Environmental Amenities on the Housing Market in Warsaw Hedonic Price Method Research

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1. Introduction

Over 1.6 million people live in Warsaw, the capital city of Poland. Additional 0.8 million live in the entire metropolitan area (3788 km^2), much of which should be seen as the geographical domain of the same labour and housing markets. Almost 1 million households living in more than 900 thousand houses or apartments are registered in the area.

For several decades the housing market in Poland had been depressed and heavily controlled by government authorities. As a result, an acute shortage of urban living space—especially in Warsaw—developed. Over the last decade, i.e. since the collapse of the central planning system in 1989, real estate market has been flourishing [Brzeski, 1996]. Initially the prices behaved rather wildly revealing a deep disequilibrium inherited from the past [Kalkowski, 1996]. Towards the end of the 1990s, the market seemed to have stabilized thus making it possible to apply statistical methods in order to identify factors that determine the observed price differentials.

Many trades or leases are carried out between two transacting parties directly. Nevertheless, an increasing volume of transactions—now totalling more than 10,000 per annum in Warsaw—flows through real estate agencies. There are dozens of intermediaries who specialize in the housing market. The level of competition is fairly high as reflected in low transaction fees. Real estate agents compete by trying to attract as many offers as possible rather than increasing the price of their service. Data bases are considered valuable assets and the agents hesitate to disclose their contents, even if those who ask provide credible assurances of no interest conflict. Hence it proved very difficult to collect a sample of observations large enough to allow for statistical analyses.

It has been commonly assumed that real estate markets should reflect environmental amenities linked to the characteristics of the site or to the structure of houses and apartments. The state of the natural environment in Warsaw is spatially diversified and therefore one can expect that market prices capture local differences in air quality, noise, the proximity of parks, etc. At the same time, however, prices may be influenced by non-environmental factors, such as building quality, availability of public transportation, street safety and so on. As the impacts of environmental and non-environmental factors may cancel out in any given transaction, a consistent pattern can be discovered by means of econometric modelling only.

2. The hedonic price model

A large body of literature on econometric modelling of real estate markets as affected by environmental factors has developed (see e.g. [Anderson and Bishop, 1986], [Huang and Smith, 1993]). Most surveys attempted to associate price differentials with air quality. Although studies explaining the variance of prices by some other environmental factors, including noise and landscape characteristics were carried out, little work has been done to model the housing market comprehensively, that is by taking into account many environmental characteristics simultaneously. In this project an attempt was made to compile an extensive data base allowing for a thorough statistical analysis. Most of the qualitative characteristics were represented by sets of dummy variables. Linear relationships were assumed to make the model easier to handle [Bateman, 1993].

There are two alternative approaches to modelling real estate markets: (1) by assuming that various characteristics affect the price p of an area unit such as 1 m^2, or (2) by assuming that they affect the total price P of the commodity such as a house or an apartment. They result in two similar but different equations:

$$p = f(S_1, \dots, S_q, L_1, \dots, L_r, E_1, \dots, E_v) \tag{1}$$

$$P = F(S_1, \dots, S_q, L_1, \dots, L_r, E_1, \dots, E_v) \tag{2}$$

where $S_1, \dots, S_q$ stand for structural characteristics of the estate including its area, vintage, construction materials, quality of interior, legal status etc.; $L_1, \dots, L_r$ stand for location characteristics including the district of the city and availability of transport infrastructure; finally, $E_1, \dots, E_v$ denote environmental attributes of the site, including air quality, noise, view, availability of recreational space in the immediate neighborhood etc.

Our behavioral assumption is that the type (1) equation characterizes the market for apartments while the type (2) is more appropriate for the market for houses which are always sold together with a larger lot whose attributes cannot be convincingly apportioned to each square meter of the house area. The obvious general hypothesis to be tested is that:

improved environmental quality characteristics of an estate positively affect its price.

As there is little evidence that buyers are fully aware of the state of the environment, the hypothesis can be rephrased as:

improved perceived environmental quality characteristics of an estate positively affect its price.

The models described by equations (1) and (2) were estimated separately for sale and rental transactions. The former explained sales prices of apartments or houses while the latter explained monthly rents. The sets of variables and their specific definitions were developed in a lengthy process of researching the real estate market in Warsaw and analyzing relevant local environmental records.

3. The data base

All major real estate agencies in Warsaw were approached by the Warsaw Ecological Economics Center in the first half of 1999 in an attempt to get access to their data bases. Unfortunately, most of them turned out to be unwilling to share their resources even when arrangements to secure data confidentionality were proposed. Only four agencies agreed to cooperate: DIPSERVICE, AZA, "Grójecka", and DOMART. These agencies offer a wide spectrum of quality as well as geographical diversity. Refusals by their competitors do not seem to have introduced any systematic bias. Thus the sample of 982 cases obtained from these agencies can be considered representative for the housing market in Warsaw [Pecikiewicz, 2000; Rozwadowska, 2000].

Several "structural" characteristics of a house or an apartment, in addition to its price, were collected directly from a respective agency's data files. These were:

- sale or rental price [PLN or PLN/month],
- housing type (detached house, terraced house, apartment) [dummies]
- height of building [number of storeys]
- vintage (1939 or older, 1945–1960, 1961–1978, 1979–1988, 1989 or newer) [dummies]
- construction material (brick, concrete) [dummies]
- district heating [dummy]
- gas heating [dummy]
- connection to municipal sewage [dummy]
- elevator [dummy]
- lobby [dummy]
- intercom [dummy]

- building recently renovated [dummy]
- basement [dummy]
- security guard [dummy]
- garage [dummy]
- parking place [dummy]
- swimming pool and sauna [dummy]
- outdoor area (for detached and terraced houses) [m^2]
- indoor area [m^2],
- floor [number]
- number of storeys [number]
- orientation of walls with windows (one-sided, two-sided, multi-sided) [dummies]
- number of rooms [number]
- passage room [dummy]
- walk-in closet [dummy]
- bathroom (no bathroom, bathroom with WC, separate WC) [dummies]
- kitchen (no kitchen, kitchen annex, kitchen with window) [dummies]
- fireplace
- balcony [dummy]
- basement storage [dummy]
- phone line [dummy]
- cable TV [dummy]
- tiles in bathroom [dummy]
- floor covering (concrete, parquet, panels, PVC, carpet lining) [dummies]
- floor heating [dummy]
- energy efficient windows [dummy]
- anti-burglary doors/windows [dummy]
- technical standard of apartment (to be finished or renovated, recently renovated) [dummies]
- mortgage [dummy]
- furnished [dummy]
- kitchen furnished [dummy]
- closets [dummy]
- TV set [dummy]
- washing machine [dummy]
- additional kitchen equipment (refrigerator, microwave oven, dishwasher) [dummies]

The reliability of structural data, whenever available, was found high, but for some observations some characteristics were simply missing in the respective agency's files. Prices were always quoted as asked by the seller. For confidentiality reasons it was not possible to obtain actual prices paid by the buyer. However, according to the agency officers, the final price is at the most 5% lower than the asked one. In most cases it is lower by no more than 3%. According to an independent survey [Koska and Przewlocki, 1997], an average difference between offer and final prices decreased between 1994 and 1997 from over 10% to 3%. As the overall variance of prices asked in the sample is much larger than this narrow margin of uncertainty, one can conclude that taking consistently these offers as proxies for actual prices is justified.

The second major group of variables comprised location characteristics determined by analyzing addresses of estates from the agencies' data bases. First of all, each observation was identified with one of the 48 districts in the Warsaw metropolitan area. Likewise each address was classified into five categories depending on its distance from the city center. Finally each site was evaluated in terms of its accessibility by public transportation. Three dummy variables were introduced for having a subway, tram, or bus stop in the immediate neighbourhood. The list of location variables reads as follows:

- district [47 dummies]
- distance from the city center [number of km]
- public transport access (subway, tram, bus) [dummies]

The third group of variables—the main focus of the project—was developed after a series of visits during which environmental attributes of the sites were determined. Additionally environmental inspection records and land use maps were consulted. It turned out, however, that many attributes can be represented by proxies that do not fully reflect environmental quality. The network of air pollution monitoring is, for instance, by far too coarse to inform about local air quality. Consequently the authors decided to have air quality represented through a combination of stationary emission source data and road traffic. The latter is also considered representative for noise. The authors assumed that the following site characteristics are proxies for ambient air quality and noise:

- low (up to 20 m) stacks in the immediate neighbourhood (no stacks, 1 to 5, more than 5) [dummies]
- medium (higher than 20 m up to 50 m) stacks in the neighbourhood, i.e. closer than 500 m (no stacks, 1 to 5, more than 50 [dummies]
- high (higher than 50 m) stacks in the neighbourhood, i.e. closer than 1 km (no stacks, 1, more than 1) [dummies]
- road with a high volume of traffic in the neighbourhood (adjacent to the estate, not adjacent but closer than 100 m, more than 100 m away)

Other environmental amenities included the local landscape quality and the proximity of green areas such as forests, parks and small gardens. It was also assumed that the neighbourhood of an industrial area decreases the attractiveness of a site. Three types of variables were supposed to reflect the landscape quality:

- green area within a 5-minute walk [dummy]
- major green area (forest or major park) within a 15-minute walk [dummy]
- adjacent industrial area (none, small, medium, large) [dummies]

Additionally, by visiting all sites, the authors subjectively determined noise and view attributes of each estate. Both houses and apartments were classified into the following categories:

- with respect to noise: quiet, one side quiet, all sides noisy [dummies]
- with respect to view: no greenery, green from one side, immersed in green [dummies]

No scientific measurements were performed in determining “the amount of green background” or noise levels. The authors assumed that potential customers apply very simple criteria to judge whether an estate is noisy or not and whether it has a green neighbourhood.

4. Linear regressions

Correlation matrices were compiled for both sale and rent data sets. As expected, many variables were highly correlated. The proximity of major green areas, for instance, was obviously correlated with districts. Many structural characteristics of houses or apartments such as energy efficient windows and anti-burglary doors were also correlated. Many dummy variables had variances close to zero. Moreover, preliminary estimation exercises demonstrated that markets for houses and apartments should be treated separately; otherwise many intuitively relevant parameters lose their statistical significance. As a result, the number of regression variables has become excessive compared to the number of observations for each of the subsamples. To cope with these problems, several groups of variables were aggregated.

First of all, 48 districts were aggregated into 21 larger units. Once this proved insufficient for estimation purposes, the following 7 categories were identified:

- city center (CENTER)
- “good” old residential districts (GOODOR)
- “bad” old residential districts (BADORE)
- traditional upper class detached house district (TUCDHD)
- new upper class detached house districts (NUCDHD)
- new residential districts (NEWRES)
- suburban areas (SUBURB)

Except for the first and fourth district, they consist of smaller non-adjacent ones. In the regression they were represented by 6 dummy variables (all dummies are zeroes for the city center).

Structural characteristics were aggregated into general housing quality indices by applying two alternative methods. According to the first one, dummy variables were simply added to, or subtracted from, the index, depending on whether a characteristic was considered as enhancing or diminishing the quality of an apartment or house. In other words, we assumed that the marginal rate of substitution between such characteristics as e.g. “garage” and “intercom” is +1, while between e.g. “passage room” and “separate WC” is 1.

According to the second one, we assumed that the marginal rates of substitution may vary. Specific weights were selected after consulting real estate experts. We collapsed 42 dummy variables into two indices:

- simple quality index (SIMPQI); and
- complex quality index (COMPQI).

Regression equations were, of course, estimated with one of the indices (either SIMPQI or COMPQI) at a time.

Having inspected the data base, all dummies with virtually no variance were eliminated. This reduced the number of variables even more. After these initial steps, we ended up with the following subsamples:

- house sales—166 observations, 32 explanatory variables
- apartment sales—229 observations, 29 explanatory variables
- house rentals—147 observations, 29 explanatory variables
- apartment rentals—440 observations, 30 explanatory variables

Estimations were carried out at the Warsaw Ecological Economics Center using the SPSS advanced software package. Most variables turned out to be statistically insignificant. Below we present four models—one for each subsample (market type) with the best statistical characteristics. As a rule, a 10% significance level has been adopted.

The following six-character variable names were applied; only significant variables are listed:

BADORE—bad old residential districts
CONSTA—constant [same units as for P or p]
DISTAN—distance from the city center [km]
GOODOR—good old residential districts [dummy]
GREENA—green area within a 5-minute walk [dummy]
GREENO—green from one side [dummy]
HEIGHT—height of the building [number of storeys]
HISTA2—2 or more high stacks in the neighbourhood [dummy]
IMMERG—estate immersed in green [dummy]
INDARE—indoor area [m^2]
LOSTA6—6 or more low stacks in the neighbourhood [dummy]
MAJORG—major green area within a 15-minute walk [dummy]
MESTA1—1–5 medium stacks in the neighbourhood [dummy]
MESTA6—6 or more medium stacks in the neighbourhood [dummy]
NEWRES—new residential districts [dummy]
NUMROO—number of rooms [number]
NUMSTO—number of storeys (of apartment or house) [number]
OQUIET—one side quite [dummy]
ROAD99—heavy traffic road less than 100 m from the estate [dummy]
ROADAD—heavy traffic road adjacent to the estate [dummy]
SUBWAY—subway stop in the neighbourhood [dummy]
TUCDHD—traditional upper class detached house district [dummy]
VINT61—vintage of building, 1961–1978 [dummy]

VINT79—vintage of building, 1979–1988 [dummy]
VINT89—vintage of building, after 1989 [dummy]

Model 1.

House Sales [*P*, 1000 PLN]

Variable	Coefficient	Standard Dev.	t-Test	Significance
GOODOR	1878.3	303.7	6.186	0.0000
INDARE	2.3	0.5	5.112	0.0000
NUMSTO	249.8	76.6	3.260	0.0015
CONSTA	1173.2	415.2	2.826	0.0056
SUBWAY	1509.4	615.6	2.452	0.0158
VINT89	366.1	151.5	2.416	0.0173
TUCDHD	925.9	390.4	2.372	0.0194
OQUIET	517.4	224.6	2.303	0.0231
DISTAN	50.6	23.3	2.169	0.0322
GREENA	285.0	146.8	1.941	0.0548

Multiple R 0.75958
R Square 0.57697
Adjusted R Square 0.54267
Standard Error 770.160
D-W Test 1.77939

Model 2.

Apartment Sales [*p*, PLN/m^2]

Variable	Coefficient	Standard Dev.	t-Test	Significance
CONSTA	4360.1	258.2	16.888	0.0000
DISTAN	157.5	28.4	5.536	0.0000
VINT89	630.2	222.5	2.833	0.0056
MAJORG	598.8	246.3	2.431	0.0169
BADORE	447.8	190.0	2.356	0.0204
INDARE	5.9	2.9	2.063	0.0417
GREENO	348.7	173.9	2.006	0.0477
HEIGHT	41.9	21.7	1.930	0.0564
NEWRES	490.2	265.3	1.848	0.0677
ROADAD	354.9	214.1	1.658	0.1006

Multiple R 0.72803
R Square 0.53002
Adjusted R Square 0.48686
Standard Error 717.341
D-W Test 2.12304

Model 3.

House Rentals [*P*, PLN per month]

Variable	Coefficient	Standard Dev.	t-Test	Significance
TUCDHD	11028.6	2289.0	4.818	0.0000
INDARE	27.643	5.824	4.746	0.0000
GREENO	9569.8	2131.1	4.491	0.0000
GREENA	4358.5	1438.6	3.030	0.0034
IMMERG	4174.2	1803.3	2.315	0.0235
ROAD99	3859.7	1912.1	2.019	0.0473
VINT61	4345.5	2201.2	1.974	0.0523
VINT79	3898.4	2196.0	1.775	0.0801
CONSTA	3702.1	2444.9	1.514	0.1344

Multiple R 0.81311
R Square 0.66114
Adjusted R Square 0.62296
Standard Error 5897.82
D-W Test 1.81697

Model 4.

Apartment Rentals [*p*, PLN/m^2 per month]

Variable	Coefficient	Standard Dev.	t-Test	Significance
CONSTA	36.387	6.416	5.672	0.0000
MESTA1	24.017	5.950	4.037	0.0001
HISTA2	82.503	21.503	3.837	0.0002
GOODOR	13.842	5.047	2.743	0.0074
VINT79	15.643	6.230	2.511	0.0139
LOSTA6	35.926	16.008	2.244	0.0274
MESTA6	15.167	7.160	2.118	0.0370
HEIGHT	1.236	0.620	1.993	0.0494
VINT89	7.730	4.191	1.845	0.0685
NUMROO	2.510	1.436	1.747	0.0841

Multiple R 0.58348
R Square 0.34044
Adjusted R Square 0.27221
Standard Error 15.0555
D-W Test 2.08824

5. Discussion of major findings

Only 24 significant explanatory variables were identified, and only up to 9 such variables in each of the four models could be included. The adjusted R square coefficients were not very high. Therefore the first major conclusion arrived at is that, despite the great variety of factors taken into account, the variance of prices in housing markets in Warsaw is difficult to be explained (at least in terms of a linear model).

Very different sets of variables explain prices in each of the four models. In apartment markets (both sales and rentals) constants proved to be the most significant elements of prices per m^2. This demonstrates that the price of an apartment reflects its floor area, and all other characteristics are of secondary importance. The indoor space is also highly significant for house prices (both sales and rentals). The indoor area, as measured in m^2, contributed 68% to the average monthly rental price of a house (11,000 PLN). The same component accounted for 64% of the average sales price of a house (1,183,727 PLN). Nevertheless other factors were also significant.

Location characteristics proved to be crucial for the price of houses. Houses in residential districts considered as good (GOODOR and TUCDHD) were selling or renting at prices much higher than average. Similarly, apartments located in such districts (GOODOR) were renting at higher prices while those in bad ones (BADORE and NEWRES) were selling at lower prices. Also transport infrastructure proved to be relevant for the housing market. A subway stop in the neighbourhood (SUBWAY) boosted the selling price of a house. Likewise the proximity of a major road (ROAD99) elevated the rental price of a house. The distance to the city center (DISTAN) had some impact on prices, but prospective buyers of houses must have had different preferences than those looking for apartments. While for the former the value of an estate increased with the distance from the center, for the latter it was the other way around. At the same time, the distance was not statistically significant for rental markets.

In all four markets people revealed similar preferences with respect to vintages of houses or apartments. New houses and apartments, i.e. built after 1989 (VINT89), were selling at higher prices. New apartments were rented at higher prices, although, rather surprisingly, rental prices of somewhat older apartments (VINT79) were high too. Older houses (VINT61 and VINT79) had definitely lower rental prices.

The size of a house was also significant. While the selling price of a house increased with the number of its storeys (NUMSTO), the selling or rental price of an apartment decreased with the overall height of the building (HEIGHT) it was located in. At the same time, the rental price of a square meter of an apartment increased with the number rooms (NUMROO), although the relationship was not very significant.

Some of the most interesting results were obtained for environmental attributes or their statistical proxies. Each of the models included some significant environmental variables.

People revealed preferences for buying houses protected from noise (OQUIET), and expected lower prices for apartments adjacent to major roads (ROADAD). The latter might have also been considered as affected by pollution from car exhaust pipes. Green areas seen from windows at one side of a building (GREENO) correlated with higher apartment prices and house rental prices. It was a bit surprising that houses immersed in green (IMMERG) were rented at somewhat lower prices than those with one green side only. A possible explanation of this paradox is that the latter might have been considered more exposed to sunshine, something people in Poland appreciate very much given the country's moderate climate. The result echoes a tendency observed in a British study [Garrod and Willis, 1992] where real estate prices were found positively affected by some types of a neighbouring woodlands and negatively by others.

In the house market the people did not reveal any preference for the proximity of green neighbourhoods. On the contrary, the closeness of a small green area (GREENA) seemed to reduce the selling price. The statistical significance of this variable in model 1 was rather small (over 5%), and the unexpected sign of its coefficient may result from the correlation with some unobserved variables like, for instance, street safety, which is probably considered lower in the vicinity of a small local park. Nevertheless in the apartment market, easy access to green areas was considered an advantage. The proximity of a major green area (MAJORG) increased the selling price of an apartment.

The air quality—represented in our data base mainly by the presence of local stationary emission sources—turned out significant in the apartment rental market only. However, the sign of relevant coefficients was sometimes surprising. As expected, the neighbourhood of high stacks (HISTA2) adversely affected the rental prices of apartments. But why did the presence of low and medium stacks (LOSTA6, MESTA1, MESTA6) positively correlated with such prices? First of all, such stacks may not be discovered by prospective tenants; their presence upsets only those who are environmentally sensitive and deliberately look for them. Second, many low and medium stacks are attached to service buildings such as schools, medical centers, shopping malls etc. Therefore their presence correlates with some site attributes—unaccounted for in our data base—that are welcome by prospective tenants.

6. Summary and conclusions

Four different housing markets in Warsaw—house sales, apartment sales, house rentals and apartment rentals—were surveyed and analyzed in terms of linear hedonic price models. More than 100 characteristics of 982 estates were collected either by inspecting four real estate agencies or through site visits and studying local maps. As a result of correlation analyses and aggregation, 24 variables were identified as significant for explaining sale or rental prices. However, the prices in each of the four markets were best explained by very different sets of variables (up to nine variables and a constant). This confirms that the four markets are governed by different preference patterns.

Structural characteristics of apartments and houses in addition to their location determined much of the price variance. Overall people prefer districts which enjoy reputation as traditionally "good", and they appreciate transport links with the city center. For apartments the prices seem to decrease with the distance from the city center, while for houses it is the other way around. Larger apartments get higher per-square-meter prices.

The urban noise, air quality, and green neighbourhood proved to be significant factors in explaining estate prices. There were, however, several results calling for a more careful scrutiny. F i r s t, high rather than low and medium stacks (serving as air pollution proxies) affected prices adversely, even though, as a rule, the former have a smaller impact on local contamination. This lends some evidence to our initial hypothesis that **perceived** rather than **actual** environmental quality explains price differentials. S e c o n d, it turned out that "moderately green" estates were more attractive than those "immersed in green". Perhaps a better exposure to sunshine and wider views from windows more than compensate for a lower quantity of trees and bushes in the immediate neighbourhood.

Our survey was the first hedonic price exercise in Poland. Its structure was modelled after similar surveys carried out in mature developed market economies. As the Polish economy still undergoes a transition, its housing market may reveal peculiar features that require additional insights. Hence our models will be further analyzed.

One possible direction of additional research is to study marginal rates of substitution between elements of structural characteristics of houses or apartments. At this stage two approaches to building a composite quality index (SIMPQI and COMPQI) were empirically verified, neither of which proved to be satisfactory. Perhaps experimenting with non-linear forms (e.g. multiplicative, logarithmic etc.) may help at better understanding how qualitative components of an estate translate into its market price.

Another potential research domain is building environmental quality indices for districts [Geoghegan *et al.*, 1997]. In all models location variables proved to be significant. However, there are no credible assessments of the state of the natural environment at district levels. Consequently, it was not possible to see how the reputation of a district correlates with ambient environmental variables. An attempt was made to link location to urban noise, local air pollution, and availability of green areas. The method applied in our survey was a very crude one, and a more systematic approach may lead to better statistical properties of hedonic price models.

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Abstract

The paper reports on a 1999 survey of prices of family houses and apartments in the metropolitan area of Warsaw, Poland. A series of hedonic price models were estimated in order to determine whether the prices reflected such environmental amenities as green neighborhood, clean air or low noise. House or apartment characteristics (including prices) recorded by four local real estate agencies provided the core data base of the survey.

All sites were visited in order to determine characteristics not registered by the agencies and yet presumed relevant for potential buyers or tenants. Additional data were obtained by consulting maps and statistics available from Warsaw environment and transport departments. The total sample consisted of 982 observations comprising 154 explanatory variables (75 house or apartment characteristics, 55 site characteristics, and 24 environmental attributes) and prices. The sample included 395 sales and 587 rentals.

Preliminary statistical analyses proved that both subsamples were very heterogeneous and hence it was necessary to analyze house and apartment markets separately. Consequently the entire data set was divided into four parts: 166 house sales, 229 apartment sales, 147 house rentals, and 440 apartment rentals. Excessive numbers of explanatory variables and multicollinearity problems called for substantial aggregation of explanatory variables. Finally 4 hedonic price equations were arrived at. These confirmed that environmental attributes did explain price differentials.

Nevertheless, it was observed that what typically mattered were perceived rather than actual attributes (such as visible high stacks rather than low stack pollution sources which are more important for the local air quality).