y1994	Dummy for 1994	.612	9.42	0.000	***
Y1995	Dummy for 1995	.686	10.95	0.000	***
Y1996	Dummy for 1996	.698	12.16	0.000	***
Y1997	Dummy for 1997	.682	13.19	0.000	***
Y1998	Dummy for 1998	.741	11.66	0.000	***
Y1999	Dummy for 1999	.734	14.35	0.000	***
Y2000	Dummy for 2000	.685	13.09	0.000	***
Y2001	Dummy for 2001	.687	12.52	0.000	***
Y2002	Dummy for 2002	.721	13.40	0.000	***
Y2003	Dummy for 2003	.627	9.70	0.000	***
Y2004	Dummy for 2004	.896	8.14	0.000	***

N = 2,176
F(71, 2104) = 45.78
Prob > F = 0.0000
Adj R-squared=0.6070

*p = 0.1, **p = 0.05, ***p = 0.01
b = basis

Appendix A2 - Basic model of Submarket 1 (Single family homes; Suburbs) - continued

Indep. Var.	Description	Coeff.	t-stat.	p-value	Level of Sig.
Type of Seller-Dummys					
ST1	City	-.212	-2.04	0.041	**
ST2	Public Utilities	.155	1.57	0.116	
ST3	housing associations	-.501	-1.74	0.082	*
ST4	Austrian republic	-.301	-3.09	0.002	***
ST5	Vienna Business Agency (WWFF)	-.014	-0.11	0.911	
ST6	land procurement and urban renewal fund (WBSF)	-.220	-2.11	0.035	**
ST7	other public association	-.355	-3.82	0.000	***
ST8	other private association	-.029	-0.81	0.419	
ST9	Private persons	b	b	b	b
Environmental characteristics					
DWI	Dummy for Garbage incinerator within 1,500 m	-.267	-2.36	0.018	**
RTN	Road Traffic Noice (measured in dB over day)	-.008	-3.35	0.001	***
AN0	no Aircraft Noice	b	b	b	b
AN1	Dummy for Aircraft Noise Level 1	-.079	-1.43	0.154	
AN2	Dummy for Aricraft Noice Level 2	.055	0.87	0.384	
BH	Height of sourroundig buildings (sightliness)	.003	0.39	0.698	
Neighbourhood Characteristics					
FNB	Newbeginner Factor	-.080	-0.75	0.455	
FE	Skills Factor	.035	1.29	0.199	
FF	Family Factor	-.196	-8.48	0.000	***
FY	Yuppy Factor	-.030	-0.30	0.763	
FO	Age Factor	.077	1.44	0.150	
EU-14	Percent of people from the EU-14	.026	1.88	0.061	*
OF	Percent of people from other countries	.001	0.28	0.782	
Important sides					
SBRUNN	Schönbrunn within 10,000 m	.284	6.47	0.000	***
DWW	Distance to Wienerwald (in meters)	-.00002	-2.76	0.006	***
PRATER	Prater within 3,000 to 14,000 m	.188	3.41	0.001	***
DOINSEL	Donauinsel within 1,800 to 7,000 m	.026	0.74	0.457	

N = 2,176
F(71, 2104) = 45.78
Prob > F = 0.0000
Adj R-squared=0.6070

*p = 0.1, **p = 0.05, ***p = 0.01
b = basis

Appendix A3 – Basic model of Submarket 2 (Multi-storey buildings; more centrally located) – Dependent Variable: Natural Log of per square meter price

Indep. Var.	Description	Coeff.	t-stat.	p-value	Level of Sig.
Constant		4.959	17.90	0.000	***
Locational Characteristics					
SC1	Dummy for Metro station corridor < 200 m	.341	4.85	0.000	***
SC2	Dummy for Metro station corridor 200 - 800 m	.253	3.69	0.000	***
SC3	Dummy for Metro station corridor 800 - 2,000 m	.130	2.36	0.018	**
SC4	Metro station corridor > 2,000 m	b	b	b	b
DLR	Distance to next Tram route (in meters)	-.00006	-2.20	0.028	**
DBUS	Distance to next Bus route (in meters)	.00001	0.38	0.566	
DCBD	Distance to City Center (in meters)	-.00006	-4.69	0.000	***
DR1	Distance to major roads of category 1 (in meters)	.00002	1.95	0.051	*
DR2	Distance to major roads of category 2 (in meters)	.00004	2.50	0.012	**
DR3	Distance to major roads of category 3 (in meters)	.00007	2.35	0.019	**
DMSC	Dummy for major shopping centers/malls within 6,000 to 10,000 m	.129	2.46	0.014	**
SCHOOLS	Number of primary schools within 250 m	.024	1.21	0.228	
DRECR	Dummy for major recreation area within 4,000 m	.056	1.70	0.089	*
PIP1	Percent of area devoted to A-type industrial processes within 1,000 m	-.002	-2.02	0.043	**
PIP2	Percent of area devoted to B-type industrial processes within 1,000 m	-.001	-0.98	0.326	
SBATH	Dummy for Summer bath within 500 to 2,500 m	.043	1.56	0.118	
FMARKET	Dummy for Farmer Market within 750 m	.077	1.72	0.086	*
POP	Population in enumeration unit	.00004	0.39	0.694	
WP	Number of Working places in enumeration unit	.00005	0.02	0.988	
PES	Persons employed in services	.00005	2.30	0.021	**
Structural characteristics					
ZP1	permissible building height: 2.5 m < x < 9 m	b	b	b	b
ZP2	Dummy for permissible building height: 4.5 m < x < 12 m	.139	3.68	0.000	***
ZP3	Dummy for permissible building height: 10 m < x < 16 m	.392	7.99	0.000	***
ZP4	Dummy for permissible building height: 16 m < x < 21 m	.655	11.10	0.000	***
ZP5	Dummy for permissible building height: 21 m < x < 26 m	.924	4.85	0.000	***
ZP6	Dummy for permissible building height: x > 26 m	.576	2.51	0.012	**
LNA	Natural Log of lot area (in square meter)	-.083	-5.39	0.000	***
SURF	Surface of Lot (Area/Perimeter)	-.063	-2.26	0.024	**
MZP	Percent of main zoning permissions	.002	2.60	0.009	***
DAO	Dummy for aborted objects	-.054	-1.44	0.151	
PLOT	Dummy for plotted lots	.150	4.48	0.000	***
SLOPE	Slope of land	.0003	0.29	0.771	
ASPECT	Dummy for south aligned parcels	.028	0.71	0.480	
Year of transaction					
Y1987	Sales year 1987	b	b	b	b
Y1988	Dummy for 1988	.146	1.91	0.057	*
Y1989	Dummy for 1989	.207	2.65	0.008	***
Y1990	Dummy for 1990	.377	4.86	0.000	***
Y1991	Dummy for 1991	.637	8.47	0.000	***
Y1992	Dummy for 1992	.760	10.28	0.000	***
Y1993	Dummy for 1993	.840	11.29	0.000	***
Y1994	Dummy for 1994	.703	9.41	0.000	***
Y1995	Dummy for 1995	.851	11.80	0.000	***
Y1996	Dummy for 1996	.733	9.59	0.000	***
Y1997	Dummy for 1997	.622	8.00	0.000	***
Y1998	Dummy for 1998	.627	7.41	0.000	***
Y1999	Dummy for 1999	.704	8.35	0.000	***
Y2000	Dummy for 2000	.592	7.33	0.000	***
Y2001	Dummy for 2001	.571	7.67	0.000	***
Y2002	Dummy for 2002	.591	7.21	0.000	***
Y2003	Dummy for 2003	.605	7.82	0.000	***
Y2004	Dummy for 2004	.742	7.49	0.000	***

N = 1,720
F(82, 1,636) = 52.87
Prob > F = 0.0000
Adj R-squared=0.7147

*p = 0.1, **p = 0.05, ***p = 0.01
b = basis

Appendix A3 - Basic model of Submarket 2 (Multi-storey buildings; more centrally located) - continued

Indep. Var.	Description	Coeff.	t-stat.	p-value	Level of Sig.
Type of Seller-Dummys					
ST1	City	-.225	-2.59	0.010	***
ST2	Public Utilities	-.008	-0.04	0.971	
ST3	housing associations	-.003	-0.03	0.975	
ST4	Austrian republic	-.070	-0.42	0.675	
ST5	Vienna Business Agency (WWFF)	-.344	-3.85	0.000	***
ST6	land procurement and urban renewal fund (WBSF)	-.133	-2.69	0.007	***
ST7	other public association	-.970	-2.12	0.034	**
ST8	other private association	.064	2.12	0.034	**
ST9	Private persons	b	b	b	b
Type of Buyer-Dummys					
BT1	City	-.304	-2.56	0.011	**
BT2	Public Utilities	1.117	9.52	0.000	***
BT3	housing associations	.202	3.75	0.000	***
BT4	Austrian republic	-.207	-1.24	0.216	
BT5	Vienna Business Agency (WWFF)	.154	1.26	0.208	
BT6	land procurement and urban renewal fund (WBSF)	-.077	-0.73	0.468	
BT7	other public association	-.553	-1.84	0.066	*
BT8	other private association	.308	6.13	0.000	***
BT8	Private persons	b	b	b	b
Environmental characteristics					
DWI	Dummy for Garbage incinerator within 1,500 m	-.248	3.68	0.000	***
RTN	Road Traffic Noice (measured in dB over day)	.0003	0.22	0.824	
AN0	no Aircraft Noice	b	b	b	b
AN1	Dummy for Aircraft Noise Level 1	-.178	-2.79	0.005	***
AN2	Dummy for Aricraft Noice Level 2	-.104	-2.03	0.043	**
BH	Height of sourroundig buildings (sightliness)	.004	0.75	0.452	
Neighbourhood Characteristics					
FNB	Newbeginner Factor	-.066	-3.57	0.000	***
FE	Skills Factor	.067	3.82	0.000	***
FF	Family Factor	-.132	-4.96	0.000	***
FY	Yuppy Factor	.038	1.85	0.065	*
FO	Age Factor	.035	2.68	0.007	***
EU-14	Percent of people from the EU-14	.025	1.71	0.088	*
OF	Percent of people from other countries	-.003	-1.29	0.199	
Important sides					
SBRUNN	Schönbrunn within 10,000 m	.123	1.41	0.159	
DWW	Distance to Wienerwald (in meters)	-0.000007	-0.94	0.346	
PRATER	Prater within 3,000 to 14,000 m	.141	2.84	0.005	***
DOINSEL	Donauinsel within 1,800 to 7,000 m	.095	2.77	0.006	***
NASCHMARKT	Naschmarkt within 750 m	-.500	-2.61	0.009	***
TRANSDANUBIEN	Dummy for districts 21 and 22	-.123	-1.66	0.097	*

N = 1,720
F(82, 1,636) = 52.87
Prob > F = 0.0000
Adj R-squared=0.7147

*p = 0.1, **p = 0.05, ***p = 0.01
b = basis

[i] The coefficient can be interpreted as approximately the percentage change in the house property given a unit change in the independent variable. The actual change, however, is better approximated by the function exp(b)-1, where b is the estimated coefficient and exp is the base of the natural logarithm.

[ii] At the time of writing the register comprises more than 25,000 transactions. Most of the transactions pertain to apartment buildings and single family homes. However, from the perspective of hedonic pricing the data on those properties transactions are not informative enough. For instance, records covering transactions of apartment buildings lack information on the number of dwellings and tenure types, as well as information on the physical condition of the structures.

[iii] In our investigation of the linearity of the price-distance relationship with kernel regressions we follow Gibbons and Machin (2004): First, we estimate the hedonic price function by regressing with OLS the dependent variable (log of price per square meter) on all the controls detailed in Appendices A1 to A3. In a second step, the residuals from the OLS regressions (the residual prices) are regressed on distance to the next subway station in meters. This provides us with a price gradient which is approximated in a new OLS regression by binary Variables (Dummy-Variables). We repeat this several times until explanatory powers of the OLS regressions are maximised.

[iv] At the end of the third construction phase in the year 2009 the whole subway system covers a network with 75 km lines and 90 subway stations. According to the announcement dates 33 of the stations were labelled as new stations and the rest (57) as old stations.

[v] For an alternative and in essence conflicting view concerning the relationship between age-structure and housing fragmentation see Fassmann and Hatz (2004).

[vi] We converted the land price surcharge into a rent surcharge based on the assumption that land costs constitute 15 per cent of total construction costs of multi-storey residential buildings on average.

[vii] A comparison of neighbourhood attributes in the two submarkets shows significant differences only in the share of families (higher in the suburbs) and the share of single person households (higher in the central districts), respectively, and in the share of Non-EU-foreigners (much higher in the central districts). All other census attributes

are rather comparable. Note however, that according to the estimates, compared to the MSB-market, the SFHO-market seems to be less segmented. From the five factors only the coefficient of the family factor is significant at the 10 percent level. This means that population formation is more homogeneous in the single family housing market segment.

[viii] To eliminate outlier effects we have truncated the samples from below. All transactions with prices below 100 Euro per square meter have been dropped from the database.

[ix] Actually, we experimented with different years, but that assumption delivered the best (interpretable) results.

[x] The reason might be the rather small number of observations closer to the stations.