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## Monument protection: internal and external price effects

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Universität Hamburg

Faculty Economics  
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Chair for Economic Policy

GABRIEL AHLFELDT / WOLFGANG MAENNIG

# MONUMENT PROTECTION: INTERNAL AND EXTERNAL PRICE EFFECTS

Urban  
Transport  
Media  
Sports  
Socio-  
Regional  
Real Estate  
Architectural

HAMBURG CONTEMPORARY

ECONOMIC DISCUSSIONS

No. 17



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# Monument Protection: Internal and External Price Effects<sup>\*</sup>

**Abstract:** This paper analyses the impact of heritage-listed buildings on condominium transaction prices in Berlin, Germany. We use transaction data to test for price differentials between listed and non-listed properties and to study their impact on surrounding property prices. Proximity to built heritage is captured by distance to listed houses and indicators capturing neighborhoods with built heritage. Impact is assessed by applying a hedonic model to micro-level data and a non-parametric approach to location. While our findings suggest that listed properties do not sell at a premium or discount, heritage-listed buildings are found to have positive external effects on surrounding property prices.

*Keywords:* Cultural economics, built heritage, heritage significance, real estate economics, Berlin

*JEL classification:* R21, R52, Z19

*Version:* February 2008

## 1 Introduction

The value of cultural heritage in general and built heritage in particular is widely recognized. Selected buildings are registered and listed in order to preserve heritage at the cost of increasing public and private spending (BENHAMOU, 2004). While theoretical work suggests that built heritage may explain the attractiveness of European downtown locations (BRUECKNER, THISSE, & ZENOU, 1999), there is little empirical evidence. The first empirical approaches explored property transaction data to assess price differentials between listed and non-listed properties. This strand of research aims to identify whether heritage values capitalize into property prices. Most studies that use hedonic approaches or that track the sales prices of heritage-listed properties over time have found positive or at least no negative effects of heritage listing for Australia (DEODHAR, 2004; PENFOLD, 1994), Canada (SHIPLEY, 2000), and the US (ASABERE, HACHEY, & GRU-

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BAUGH, 1989; FORD, 1989), whereas CREIGH-TYTE (2000) found adverse effects during the 1980s in the UK and BENHAMOU (2004), demonstrating that the direction of effect depends on the strength of constraints linked to the heritage listing.

However, the results of such studies may vary considerably across countries (BENHAMOU, 2004), which necessitates studies in other regional contexts. In addition, besides assessing price differentials for listed properties, another feasible approach for assessing whether real estate markets value built heritage is to examine the external effects of built heritage on surrounding properties. If listed properties are perceived as valuable location amenities due to appealing appearance and historic importance and real estate markets are in equilibrium, then the closer a location is to the listed properties, the greater its desirability, which will translate into higher property prices. SCHAEFFER & MILLERICK (1991) provide some evidence for such external benefits within a district in Chicago, Illinois designated as a National Historic District.

This study, besides testing for price differentials of listed properties, aimed to attribute price variation to the location of heritage-listed houses. It is unique in using a rich sample of condominium transactions, micro-level data, recently developed GIS tools, and a spatial econometric approach controlling for housing and location characteristics, as well as for spatial autocorrelation. A hedonic approach was employed to correct property transactions for structural characteristics and details of the purchase agreements. Location was captured in two alternative specifications, either in an amenity-based approach by a set of variables representing location and neighborhood characteristics or in a non-parametric specification where we allowed for a full set of neighborhood fixed effects. Property transaction data were merged with data on 16,142 listed properties and micro-level data disaggregated to the level of 15,937 official statistical blocks. These included area-typical building structures, natural amenities, publicly and privately provided infrastructure, population, including such characteristics as age and origin, automobile registrations, and employment. The external effects of built heritage were assessed using distances to the closest heritage-listed properties and a

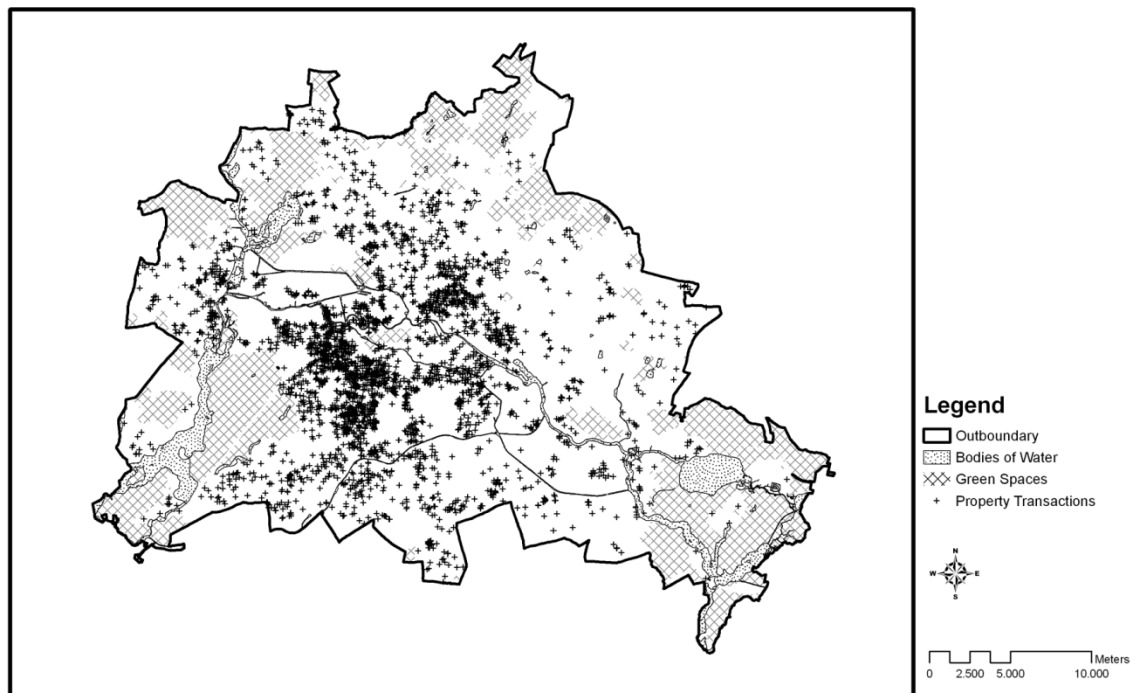
heritage potentiality indicator representing a built heritage environment weighted by the distance from and size of heritage-listed properties.

The remainder of this article is organized as follows. The next section introduces the data. Section three discusses methodological issues and presents our empirical strategy. In section four, we present our empirical results, while the last section presents conclusions.

## 2 Data

Most available hedonic price studies, including a few publications assessing price differentials for listed properties, rely on data on single-family houses. In contrast, we focused on condominium apartment transactions, which account for the vast majority of residential property transactions in Berlin, Germany. In general, condominiums are the most relevant submarket in central European capitals, particularly in downtown areas where built heritage is expected to be of the greatest relevance (BRUECKNER, THISSE, & ZENOU, 1999). We considered all 6,150 transactions of condominium properties occurring between January and September 2007 in Berlin, which were the most recent data available at the local Committee of Valuation Experts (2007) when the analysis was conducted. After excluding observations with missing values for key characteristics, we conducted our analysis on a sample of 5,769 transactions. Data included the usual parameters such as age, size, number of rooms, and balcony, as well as information on the type of condominium (e.g., maisonette, penthouse, etc.) and contract details containing information on the buyer, seller, type of agreement, and tax privileges, among other things. Based on geographic coordinates, property transactions were georeferenced and merged with data on 16,142 heritage-listed buildings within a GIS-environment. Because we obtained data on protected monuments in form of a shapefile accurate to the ground plan of houses, we were able to identify 494 condominium transactions that occurred within heritage-listed tenements. Figure 1 shows the spatial distribution of condominium transactions considered in this study. The heritage geography of Berlin is shown in Figure 2.

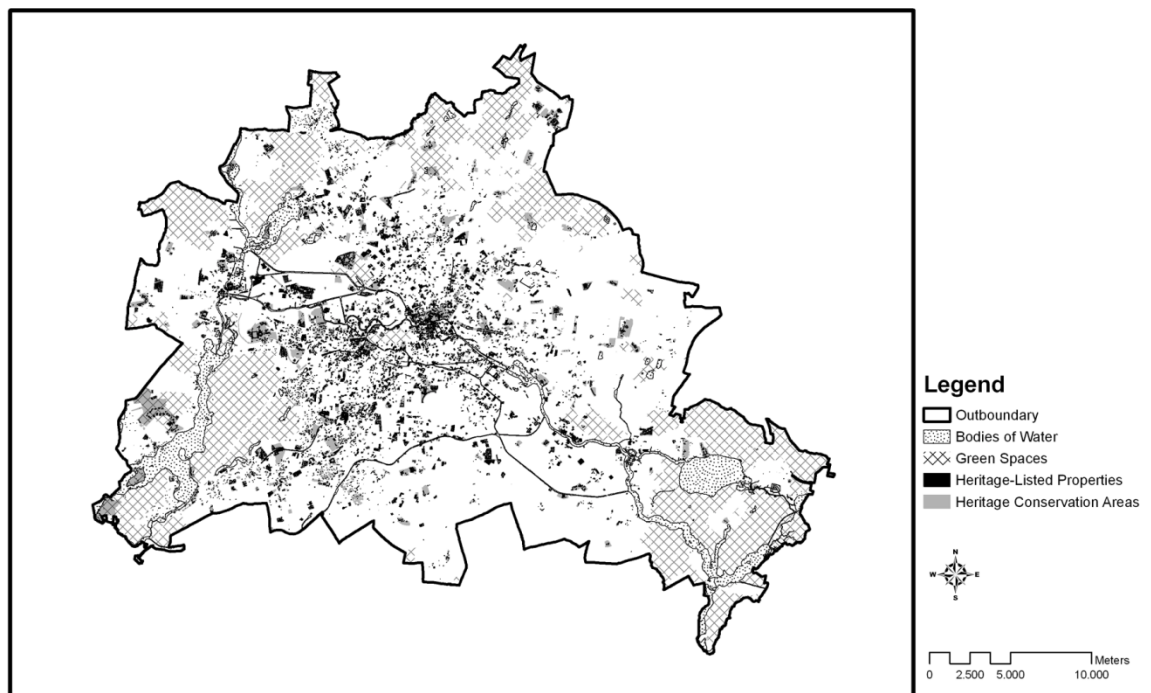
**Fig. 1 Spatial Distribution of Condominium Transactions**



Notes: Map created on the basis of the Urban Environmental Information System.

Source: COMMITTEE OF VALUATION EXPERTS IN BERLIN (2007), SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN (2006).

**Fig. 2 Heritage Geography**



Notes: Map created on the basis of the Urban Environmental Information System.

Source: SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN (2006).

We controlled for location using variables that capture location and neighborhood characteristics for the whole of Berlin, which on July 31, 2007 had 3,405,483 inhabitants and an area of approximately 892 km<sup>2</sup>. Data refer to the 15,937 official statistical blocks, the most disaggregated level available at the Statistical Office of Berlin. The statistical blocks have a median surface area of less than 20,000 m<sup>2</sup>, approximately the size of a typical inner-city block of houses. The mean population of the 12,314 populated blocks was 271 (median 135). Information on public infrastructure such as schools, suburban and metro railway stations and networks, shopping centres, and natural amenities, was used to generate impact variables that are discussed in more detail in the section below. Based on the City and Environmental Information System of the Senate Department, a full set of variables representing typical residential building structures at the block level were also created by applying GIS tools. Furthermore, automobile registrations and population data at block-level were considered, including demographic characteristics and the origin of the resident population. All data used in this paper refer strictly to the end of 2005, with the exception of employment at workplaces, which was only available at the Senate Department for the end of 2003.<sup>1</sup>

### 3 Empirical Strategy and Methodological Issues

Our research strategy basically consisted of two steps. First, we developed a hedonic pricing model explaining property prices using a comprehensive set of structural, location, and neighbourhood characteristics. In the second step, we extended the baseline model to test for price differentials for condominiums that were heritage-listed in order to attribute price variation to monuments' locations. An alternative approach to location was also considered that captured location and neighbourhood characteristics non-parametrically using a full set of neighbourhood fixed effects.

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<sup>1</sup> Data on employment at workplaces includes all employees contributing to national social insurance.



The next sub-sections provide a brief introduction into hedonic modelling, discuss the generation of potentiality variables that capture location characteristics, and present our empirical strategy.

### 3.1 Hedonic Modelling

If real estate markets are in equilibrium, the attractiveness of location is fully capitalised into property prices. The attractiveness of a real estate commodity can be assumed to depend on structural attributes [ $S$ ], a set of attributes capturing the effects of the neighbourhood [ $N$ ] and local amenities [ $L$ ], whose implicit prices are estimated using multiple regression (GALSTER, TATIAN, & PETTIT, 2004; MUELLBAUER, 1974; ROSEN, 1974). A typical hedonic regression equation may take the following form (TU, 2005).

$$\log(P) = \alpha + \beta_1 S_1 + \dots + \beta_i S_i + \gamma_1 N_1 + \dots + \gamma_j N_j + \delta_1 L_1 + \dots + \delta_k L_k + \varepsilon \quad (8)$$

where  $P$  is transaction price;  $i, j$  and  $k$  represent the number of attributes;  $\alpha, \beta, \gamma$  and  $\delta$  are coefficients; and  $\varepsilon$  is an error term. Log-linear specifications are commonly chosen since they allow for non-linearity and are intuitively interpretable. The attribute coefficient gives the percentage impact of changes in attribute values on property values. For coefficient values smaller than 10%, this rule may also be applied to dummy-variables (ELLEN *et al.*, 2001).<sup>2</sup>

Examples of hedonic house pricing models include construction of house indices (CAN & MEGBOLUGBE, 1997; MILLS & SIMENAUER, 1996; MUNNEKE & SLADE, 2001), impact assessment of quality of public services (BOWES & IHLANFELDT, 2001; GATZLAFF & SMITH, 1993), school quality (MITCHELL, 2000), group homes (COLWELL, DEHRING, & LASH, 2000), churches (CAROLL, CLAURETIE, & JENSEN, 1996), aircraft noise (AHLFELDT & MAENNIG, 2007a), impact of stadium construction (AHLFELDT & MAENNIG, 2007b; TU, 2005) and announcement (DEHRING, DEPKEN, & WARD, 2007) or even supportive housing (GALSTER, TATIAN, & PETTIT,

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<sup>2</sup> For larger coefficient values, a simple formula is strongly recommended, which provides a much better approximation. For a parameter estimate  $b$  the percentage effect is equal to  $(e^b - 1)$  (HALVORSEN & PALMQUIST, 1980).

2004). SIRMANS, MACPHERSON & ZIETZ (2005) provide a review and meta-analysis of recent hedonic pricing studies.

Most hedonic studies find that much price variation is explained by standard attributes like age, size, parking, and time of sale (DEHRING, DEPKEN, & WARD, 2007). We also considered variables denoting the condition and type of condominium (e.g., maisonette, penthouse, etc.) and tenement (e.g., block, row development, etc.), the size of the tenement, the number of stories in the condominium, the number of rooms and numerous features like basements, roof rooms, or balconies. In addition to correcting transactions for property characteristics and sales time, we controlled for agreement type (e.g., purchase, exchange, private, or compulsory auction), buyer and seller (e.g., private, public, institutional investors), whether the condominium was occupied by renters or was subject to tax privileges, rent guarantees, public subsidies, and other legal details.

In our amenity-based approach, in addition to adjusting isolating for unit and transaction characteristics, we addressed details of both location and neighborhood, since our observation area covered both the urban periphery and the core. While traditional approaches restrict themselves to taking into account distances to amenities like green spaces, schools, and railway stations, we allowed for a multidimensional consideration of surrounding amenities.

### 3.2 Potentiality Variables

In the economic geography literature, a long tradition dating back to HARRIS (1954) models agglomeration forces by calculating market access indicators as the distance-weighted sum of population. For instance, if  $P_i$  is the population of block  $i$ , then

$$PP_i = \sum_j Pop_j e^{-a d_{ij}} \quad (1)$$

is the population potentiality ( $PP_i$ ) of block  $i$ , where  $Pop_j$  is the population of block  $j$ ,  $a$  is a distance decay factor implicitly determining transport costs, and  $d_{ij}$  is the straight-line distance between the geographic centroids of blocks  $i$  and  $j$ . Because we dealt with blocks of different size, a basic concept of empirical economic geog-

raphy (CRAFTS, 2005; KEEBLE, OWENS, & THOMPSON, 1982) was employed to generate a block internal distance measure based on surface area, which can be used to determine the self-potential:

$$d_{ii} = \frac{1}{3} \sqrt{\frac{\text{blockarea}_i}{\Pi}} \quad (2)$$

where  $d_{ii}$  is block  $i$ 's internal distance, equal to one-third of the diameter of a circle of block  $i$ 's surface area ( $\text{blockarea}_i$ ).

This concept can be employed to capture natural amenities like bodies of water or green spaces:

$$AP_i = \sum_j \text{area}_j e^{-a d_{ij}}, \quad (3)$$

where  $AP_i$  is the potentiality corresponding to the considered amenity (e.g., green spaces or water spaces) for statistical block  $i$  and  $\text{area}_j$  is the aggregated surface area of the considered amenity within statistical block  $j$ . Similarly, a potentiality variable representing a reduced Retail Gravity Model (EPPLI & SHILLING, 1996) captures shopping opportunities in terms of the spatially discounted retail area:<sup>3</sup>

$$RP_i = \sum_r RA_r e^{-a d_{ir}}, \quad (4)$$

where  $RP_i$  is the retail potentiality for block  $i$ ,  $RA_r$  is the aggregated retail area of centre  $r$  as defined in the centre atlas published by the Senate Department (SENATSVERWALTUNG FÜR WIRTSCHAFT ARBEIT UND FRAUEN, 2004), and  $d_{ir}$  is the straight-line distance from block  $i$ 's geographic centroid to the officially defined central location of the retail centre  $r$ .<sup>4</sup>

Because of the normally strong correlation between availability of provision with schools and property values (DOWNES & ZABEL, 2002) we employed an indicator

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<sup>3</sup> Shopping has been theoretically proven to be relevant for residents' location choices (ANAS & KIM, 1996).

<sup>4</sup> The centre atlas defines 28 major and minor retail areas.

representing the availability of schools relative to the population of young people aged 6-18:

$$RSP_i = \frac{\sum_j S_j e^{-a d_{ij}}}{\sum_j RP_j e^{-a d_{ij}}}, \quad (5)$$

where  $RPS_j$  represents the relative school potentiality for block  $i$ ,  $S_j$  is the number of schools, and  $RP_j$  is the relevant population living within block  $j$ . The parameter  $d_{ij}$  is defined as in equation (3) for equations (3) – (5), while  $a$  takes the parameter value of 2, which corresponds to walking speed (AHLFELDT, 2007a).

In the empirical urban economic geography literature, distance to central business district (CBD) is considered to be one of the most important location characteristics (CHESHIRE & SHEPPARD, 1995; DUBIN & SUNG, 1990; HEIKKILA *et al.*, 1989; ISAKSON, 1997; JORDAAN, DROST, & MAKGATA, 2004). The original idea that land values decrease with increasing distance from the urban core dates back to VON THÜNEN (1826). ALONSO (1964) postulated the idea of increasing rents due to outbidding of residents who appreciate proximity to employment, which concentrates in the CBD. This concept has fallen under heavy criticism, mostly because it fails to describe the polycentric distribution of employment (GARREAU, 1991; GIULIANO & SMALL, 1991; MCDONALD, 1987; WHEATON, 1982). LUCAS & ROSSI-HANSBERG (2002) proved theoretically that an urban polycentric structure represents a stable equilibrium outcome. Berlin is characterised by a striking duo-centricity which emerged during the 1920s and was strengthened during the period of division (ELKINS & HOFMEISTER, 1988). Modelling Berlin as an ideal mono-centric city could lead to biased estimates (DUBIN & SUNG, 1990). In past research, this issue has been addressed by considering minimum distances to both CBDs (AHLFELDT & MAENNIG, 2007a, 2007b). While this concept picks up proximity effects to both urban cores, we added accessibility indicators to account for the uneven spatial distribution of employment. Adopting ALONSO's (1964) idea that residents may be compensated for increasing rents based on their proximity to employment, we represented employment opportunities in terms of spatially aggregated employment at the workplace. To capture

employment opportunities within walking distance, we employed spatially weighted employment in analogy to equation (1):

$$EP_i = \sum_j E_j e^{-a d_{ij}} \quad (6)$$

where  $EP_i$  is employment potentiality within walking distance of block  $i$ ,  $E_j$  is employment at block  $j$ ,  $a$  takes the parameter value of 2, and  $d_{ij}$  is defined as in equation (2).

Accessibility within metropolitan areas is also largely determined by metro-rail and suburban railway networks. We captured accessibility generated by urban railway networks using an indicator on the basis of integrated metro-rail and suburban railway networks that considers both distance to stations and the centrality of stations within the network. This has proven to be a significant determinant of land valuation in Berlin (AHLFELDT, 2007a, 2007b). Employment accessibility generated by the railway network may thus be interpreted as a proxy for centrality in a more general sense, implicitly capturing shopping, cultural, and other central activities that, due to problems of multicollinearity, may not be modelled explicitly.

Assuming that residents use the nearest station, choose the shortest network connection within the combined metro and suburban railway network, and leave the railway system at the station located closest to their place of work, the generation of employment potentiality basically consists of three steps.<sup>5</sup>

Firstly, the employment potentiality of each station within the network is the distance-weighted sum of surrounding blocks' employment:

$$SP_m = \sum_j E_j e^{(-b d_{mj})}, \quad (7)$$

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<sup>5</sup> The combined Berlin metro and suburban railway network consists of 275 stations and has a length of 475 km. Yearly passenger numbers come to approximately 790 million (2006) [URL: [www.oepnv-berlin.de](http://www.oepnv-berlin.de) (07/01/11)].

where  $SP_m$  is the employment potentiality of station  $m$ ,  $E_j$  is employment at workplaces of block  $j$ ,  $b$  is a distance decay factor taking the value of 2, and  $d_{mj}$  is the straight-line distance between station  $m$  and block  $j$ .

Secondly, employment potentiality generated by the rail network is the distance-weighted sum of the station potentialities of all other stations within the network:

$$NSP_s = \sum_m SP_m e^{(-a d_{sm})}, \text{ for } m \neq s \quad (8)$$

where  $NSP_s$  is the employment potentiality of station  $s$ , which can be thought of as the potential for a resident who lives immediately adjacent to station  $s$  and wishes to commute by rail-based public transportation. Decay parameter  $a$  takes the value of 0.5 to account for train velocity, and  $d_{sm}$  is the shortest network distance between stations  $s$  and  $m$ . Stations' self-potentials are not considered since residents living and working within the catchment area of the same station will obviously not take the train.<sup>6</sup>

Finally, as commuters typically do not live within railway stations, network station potentiality has to be discounted by the distance from the residence in order to reflect the transport costs of walking to the nearest railway station:

$$EP\_Rail_t = NSP_s e^{(-b d_{ts})}, \quad (9)$$

where  $EP\_Rail_t$  is the employment potentiality generated by the urban railway network at the location of transaction  $t$ ,  $b$  takes the value of 2, and  $d_{ts}$  is the distance from transaction  $t$  to the nearest station  $s$ . Combining equations (6) – (8), employment potentiality can be written as:

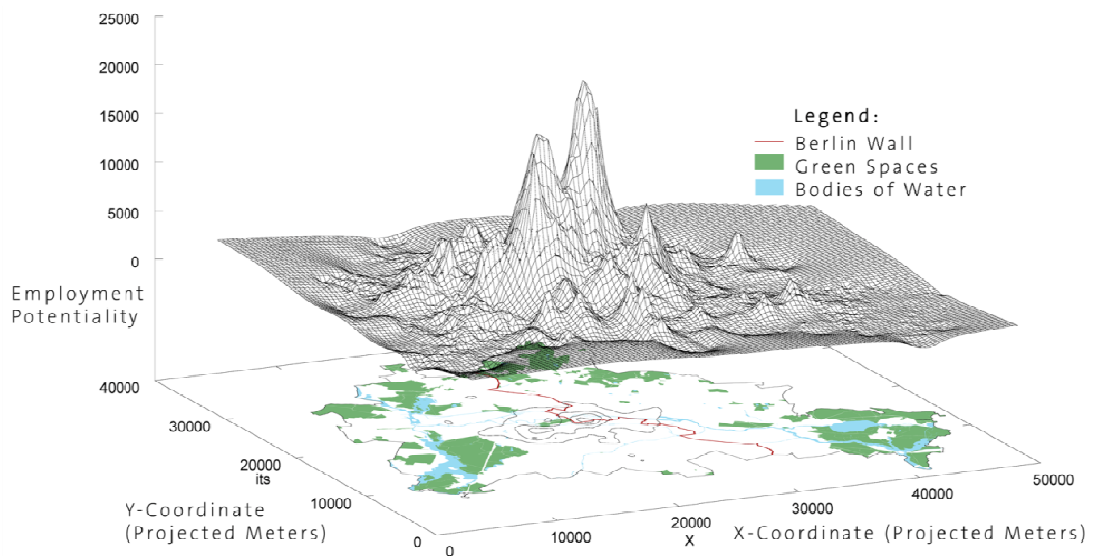
$$EP\_Rail_t = e^{(-b d_{ts})} \sum_m \left( \sum_j E_j e^{(-b d_{mj})} \right) e^{(-a d_{sm})}, \text{ for } m \neq s \quad (10)$$

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<sup>6</sup> The employment potential is captured by the employment access indicator based on walking speed.

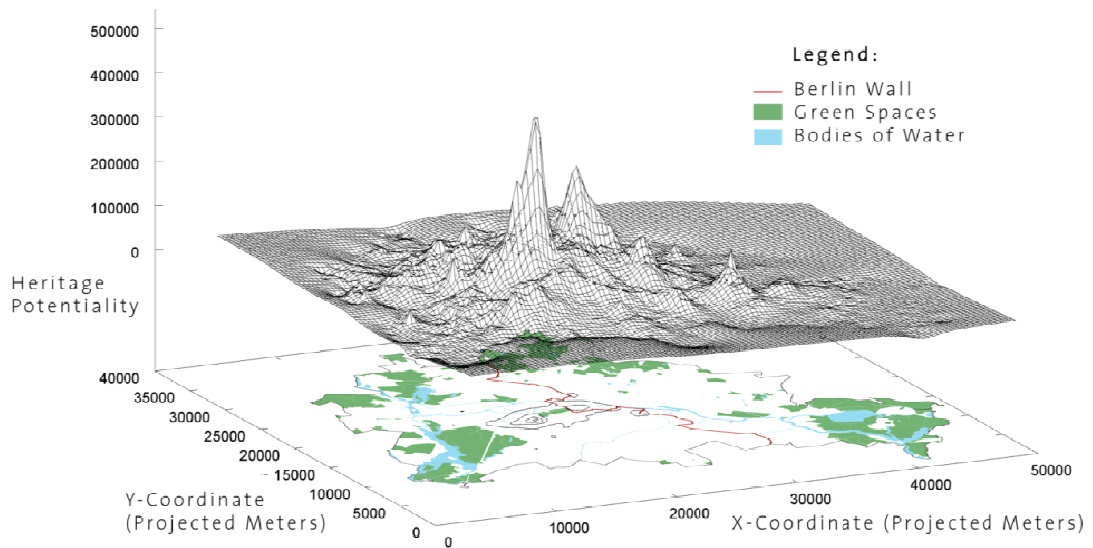
The potentiality concept is also adopted to generate a heritage indicator representing a given location’s endowment with built heritage. We spatially aggregated heritage-listed houses corresponding to equation (3), where  $area_i$  represents the aggregated building area of heritage-listed houses within block  $i$ . Figures 3 and 4 compare employment and heritage potentiality in three-dimensional space. While Figure 2 shows the locations of all heritage-listed properties, the heritage potentiality in Figure 4 illustrates endowment with built-heritage, taking into account all surrounding heritage-listed properties weighted by distance and size for each of 15,937 statistical blocks. The figures reveal a striking similarity, which highlights the high concentration of built heritage in downtown areas, which is typical for European metropolises (BRUECKNER, THISSE, & ZENOU, 1999).

**Fig. 3 Employment Potentiality**



Notes: The figure represents block-level employment potentiality as defined in equation (6) assuming a decay parameter  $a$  of 2. Coordinates refer to the “Soldner” coordinate system used by the Senate Department of Berlin.

**Fig. 4 Heritage Potentiality**



Source: The figure represents block level heritage potentiality as defined in equation (3) assuming a decay parameter  $\alpha$  of 2. Coordinates refer to the “Soldner” coordinate system used by the Senate Department of Berlin.

### 3.3 Empirical Strategy

We followed a standard hedonic approach to assess implicit prices of transaction and location characteristics. Our baseline model was then extended to assess the impact of heritage-listing and the external effects of heritage-listed houses. Two alternative specifications were considered to control for location. In our amenity-based approach we controlled for location using variables that capture accessibility, shopping opportunities, natural amenities, and a set of dummy variables representing area-typical building structures. Neighbourhood was captured by the density and composition of the resident population and by automobile registrations per capita.

$$\log(P_t) = \alpha + TRANSACTION_t a_1 + LOC_t a_2 + NEIGH_t a_3 + HERITAGE_t a_4 + \beta Spatial\_Lag_t + \varepsilon_t, \quad (11)$$

where *TRANSACTION* is a vector of transaction attributes, including unit and contract characteristics, time trends, and monthly dummies. *LOC* is a vector of location attributes capturing accessibility, natural endowments, and availability of public and private services, as discussed in the subsection above. *NEIGH* is a vector capturing block density, the composition of the resident population, and



automobile registrations per capita. *HERITAGE* is a vector of heritage characteristics.  $\alpha$ ,  $\beta$  and  $a_x$  represent the set of coefficients to be estimated and  $\varepsilon$  is a random error Term. *Spatial\_Lag* is a spatial autoregressive term accounting for spatial autocorrelation, which may result when omitted variables are correlated across space or transaction prices are endogenous transactions occurring in the vicinity. The lag term is a distance-weighted average of transactions occurring within the same neighbourhood, and it takes the following form for transaction  $t$ :

$$Spatial\_Lag_t = \sum_u \frac{1/(1/d_{tu})}{\sum_u 1/d_{tu}} P\_sqm_u, \quad (12)$$

where  $P\_sqm_u$  is the sales price per square meter of transaction  $u$  and  $(1/d_{tu})$  represents the inverse of the distance between the centroids of blocks  $t$  and  $u$ . Here, the lag term considers the three nearest transactions in each case, as suggested by CAN & MEGBOLUGBE (1997). To account for spatial correlation affecting the variance of sales prices, we clustered standard errors on statistical blocks (DEHRING, DEPKEN, & WARD, 2007).

In our alternative specification, we chose to control for location non-parametrically by introducing a full set of neighbourhood fixed effects. Two levels of neighbourhoods were specified for robustness tests: traffic cells (“Verkehrszellen”) dividing Berlin into 338 sections, and statistical blocks drawn from the micro-level data used in our amenity-based approach. This specification addressed spatial autocorrelation by allowing for mean-shifting and variance-shifting (DEHRING, DEPKEN, & WARD, 2007). Again, variance was allowed to vary across space by clustering standard errors on the respective level of neighbourhood. Our alternative specification thus took following form:

$$\log(P_t) = \gamma + TRANSACTION_t b_1 + HERITAGE_t b_2 + \mu_t, \quad (13)$$

$$\text{where } \mu_t = \theta_t + \varphi_t$$

*TRANSACTION* and *HERITAGE* are the same as in equation (10),  $\gamma$  and  $b_x$  are coefficients to be estimated, and  $\mu_t$  is a composite zero-mean error term allowing for neighborhood fixed effects ( $\theta_t$ ) and a random component ( $\varphi_t$ ).

Heritage characteristics include dummy variables denoting transactions occurring within heritage-listed buildings to identify whether there are significant price differentials. The external effects of heritage-listed houses are assessed by considering distance to the closest heritage-listed building and heritage potentiality as defined in the subsection above.

## **4 Empirical Results**

### **4.1 Baseline Models**

Complete empirical results from our baseline models are presented in Table A1. Prices increased at a decreasing rate with condominium size. Features such as the number of living rooms and the presence of a balcony, hobby room, roof room, or garage had positive effects on sale prices. We found significantly positive price differentials for penthouses and attic flats, whereas condominiums at or below street level sold at discounts. Age and bad condition also caused price depreciation, with the condominium's condition being more important than the condition of the respective tenement. Agreement details such as the constellation of buyers and sellers also had a significant impact on sale prices. Prices realized in auctions tended to be significantly lower compared to those associated with standard purchasing procedures. Significantly higher prices resulted in transactions where non-profit housing associations, fund companies, religious communities, or other corporate bodies were involved as buyers. In contrast, companies constituted under civil law, public authorities, and other corporate bodies selling properties tended to realize premiums. While rent guarantees and additional joint property raised sale prices, condominiums that were occupied or leased by renters or that belonged to social housing projects sold at discounts.

Our amenity-based approach yielded additional insights about location and neighborhood as determinants of property prices. Positive price differentials are attributable to established areas of low housing density, but not for areas of low housing density covered with buildings in the 1990s. In line with theory, proximity to CBD was highly statistically significant. The significance of shopping potentiality indicates that access to minor shopping centers positively affects location

desirability, while for our sample of condominium transactions no significant effects for employment potentiality corresponding to walking speed and urban railway network were observed. The latter might be attributable to condominium transactions that occur largely within downtown tenement blocks located in areas that are similarly well connected to the railway network. Similar reasoning may explain the statistical insignificance of relative school potentiality. Somewhat surprisingly, the coefficient on green potentiality was significantly negative. Confirming the above mentioned effects of housing density, population density had a significantly negative impact on condominium prices. The coefficient on the proportion of foreign-born residents, which – in Berlin – can be interpreted as a proxy for socially disadvantaged areas, was also significantly negative. In contrast, the coefficient for automobile registrations per capita, presumably positively correlated with income, was significantly positive, as expected.

#### 4.2 Impact of Built Heritage

The baseline models presented in Table A1 are extended by variables that attribute price variation to heritage attributes. Empirical results for extended hedonic models corresponding to our amenity-based approach are shown in Table 1.

**Tab. 1 Results for Extended Models (Amenity-Based Approach)**

	(1)	(2)	(3)	(4)
	Log(Price)	Log(Price)	Log(Price)	Log(Price)
Monument	-0.02143 (0.0217)			-0.01556 (0.03780)
Distance to Monument		-0.02455 (0.03725)		
Heritage Potentiality			0.00533*** (0.00168)	0.00547*** (0.00180)
Spatial Lag	Yes	Yes	Yes	Yes
Fixed Effects	-	-	-	-
Observations	5720	5309	5720	5720
R squared	0.7862	0.7896	0.7904	0.7905

Notes: The basic model is model (1) of Table A1. To save space, results are presented for heritage variables only. Robust standard errors (in parenthesis) are clustered on statistical blocks. \* denotes significance at the 10% level; \*\* denotes significance at the 5% level; \*\*\* denotes significance at the 1% level.

Based on the geographic coordinates of property transactions and a precise electronic map of heritage-listed properties, we defined a dummy variable (Monu-

ment) identifying all property transactions occurring within heritage-listed buildings. In model (1) of Table 1, we introduced this dummy variable into our amenity-based hedonic model environment. The coefficient on *Monument* was not statistically significant at conventional levels, indicating that there were no significant price-differentials for the listed properties. This result suggests that the potentially negative effects of development constraints and maintenance obligations may be cancelled out by the potentially positive effects from tax abatement, the intangible value of historic importance, and aesthetic appeal.

To assess whether the external effects of heritage-listed buildings capitalize into property prices, we introduced shortest straight-line distances to heritage-listed buildings (*Distance to Monument*) and heritage potentiality as defined in the methodological section. To avoid bias, we excluded transactions occurring within heritage-listed buildings when assessing the impact of distance to the closest monument. The results shown in column 2 of Table 1 reveal that simple proximity to the closest monument was not a significant price determinant.

However, the coefficient on heritage potentiality, which takes into account all neighboring monuments weighted by distance and size, was highly statistically significant (column 3, Table 1). Thus, positive external effects due to heritage-listed buildings become measurable when considering the whole ensemble of monuments within the neighborhood. This dimension has to be considered when assessing price differentials for heritage-listed properties. Since monuments are likely to cluster, a positive impact on property prices may erroneously be attributed to a property being heritage-listed, when in fact it is benefiting from external effects due to neighboring monuments. Therefore, in column 4 of Table 1, we reassessed price differential for heritage-listed properties while controlling for monuments within the neighborhood by heritage potentiality. The results proved to be robust in that we found no significant impact of heritage listing, even though a neighborhood containing many heritage-listed buildings is perceived as a valuable location amenity.

In Table 2, we repeated the estimates from Table 1 while controlling for location non-parametrically using a full set of block fixed effects. The baseline specifica-

tion corresponds to column 2 of Table A1. The pattern of impact is analogous to that in Table 1, providing evidence for the estimates’ robustness. The results were also robust to changing levels of neighborhood fixed effects. Extended models for baseline specification with traffic cell fixed effects are presented in Table A2 in the appendix.

**Tab. 2 Results for Extended Models (Statistical Block Fixed Effects)**

	(1)	(2)	(3)	(4)
	Log(Price)	Log(Price)	Log(Price)	Log(Price)
Monument	0.01153 (0.04503)			0.01153 (0.04503)
Distance to Monument		0.54481 (0.35097)		
Heritage Potentiality			0.04726*** (0.00328)	0.04727*** (0.00329)
Spatial Lag	-	-	-	-
Fixed Effects	Stat. Blocks	Stat. Blocks	Stat. Blocks	Stat. Blocks
Observations	5769	5324	5769	5769
R squared	0.8977	0.8998	0.8977	0.8977

Notes: Variables are defined as in Table 1. The basic model is model (2) of Table A1. To save space results are presented for heritage variables only. Robust standard errors (in parenthesis) are clustered on traffic cells. \* denotes significance at the 10% level; \*\* denotes significance at the 5% level; \*\*\* denotes significance at the 1% level.

## 5 Conclusion

This study adds to the discussion on the value of built heritage by a) making use of GIS-tools, detailed transaction data, and highly disaggregated data on location and neighborhood, and b) assessing the internal *and* external price impacts of heritage listing. While no significant price differentials were found for heritage-listed buildings, indicating that positive and negative effects cancel each other out, compelling evidence was found that built heritage positively affects the prices of surrounding properties. Given that properties are chosen for heritage listing due to outstanding architectural quality (CREIGH-TYTE, 1998), there is evidence for architecture representing a source of positive externalities capitalizing into the prices of neighboring properties.

Our results proved to be robust to changes in model specifications, and they controlled for neighboring monuments when assessing the impact of heritage listing.

In light of our results, future research on the impact of heritage listing should focus on the built heritage environment. Considering that monuments are likely to cluster, property values may appear to be raised by heritage listing, when in fact, the owners of heritage-listed properties are benefiting from external effects due to neighboring monuments. This distinction is crucial when determining whether owners of heritage-listed houses are appropriately compensated for legal constraints and obligations. Indeed, our results suggest that the legal system should incentivize the conservation of monuments because of their positive external effects on the neighboring community.

One important finding from this study is that it is worth conserving the fabric of built heritage as a whole. While the aesthetic appeal of particular buildings of historical importance may be indisputable, our results suggest that, more than proximity to a single monument, it is the totality of the built environment that constitutes the amenity recognized by real estate markets. Thus the urban environment adheres to a principle stated by Aristotle over 2000 years ago in a more general context: *“The whole is more than the sum of its parts”*.

## Appendix

Tab. A1 Results for Baseline Models (I-V)

	(1) Log(Price)	(2) Log(Price)	(3) Log(Price)
Block Development	0.13748 (0.17644)	-0.02602 (0.40750)	0.20810 (0.18204)
Row Development	0.17211 (0.17747)	0.00126 (0.41744)	0.23519 (0.18427)
Detached Houses	0.21936 (0.17502)	0.03649 (0.41059)	0.31241* (0.17992)
Semidetached Houses	0.27822 (0.18816)	-0.26553 (0.27916)	0.35581* (0.19386)
Row Houses	0.33924* (0.18680)	-0.02161 (0.30026)	0.45759** (0.18243)
Yard Development	0.11841 (0.17746)	-0.07511 (0.40914)	0.20894 (0.18306)
Tenement Stories	0.00491 (0.00861)	0.01282 (0.02698)	0.01709 (0.01413)
Tenement Stories squared	-0.00060** (0.00030)	-0.00133 (0.00150)	-0.00167** (0.00069)
Tenement Size (10,000 m <sup>2</sup> )	0.06953** (0.03486)	0.10233 (0.10681)	0.06570 (0.04917)
Tenement Size (10,000 m <sup>2</sup> ) squared	-0.01423 (0.01147)	-0.03947 (0.02512)	-0.00180 (0.02114)
Commercial Area (10,000 m <sup>2</sup> ) in Tenement	-0.03821 (0.13092)	-0.24070 (0.69647)	-0.41807 (0.25797)
Elevator	0.00819 (0.01573)	0.02390 (0.03234)	0.02613 (0.02218)
Below Street Level	-0.39646*** (0.12816)	-0.25004 (0.18607)	-0.24016* (0.13789)
Street Level	-0.05793*** (0.01667)	-0.03612* (0.02144)	-0.04520** (0.01785)
Story	0.00386 (0.00394)	0.00883** (0.00430)	0.00741 (0.00452)
Penthouse	0.53326*** (0.17101)	0.39886* (0.23406)	0.45669*** (0.14051)
Maisonette	-0.03062 (0.04588)	-0.00600 (0.05275)	-0.01170 (0.04593)
Attic Flat	0.12792*** (0.02790)	0.09524** (0.04708)	0.12337*** (0.03216)
Terrace Flat	0.11391 (0.24147)	-0.31078 (0.23558)	0.11160 (0.23197)
Shop Flat	-0.03341 (0.10990)	-0.00597 (0.18247)	0.10894 (0.14938)

**Tab. A1. Results for Baseline Models (II-V)**

	(1) Log(Price)	(2) Log(Price)	(3) Log(Price)
Homestead	-0.01011 (0.07273)	0.27174 (0.36294)	0.02316 (0.08777)
Size (sqm)	0.02201*** (0.00100)	0.02353*** (0.00140)	0.02253*** (0.00104)
Size (sqm) squared	-0.00005*** (0.00000)	-0.00006*** (0.00001)	-0.00005*** (0.00000)
Number of Living Rooms	0.01921** (0.00855)	0.01892 (0.01410)	0.01838* (0.01058)
Pantry Kitchen	0.10414* (0.05830)	0.19216 (0.11989)	0.07500 (0.07766)
Vestibule	0.01072 (0.01452)	0.01688 (0.02491)	-0.01097 (0.01803)
Store Room	-0.00624 (0.01218)	0.00808 (0.01952)	-0.00573 (0.01535)
Balcony	0.03784*** (0.01237)	0.03571* (0.01892)	0.03513** (0.01615)
Artist Studio	-0.08044 (0.17880)	0.13685 (0.21607)	0.01866 (0.16319)
Hobby Room	0.13434*** (0.04426)	0.11668 (0.09236)	0.11330*** (0.04208)
Basement Room	-0.01575 (0.01358)	-0.01900 (0.03420)	-0.02958 (0.01797)
Roof Room	0.14070*** (0.04385)	0.09796 (0.10246)	0.09138 (0.05878)
Garage	0.04692 (0.03146)	-0.04867 (0.07598)	0.07715** (0.03794)
Parking Lot	0.04027 (0.02615)	-0.01840 (0.04725)	0.04434 (0.03590)
Easement at Plot	0.06465** (0.02854)	0.04255 (0.03942)	0.11554*** (0.03028)
Age	-0.00258*** (0.00099)	-0.00611* (0.00339)	-0.00408*** (0.00155)
Age squared	0.00002*** (0.00001)	0.00005* (0.00003)	0.00003*** (0.00001)
Condominium in Bad Condition	-0.40715*** (0.06380)	-0.45467*** (0.10238)	-0.46389*** (0.07347)
Tenement in Bad Condition	-0.16155 (0.18924)	-0.45315* (0.27273)	-0.42073** (0.17038)
Exchange	-0.18819*** (0.07274)	1.15961*** (0.12484)	-0.05927 (0.06054)
Compulsory Auction	0.15157 (0.10458)	0.06886 (0.14673)	0.08346 (0.12594)



**Tab. A1. Results for Baseline Models (III-V)**

	(1) Log(Price)	(2) Log(Price)	(3) Log(Price)
Private Auction	-0.20773*** (0.05493)	0.02250 (0.10786)	-0.15579** (0.06493)
Buyer is Comp. Const. Under Civil Law	-0.01512 (0.06329)	-0.04514 (0.08057)	0.01648 (0.07397)
Buyer is Non-Profit Housing Association	-0.16502*** (0.03419)	-0.27354*** (0.03022)	-0.24893*** (0.04706)
Buyer is Insurance Company	-0.37054 (0.50866)	-0.76683 (0.56646)	-0.29204 (0.49842)
Buyer is other Corporate Body	-0.20679*** (0.02501)	-0.25445*** (0.04783)	-0.24126*** (0.03581)
Seller is Comp. Const. Under Civil Law	0.07812*** (0.02836)	0.08593 (0.06271)	0.10641** (0.04262)
Seller is Public Fund	-0.17674*** (0.05173)	1.01822*** (0.13417)	-0.25469*** (0.06115)
Seller is Non-Profit Housing Association	0.00530 (0.02676)	-0.07658 (0.06207)	-0.00057 (0.05052)
Seller is Public Authority	0.10399** (0.04669)	0.16937*** (0.03985)	0.16745*** (0.05834)
Seller is Fond Company	-0.38022*** (0.04010)	-0.12144 (0.08841)	-0.09183* (0.04816)
Seller is other Corporate Body	0.14357*** (0.01871)	0.15877*** (0.03989)	0.21059*** (0.02549)
Seller Religious Community	-0.11022 (0.13728)	-0.30940*** (0.11955)	-0.24485* (0.14824)
Seller is Public Housing Association	0.07028* (0.04105)	0.12309 (0.08023)	0.13177** (0.06623)
Condominium is Occupied by Renter	-0.04492*** (0.01469)	-0.05844** (0.02557)	-0.05133** (0.02449)
Condominium is Leased	-0.18208*** (0.03145)	-0.21035*** (0.04472)	-0.23803*** (0.04232)
Social Housing	-0.06297*** (0.01972)	-0.10796** (0.05316)	-0.07338** (0.03150)
Tax Privileged Housing	-0.06160 (0.03752)	-0.10888 (0.11735)	-0.06546 (0.04208)
Rent Regulation	0.09939 (0.06964)	0.27646 (0.20493)	0.06101 (0.10893)
Rent Guarantee	0.09648*** (0.03034)	0.07764* (0.04150)	0.18228*** (0.03988)
Additional Joint Property	0.00479*** (0.00140)	0.01009** (0.00417)	0.00428*** (0.00145)

**Tab. A1. Results for Baseline Models (IV-V)**

	(1) Log(Price)	(2) Log(Price)	(3) Log(Price)
Predominant Building Structure is Prefabricated Housing Post-War	0.01509 (0.02481)		
Predominant Building Structure is Low Density Wilhelminian Style	-0.00101 (0.02575)		
Predominant Building Structure is High Density Wil. Style with Modifications	0.03428 (0.02691)		
Predominant Building Structure is High Density Wil. Style	0.01948 (0.02448)		
Predominant Building Structure is Post-War Villas	0.13216*** (0.04203)		
Predominant Building Structure is Low Density Early 20 <sup>th</sup> Cent. Detached	0.02784 (0.03170)		
Predominant Building Structure is Low Density 1990 <sup>th</sup>	-0.11987** (0.04880)		
Predominant Building Structure is High Density Post War	0.01126 (0.04020)		
Predominant Building Structure is Low Density Post War	0.07955** (0.03676)		
Predominant Building Structure is Village-like	0.12020*** (0.03633)		
Predominant Building Structure is Block Development 1920s and 1930s	0.01529 (0.02759)		
Predominant Building Structure is Prefabricated 1980s and 1990s	-0.07404 (0.06903)		
Predominant Building Structure is High Density 1990s	-0.13539 (0.10427)		
Shopping Potentiality (10,000 sqm)	0.00923** (0.00426)		
Water Potentiality (10,000 sqm)	0.00006 (0.00087)		
Green Potentiality (10,000 sqm)	-0.00075** (0.00034)		
Relative School Potentiality	4.23956 (3.01713)		
Min. Distance to CBD West and East (km)	-0.02191*** 0.00297		
Rail Employment Potentiality (10,000)	-0.00036 (0.01145)		
Employment Potentiality (10,000) Walking Speed	0.01326 (0.01487)		
Population Density (Inhabitants/sqkm)	-0.00000** (0.00000)		
Proportion Pop. under 6 Years Old (%)	-0.00246 (0.00286)		

**Tab. A1. Results for Baseline Models (V-V)**

	(1) Log(Price)	(2) Log(Price)	(3) Log(Price)
Proportion Pop. 6 – 15 Years Old (%)	-0.00209 (0.00206)		
Proportion Pop. 15 – 18 Years Old (%)	-0.00724*** (0.00204)		
Proportion Pop. 18 – 27 Years Old (%)	-0.00039 (0.00143)		
Proportion Pop. 65 Years and Older (%)	-0.00080 (0.00094)		
Proportion Foreign Population	-0.00336*** (0.00088)		
Automobile Registrations per Capita	0.00037*** (0.00006)		
Spatial Lag	Yes		
Fixed Effects		Stat. Blocks	Traffic Cells
Observations	5720	5769	5769
R squared	0.7900	0.8977	0.7860

Notes: Endogenous Variable is log of sales prices in all models. All models include daily time trend and monthly dummy variables. Spatial lag is a spatial autoregressive term representing the distance-weighted average of sales price per square meter of the three nearest condominium transactions, converted to a logarithm. Standard errors are clustered on statistical blocks in models (1) and (2) and traffic cells in model (3). Standard errors (in parenthesis) are heteroscedasticity robust. \* denotes significance at the 10% level; \*\* denotes significance at the 5% level; \*\*\* denotes significance at the 1% level.

**Tab. A2. Results for Extended Models (Traffic Cell Fixed Effects)**

	(1) Log(Price)	(2) Log(Price)	(3) Log(Price)	(4) Log(Price)
Monument	-0.02213 (0.02953)			-0.02927 (0.02925)
Distance to Monument		0.03902 (0.11415)		
Heritage Potentiality			0.01109*** (0.00510)	0.01165*** (0.00512)
Spatial Lag				
Fixed Effects	Traffic Cells	Traffic Cells	Traffic Cells	Traffic Cells
Observations	5769	5324	5769	5720
R squared	0.7860	0.7877	0.7870	0.7905

Notes: Variables are defined as in Table 1. The basic model is model (3) of Table A1. To save space results are presented for heritage variables only. Robust standard errors (in parenthesis) are clustered on traffic cells. \* denotes significance at the 10% level; \*\* denotes significance at the 5% level; \*\*\* denotes significance at the 1% level.

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