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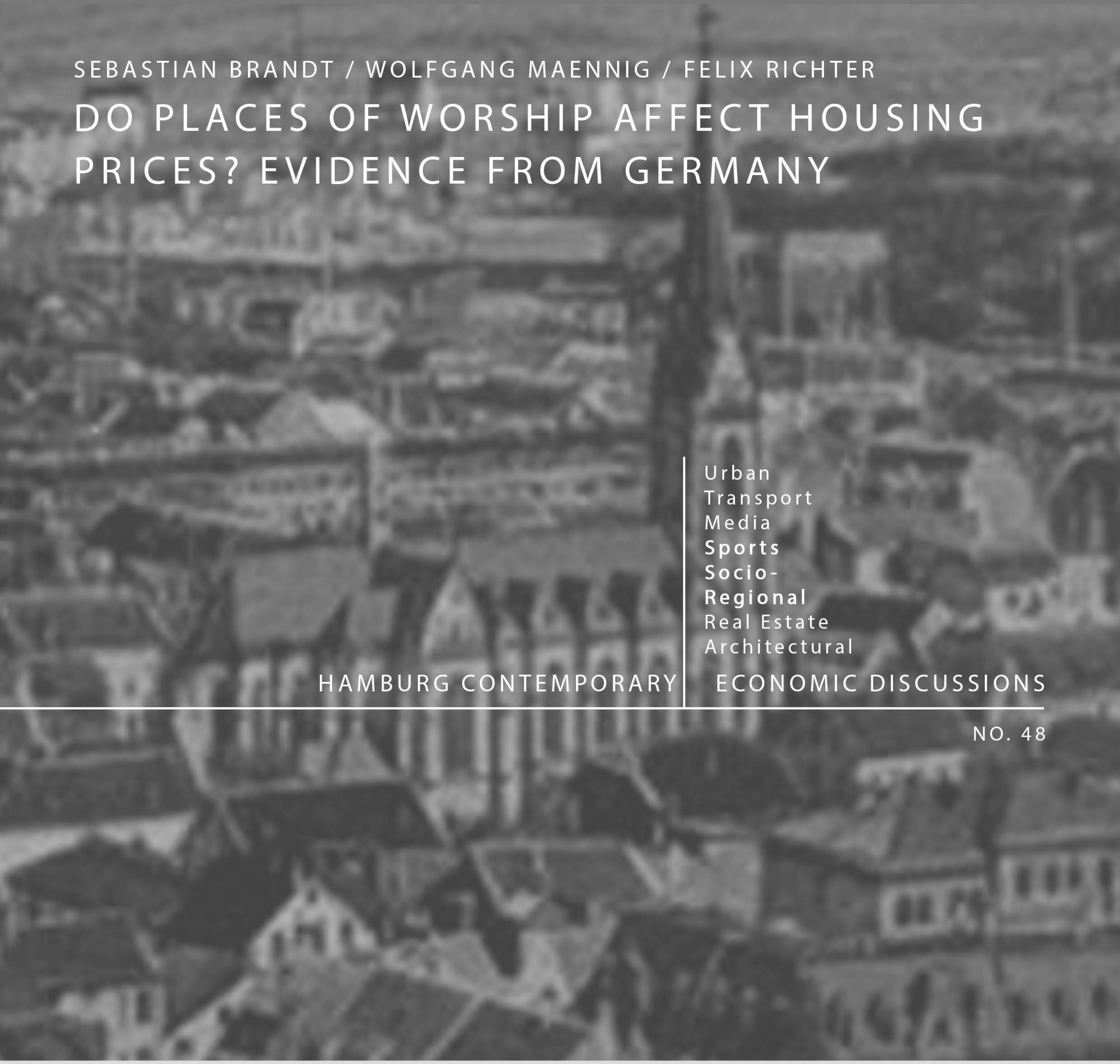

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DO PLACES OF WORSHIP AFFECT HOUSING PRICES? EVIDENCE FROM GERMANY

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Do places of worship affect housing prices? Evidence from Germany

Abstract: Using hedonic pricing models, this paper analyzes the impact of places of worship on the prices of adjacent condominiums in Hamburg, Germany. This is the first study on this subject to have been conducted outside the United States. It is also the first work to examine the externalities of places of worship of all five world religions. Furthermore, it is the first study that analyzes the effect of bell ringing on the adjacent residential property prices. Controlling for spatial dependence and by using potentiality variables positive externalities of places of worship within a radius of 1,000m were identified. Compared to properties beyond this threshold, price premiums of 4.8% were detected for condominiums at distances of 100m to 200m to the next place of worship. The results also show that the positive externalities near mosques do not differ from those of places of worship of other religions and that the positive effect of churches continues to be felt even after they have been deconsecrated. The influence of church bell ringing on the prices of surrounding residential properties, however, could not be substantiated.

Keywords: hedonic pricing, places of worship, external effects, residential property prices, Hamburg.
JEL classification: R12; R21; R31; R34; Z12
Version: January 2013

1 Introduction

The fact that places of worship (POWs) create externalities is not disputed in the literature or by local residents. However, there is disagreement on whether the externalities are positive or negative. While Do, Wilbur, and Short (1994) have identified a negative effect of churches on adjacent residential property prices, Carroll, Clauretie, and Jensen (1996) find a positive effect of churches on the prices of nearby single-family houses. While complaints from local residents against liturgical ringing or the marking of time by bells keep the courts busy, the discussion on the construction of minarets and the muezzin's call have triggered political debates. Possible further negative externalities of places of worship, such as noise caused by the arrival or departure of visitors or through community and cultural events, as well as architectural disharmony with the surrounding buildings are also being considered (Do, Wilbur, and Short 1994). Possible positive externalities are visual amenities that originate in Hamburg from the many old churches built in the 19th century and the green belt that surrounds many of these places of worship. Other positive effects could be created by access to services, community events and recreational activities for the young and old (Carroll, Clauretie, and Jensen 1996; Do, Wilbur, and Short 1994), as well as by the reduction in crime rates (Lee and Ousey 2005).

The fact that residential property markets value externalities of churches has been confirmed on the basis of hedonic pricing only in a few studies on U.S. markets.[1] Do, Wilbur, and Short (1994) observed a negative influence of churches on the prices of neighboring single-family homes within a radius of approx. 850 feet in a community in the metropolitan region of San Diego, California. Maximum price discounts identified amount to 3.0%. These findings are contradicted by Carroll, Clauretie and Jensen (1996), who found a positive influence of churches on the prices of single-family homes in the neighborhood in Henderson, Nevada, where the primary effect was felt at a distance of up to 2,910 feet. Properties that are only 100 feet, rather than 2,910 feet, from the nearest church experience price premiums of 3.1%. Bielefeld et al. (2006) observed price increases of 5.1% for residential properties in Marion County, Indiana, if they were located within a radius of one mile of at least four religious nonprofits. In Cleveland, Ohio, Ottensmann (2000) noted for census tracts with, or close to, a building of the Catholic diocese higher mean values of owner-occupied housing by 6.4%. One reason for the divergent results of different studies may lie in the different levels of religiosity of the local population[2]. The findings of Do, Wilbur, and Short (1994), which differ from other studies, could also be explained by methodological shortcomings of their study (for details, see Carroll, Clauretie, and

[1] However, over the past decades studies on the effects of externalities have commonly relied on the hedonic pricing technique. The impact on residential property prices has in recent years been analyzed using the hedonic framework, e.g., for air noise (e.g., Cohen and Coughlin 2009; McMillen 2004), road noise (e.g., Wilhelmsson 2000), rail noise (e.g., Clark 2006), (air) pollution (e.g., Decker, Nielsen, and Sindt 2005; Kim, Phipps, and Anselin 2003), rail transit stations (Bowes and Ihlanfeldt 2001), built heritage (e.g., Ahlfeldt and Maennig 2010) and school attributes (e.g., Clark and Herrin 2000).

[2] For a comparison of the proportion of regular churchgoers in U.S. states, cf. Newport (2010).

Jensen (1996)). The authors are not aware of studies on the externalities of places of worship other than churches.

Hamburg today is a cosmopolitan metropolis, where followers of all five world religions have settled and built their places of worship. Churches dating back to two construction periods characterize the cityscape of Hamburg. On the one hand, there are a large number of churches from the late 19th century and early 20th century, reflecting the quick economic development of the port city. Accordingly, four of the fifteen tallest churches in the world are located in Hamburg. On the other hand, the two post-war decades between 1950 and 1970 resulted in a number of churches being built in the city. Today, however, it is mostly Lutheran communities that now experience difficulty in paying the operating costs for their churches from their community budgets. This has to do with the high number of people leaving the Lutheran church in recent years and decades, resulting in lower revenue from the church tax, as well as with the increase in energy and maintenance costs of church buildings (Konerding 2007)[3]. Consequently, as many as eleven Lutheran churches have been[3] deconsecrated and then taken over by other denominations, rededicated or demolished (Ulrich 2010a). Numerous church buildings will likely meet the same fate in coming years (Benedict 2007).

After the Christians, Jews have lived the longest in Hamburg. The first arrived at the end of the 16th century (Bauche 1991). During Nazi rule, all synagogues in Hamburg were vandalized and subsequently rededicated, torn down or destroyed in the war. In 1960, the re-constituted Jewish community opened a new - and to date, the only - synagogue in Hamburg. After the Jews came the Buddhists, who founded their first association in 1906 (den Hoet 2006). Today there are six temples in Hamburg, where followers of the different Buddhist schools congregate. The first mosque in Hamburg was built in 1957, followed by many others over the following decades. Of the more than fifty mosques in Hamburg, during the study period only three had a dome and/or minarets that clearly

[3] Particularly the buildings of the two post-war decades constructed with concrete and its new structural possibilities show a high structural sensitivity (Konerding 2007), which necessitates high maintenance costs over the short and medium term.

identified them as mosques to the outside world. Most mosques in Hamburg are housed in former commercial facilities or warehouses. The muezzin's call cannot be heard outside the Hamburg mosques. The last of the five world religions to settle in Hamburg were the Hindus in 1969 (Ulrich 2010a). They have set up two temples in former commercial facilities.

This study examines three current issues regarding the externalities of places of worship, which, to the authors` knowledge, have not been studied in the literature yet:

1) Against the background of the current political and social debate on the building of new minarets and the public call of the muezzin, the answer to the question whether mosques affect prices of adjacent residential properties differently than the places of worship of other religions could provide new stimulus for the debate.

2) In recent years, a number of churches have had to be closed down due to declining congregations. In light of the fact that more communities will have to abandon their church buildings in coming years (Benedict 2007), the question whether the externalities of buildings used for worship have different effects than deconsecrated church buildings was addressed. The answer to this question might be of useful help in deciding whether to tear down or rededicate a former church building.

3) Third, the question whether church bells affect the prices of residential properties was examined. The results can form the basis of a solution for some of the disputes being fought in court over bell ringing in residential areas.

Section 2 describes the data on which the study is based. Section 3 provides a description of the hedonic models used. The results are presented in Section 4. A summary and conclusion are provided in Section 5.

2 Data

Housing price studies widely rely on sales prices for single- and two-family homes. This paper departs from this approach by using prices of condominiums, which make up the largest share of transactions involving residential properties in Hamburg (Committee of Valuation Experts in Hamburg 2009) and by using listing prices instead of sales prices.[4] Using list prices may cause problems if the difference between the offer and transaction price is correlated with a condominium's physical characteristic or groups of characteristics.

Knight (2002) as well as Merlo and Ortalo-Magné (2004) show that the difference between offer and transaction prices is greater the longer a property is on the market. If we observed a correlation between time on market and distance to the closest place of worship, an unsystematic variance of the difference between listing and sales prices in relation to the distance to the closest place of worship would, thus, be doubtful. Here the Pearson correlation coefficient for time on market and distance to next place of worship, however, is small (0.015) and insignificant at conventional levels.[5] For the condominium market in Hamburg, where the average differential between listing and transaction prices is approx. 8%, no systematic variance of this difference for properties of different age, size or price category has been observed.[6] Since this paper uses semi-logarithmic forms, which reflect relative – and not absolute – changes in property prices for an additional unit of a characteristic, the offer prices should yield unbiased coefficients.

The study area comprises the entire city of Hamburg, which has an area of 755.2 km² and at the end of the study period a population of 1.767 million (March 31,

[4] In fact, in Germany a Committee of Valuation Experts that collects sales prices of housing units is located in every county. But in practice strict data protection regulations and high fees make it difficult to get access to detailed datasets of actual sales prices containing information on property's addresses.

[5] Grether and Mieszkowski (1974) also note that it is reasonable to assume that missing information on property characteristics, which may be connected to the use of offer data, does not give rise to a systematic bias of coefficients.

[6] Unpublished study of F+B GmbH from the year 2002. To the authors' knowledge, there have not been any further studies on the influence that property characteristics or the location of a property have on the difference between offer and transaction prices.

2008). Hamburg is the second largest city in Germany, both in terms of its area and population. The primary source of data for this study is a dataset supplied by F+B GmbH that contains 4,832 listing prices for condominiums in Hamburg that were put up for sale on Internet portals between April 1, 2002 and March 31, 2008. All datasets contain information on the year of construction, size of the condominium, listing price and date, time on market, the complete address of the property as well as information on the characteristics of the condominium. Using a directory supplied by the Hamburg Office for Urban Development and the Environment (BSU), each address was allocated to one of the 938 statistical districts of Hamburg. A statistical district is the smallest statistical unit for which the Statistics Office of Hamburg collects demographic and socioeconomic population data.[7] In addition, GIS was used to calculate distances between properties and public infrastructure (such as train stations, schools, kindergartens and shopping), bodies of water, green spaces and jobs. Employing small-scale datasets on the noise pollution caused by road, air and rail traffic supplied by the BSU, property-specific noise pollution levels in dB(A) were determined.

Data on the addresses, religious affiliations and heights of Hamburg places of worship were collected in numerous sources. Using GIS, we geo-coded the locations of places of worship, assigned to each condominium the nearest place of worship and measured the distance between the two. Also, the floor space of each place of worship was estimated by means of aerial photographs. In addition, all church communities in Hamburg were contacted to determine whether or not a church has bells. For each church with bells, information was collected on whether they are used to mark the time (hourly, half-hourly or every fifteen minutes) and whether the marking of time of the church clock is turned off at night.[8]

[7] All population data refer to the year in which the property was offered for sale most recently. The information regarding average income, however, was available only for 1995.

[8] For descriptive statistics of POW indicators see Table 3 and Table 4 in the appendix.

3 Empirical Methodology

Choice of functional form

The choice of the proper parametric form of the hedonic regression equation is the subject of several publications (e.g., Bartik 1987; Cassell and Mendelsohn 1985; Cropper, Deck, and McConnell 1988; Halvorsen and Pollakowski 1981). However, since their advantage of allowing for non-linearity effects as well as intuitive interpretation of coefficients housing studies commonly rely on semi-logarithmic functional forms. In recent years, authors have tended to use flexible forms such as the Box-Cox transformation (Box and Cox 1964). But, so far, the literature has not overcome the problems of implementing flexible functional forms in the presence of spatial dependence (Kim, Phipps, and Anselin 2003). As the models described below consider spatial-lag terms, this paper relies on semi-logarithmic functional forms.

Spatial dependence

By introducing a spatial lag term (*AUTOREG*) it is assumed that listing prices also depend on the prices of the properties previously put up for sale in the neighborhood (Ahlfeldt and Maennig 2010). Owing to the nature of listing prices, which are generally guided by neighboring property prices, the spatial lag model is favored over the spatial error model, which assumes that spatial autocorrelation emerges from omitted variables that follow a spatial pattern (Kim, Phipps, and Anselin 2003). For condominium *i* the value of the lag term is equivalent to the prices weighted by $w_{ij} = (1/d_{ij}) / \Sigma_j 1/d_{ij}$ of the surrounding *j* summed-up apartments, when $1/d_{ij}$ is the reciprocal distance between the condominiums *i* and *j* (Can and Megbolugbe 1997):[9]

[9] Can and Megbolugbe (1997) consider properties within a radius of 3 kilometers if the surrounding properties were sold in the previous six months. However, their study area covers a large-area suburban county in the metropolitan region of Miami. Regarding the small-scale housing market in Hamburg, it is reasonable to assume that the offer price of a condominium is affected only by prices of properties that are located in the immediate vicinity. However, *AUTOREG* was computed using various critical distances (0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 7.5

$$AUTOREG_i = \sum_j \frac{(1/d_{ij})}{\sum_j 1/d_{ij}} P_{j,t-m}, \; m = 1,...,12; \; j = 1,..., N; d_{ij} \leq 1\,km. \quad (1)$$

Model 1

All models employ hedonic approaches that control for property, neighborhood, accessibility and noise indicators. Furthermore, Model 1 takes into account the proximity to POWs measured by a potentiality variable and can be written as:

$$\ln(P) = \alpha + \beta\ PROP + \gamma\ NEIGH + \delta\ ACCESS + \eta\ NOISE\_VIS\_DIS + \theta\ AUTOREG + \lambda\ TREND + \mu\ POW\_POTENTIALITY + \varepsilon, \quad (2)$$

where α, β, γ, δ, η, θ, λ and μ are the coefficients to be estimated and ε is an error term. Property characteristics are captured by the vector *PROP* that includes information regarding age and size – which are considered in both linear form and with an additional quadratic term (e.g., Rickman 2009) – as well as dummy variables for the property's physical attributes.[10] *NEIGH* is a vector of neighborhood characteristics, consisting of the proportion of those aged 65 and older (*ELDERLYPOP*), the average income (*INCOME*), the proportion of foreign population (*FOREIGNPOP*) as well as the number of social housing units per 1,000 inhabitants (*SOCHOUSE*). Descriptive statistics of the variables included in the final model specifications are listed in Table 1.

and 10.0 km) and the best fit of the model was found when considering properties within a radius of 1 km. In contrast to Can and Megbolugbe (1997), who take into account surrounding properties if they were sold in the previous six months, given the relatively low volatility of the condominium market in Hamburg during the study period, it is reasonable to include properties in the neighborhood that were offered for sale within the previous 12 months.

[10] In selecting the property variables, we widely follow Sirmans, Macpherson, and Zietz (2005) as well as Wilhelmsson (2000), who evaluated the control variables most commonly used in hedonic studies.

Table 1 Variable Names, Definitions and Summary Statistics

Variable	Definition	Mean	Std. dev.
Dependent variable			
PRICE	Last asking price of property	193,897	177,747
Property			
SIZE	Living area in square meters	81.78	47.10
AGE	Age of property in years	39.41	35.25
ROOMS	Number of rooms	2.79	1.73
GARAGE	1 if property has a garage, 0 otherwise	0.52	0.50
BALCONY	1 if property has a balcony, 0 otherwise	0.82	0.38
TERRACE	1 if property has a terrace, 0 otherwise	0.77	0.42
KITCHEN	1 if property has a built-in kitchen, 0 otherwise	0.65	0.48
POOL	1 if property has a pool, 0 otherwise	0.03	0.16
FIREPLACE	1 if property has a fireplace, 0 otherwise	0.04	0.20
GOODCOND	1 if property is in good condition, 0 otherwise	0.13	0.34
BADCOND	1 if property is in bad condition, 0 otherwise	0.06	0.24
Neighborhood			
ELDERLYPOP	Proportion of population in statistical district that is 65 years or older	18.93	6.73
INCOME	Mean income of population in statistical district (in 1,000 €)	34.80	15.18
FOREIGNPOP	Proportion of foreign population in statistical district	13.06	6.64
SOCHOUSE	Number of social housing units per 1,000 inhabitants in statistical district	40.65	62.27
Access			
DIST_CENT	Distance to next sub center according to zoning plan (in kilometers)	1.16	0.82
EMPGRAV	District proximity to employment (measured by a gravity variable)	145,867	43,925
DIST_STAT	Distance to next metro station (in kilometers)	0.78	0.54
DIST_WATER	Distance to closest of the bodies of water Elbe and Binnen-/Aussenalster (in kilometers)	4.68	3.67
DIST_PARK	Distance to next park, forest or nature protection area (in kilometers)	0.69	0.51
DIST_SCH	Distance to next school (in kilometers)	0.40	0.22
Noise exposure / visual intrusions			
WIDEROAD	1 if property is located on a wide road (with at least two lanes per driving direction), 0 otherwise	0.08	0.27
NOISE_ROAD	Road noise in dB(A) as measured by a L_{DEN} index	56.67	11.69
NOISE_AIR	Air noise in dB(A) as measured by a L_{DEN} index if property is located within noise protection zone 2 (≥ 67 dB(A)) or 3 (≥ 62 dB(A)) around Hamburg airport, 0 otherwise	2.19	10.95
NOISE_RAIL	Rail noise in dB(A) as measured by a L_{DEN} index if property is located in the vicinity of rail tracks, 0 otherwise	9.20	20.78
DIST_IND	Distance to next industrial area (in kilometers)	0.55	0.46

Table 1 (Continued)

Variable	Definition	Mean	Std. dev.
Place of worship			
POW_POTENTIALITY	POW potentiality variable as defined in equation (4)	196.01	228.48
DIST_POW_100	1 if distance to next POW ≤ 100m, 0 otherwise	0.05	0.21
DIST_POW_100_200	1 if distance to next POW > 100m and ≤ 200m, 0 otherwise	0.14	0.35
DIST_POW_200_400	1 if distance to next POW > 200m and ≤ 400m, 0 otherwise	0.35	0.48
DIST_POW_400_600	1 if distance to next POW > 400m and ≤ 600m, 0 otherwise	0.24	0.43
DIST_POW_600_1000	1 if distance to next POW > 600m and ≤ 1,000m, 0 otherwise	0.18	0.39
MOSQUE	1 if next POW is a mosque, 0 otherwise	0.04	0.19
DECON	1 if next POW is a deconsecrated church, 0 otherwise	0.05	0.21
CHIME_DAY_	Index of chime during day as defined in equation (8)	0.00063	0.00920
CHIME_NIGHT_ POTENTIALITY	Index of chime during day as defined in equation (9)	0.00029	0.00741

Access to jobs is measured by a gravity variable (Bowes and Ihlanfeldt 2001) that weights the number of jobs located in the 103 districts of Hamburg and the 307 surrounding communities in the metropolitan region of Hamburg each with their reciprocal distance to the city district where a condominium is located.[11] To measure the access to public transport network the distance to the next railway station (*DIST_STAT*) was included – which is considered in both linear form and with an additional quadratic term *(*Agostini and Palmucci 2008). Proximity to shopping and recreation facilities has been captured by the distance to (sub-) centers (*DIST_CENT*) according to the zoning plan of Hamburg (BSU 2003) as well as the distance from the closest green space (*DIST_PARK*) and from the nearest bodies of water (*DIST_WATER*).[12] Since schools and kindergartens are often

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11 $$EMPGRAV_i = \sum_j \frac{Emp_j}{d_{ij}} \quad , d_{ii} = \frac{1}{3}\sqrt{\frac{area_i}{\Pi}} \qquad (3)$$

where *Emp* represents all jobs subject to social insurance in a city district or in one of the surrounding communities. *j* stands for all city districts and communities other than *i*, and d_{ij} is the distance between the centroids of *i* and *j*. Since some of the city districts cover relatively large areas, a district-internal distance measure d_{ii} is employed (e.g., Crafts 2005). In order to avoid overestimation of Emp_j and/or Emp_i, d_{ij} and/or d_{ii} was not allowed to take on values smaller than 1. The regression coefficient of the gravity variable calculated from the graded weights shows a higher t-value than the coefficient of the variable calculated from non-graded weights.

12 All distance variables are stated as straight-line distances.

located near places of worship, the models also capture the distance to such educational establishments.[13] *ACCESS* is thus a vector to map the previously discussed accessibility indicators.

NOISE_VIS_DIS is a vector that, in addition to noise pollution in the entry and exit lanes of the Hamburg airport (*NOISE_AIR*), also takes into account noise and visual nuisances stemming from road traffic (*NOISE_ROAD_SQ*, *WIDEROAD*) as well as railway noise near railway tracks (*NOISE_RAIL*) and that captures the distance to industrial sites (*DIST_IND*). The vector *TREND* stands for a set of dummy variables that capture the most recent year and the most recent season in which a property was offered for sale.

$$POW\_POTENTIALITY_i = \sum_j A_j \, e^{-zd_{ij}} \tag{4}$$

First, the spatial extent of the effect of places of worship is examined using a potentiality variable, which is estimated as an exponential spatial weight function (Ahlfeldt and Maennig 2010). For condo *i* *POW_POTENTIALITY* corresponds to the sum of the floor space *A* weighted with the term exp($-zd_{ij}$) of all places of worship *j* in Hamburg. d_{ij} is the distance between property *i* and the place of worship *j*, and *z* is a spatial weight used to weight the floor space[14] of the places of worship in relation to their distance from property *i*. By calculating *POW_POTENTIALITY* for different values of *z* (0.1 to 15) the best fit is found for *z* = 5 (cf. also Fig. 1).[15] The spatial effect of places of worship in Hamburg is thus

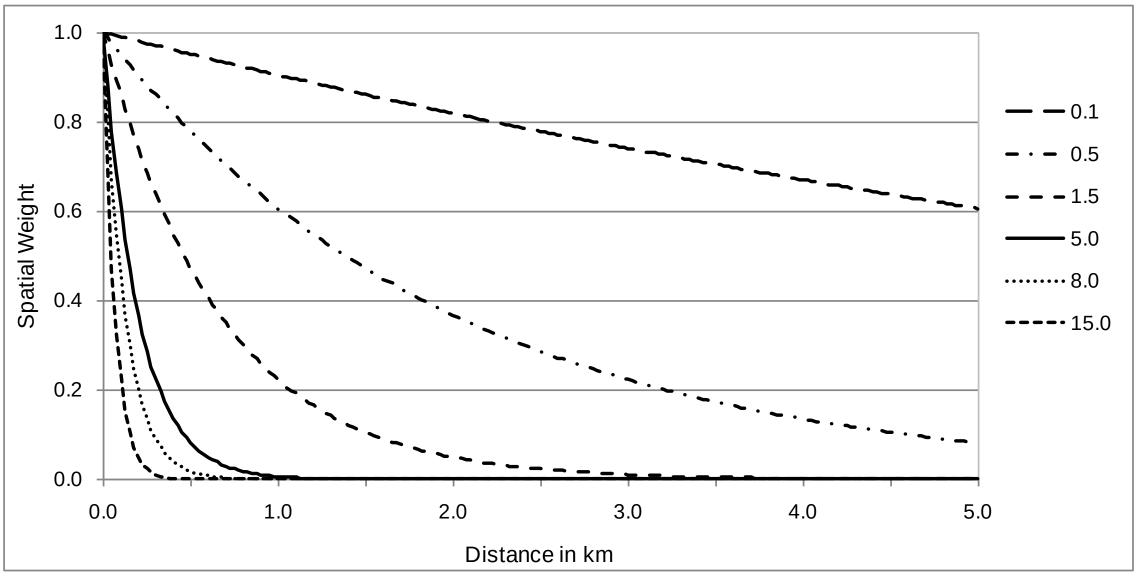
[13] The best fitting model was retrieved when considering the distance to the closest school both in linear and quadratic form. The influence of the distance to the nearest kindergarten was insignificant for all tested terms, which is why this indicator has been excluded from the final model specifications.

[14] In preliminary estimations, not only the floor space but also the height of places of worship was tested. Also, the volume of places of worship was approximated using various terms. However, the height and/or volume of places of worship was insignificant for all tested terms, which is why these indicators were excluded from the final models. One reason for the insignificant findings could be found in the deficient data quality of height information. For many buildings, it was impossible to research the height, which then had to be estimated from photographs of the properties. Another reason for the insignificant coefficients could lie in the variety of building structures of places of worship, which probably can be approximated only insufficiently using uniform terms.

[15] *POW_POTENTIALITY* was tested with *z* = 0.1, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 15.0.

halved approx. every 140m and is limited to a radius of approx. 1 km.[16] This is also plausible when compared to the findings of Ahlfeldt and Maennig (2010), who, using potentiality variables, have observed a spatial effect of built heritage at distances of up to 600m. Since places of worship are normally taller than heritage-listed properties, they may also have a stronger spatial effect on the prices of surrounding residential properties.

Fig. 1 Selection of Estimated Spatial Weight Functions for Different *z (0.1 – 15.0)*



Model 2

Taking into account the findings gained from Model 1, in Model 2 the influence of places of worship is examined by means of a conventional approach. That is, by introducing a set of dummy variables that capture distance contours around POWs. Model 2 can thus be written as follows:

$$\ln(P) = \alpha + \beta\ PROP + \gamma\ NEIGH + \delta\ ACCESS + \eta\ NOISE\_VIS\_DIS + \theta\ AUTOREG \tag{5}$$

$$+ \lambda\ TREND + \sigma\ DIST\_POW + \varepsilon\ ,$$

[16] For d_{ij} = 1.0, the weight $\exp(-5d_{ij})$ = 0.0067.

where σ is a vector of the coefficients to be estimated. *DIST_POW* is a vector of five dummy variables that each take on the value of 1 if a property is located at a distance of up to 100m (*DIST_POW_100*), more than 100m and up to 200m (*DIST_POW_100_200*), more than 200m and up to 400m (*DIST_POW_200_400*), more than 400m and up to 600m (*DIST_POW_400_600*) or more than 600m and up to 1,000m (*DIST_POW_600_1000*) from the next POW; otherwise the value is 0.[17] Accounting for the findings from Model 1, 1,000m is defined as the maximum cutoff, using properties at distances of more than 1,000m to the next POW as the reference group. The use of dummy variables has the advantage that their coefficients, in contrast to those of spatial weight terms, are easy to interpret and present an intuitive measure of the influence of POWs on residential property prices.

Model 3

In Model 3, we first analyze whether the externalities of mosques are different than those of other places of worship. In answering this question, we hope to obtain new input for the social debate on the construction of minarets and/or the public muezzin's call. Secondly, it is examined whether the externalities of deconsecrated churches differ from those of buildings used as places of worship. Taking into account the uncertain future of many - primarily Lutheran - churches, answering this question may supply impulses for the debate on the future use of former places of worship.

DIST_POW is additionally interacted with the variables *MOSQUE* and *DECON*. Thus, Model 3 is as follows:

$$\ln(P) = \alpha + \beta\ PROP + \gamma\ NEIGH + \delta\ ACCESS + \eta\ NOISE\_VIS\_DIS + \theta\ AUTOREG \qquad (6)$$

$$+ \lambda\ TREND + \sigma\ DIST\_POW + \varphi\ DIST\_POW \times MOSQUE$$

$$+ \psi\ DIST\_POW \times DECON + \varepsilon\ ,$$

[17] All other terms in equation (5) have the meanings previously described for model 1.

where φ and ψ are the coefficients to be estimated. *MOSQUE* and/or *DECON* take on the value of 1 if the next POW is a mosque and/or a deconsecrated church; otherwise the value is 0.[18] For example, the interactive variable *DIST_POW_100_200* x *MOSQUE* takes on the value of 1 if the next POW is a mosque that is located within a radius of 100m to 200m from the property; otherwise the value is 0. The coefficient of the interactive variable *DIST_POW_100_200* x *MOSQUE* thus indicates, for example, the price differential of properties within a radius of 100m to 200m around mosques compared to properties that are located at distances between 100m and 200m around POWs of other religions that were not deconsecrated.

Model 4

Finally, in Model 4, the extent to which residential property prices are influenced by the bell ringing of nearby churches is examined. First, a distinction must be made between liturgical bell ringing - e.g., on church holidays, to mark services and official church acts such as baptisms, weddings or funerals - and the secular marking of time of the church clock at quarterly, half-hourly or hourly intervals. In preliminary analyses, various terms were included to test whether it makes a difference that adjacent church spires have bells or not. However, the variables did not yield any significant results, which may primarily be due to the fact that bells are rung with varying frequency and intensity in each community. However, data on the frequency and intensity of liturgical bell ringing in the various communities was not available, because the variety of ringing could be quantified - if at all - only with disproportionate effort for the entire metropolitan area of Hamburg. Besides, the regular marking of time, which is more frequent than liturgical bell ringing and can be heard even at nighttime in many communities, probably creates greater noise pollution anyway. Therefore, for each church in Hamburg it is considered whether the church marks the time and if so, at what

[18] Deconsecrated churches are properties that were not used as places of worship anymore during the study period but whose buildings still existed.

frequency and at what time of day this occurs. Model 4 can thus be written as follows:

$$\ln(P) = \alpha + \beta\, PROP + \gamma\, NEIGH + \delta\, ACCESS + \eta\, NOISE\_VIS\_DIS + \theta\, AUTOREG \tag{7}$$

$$+ \lambda\, TREND + \sigma\, DIST\_POW + \varphi\, DIST\_POW \times MOSQUE$$

$$+ \psi\, DIST\_POW \times DECON + \omega\, CHIME + \varepsilon\,,$$

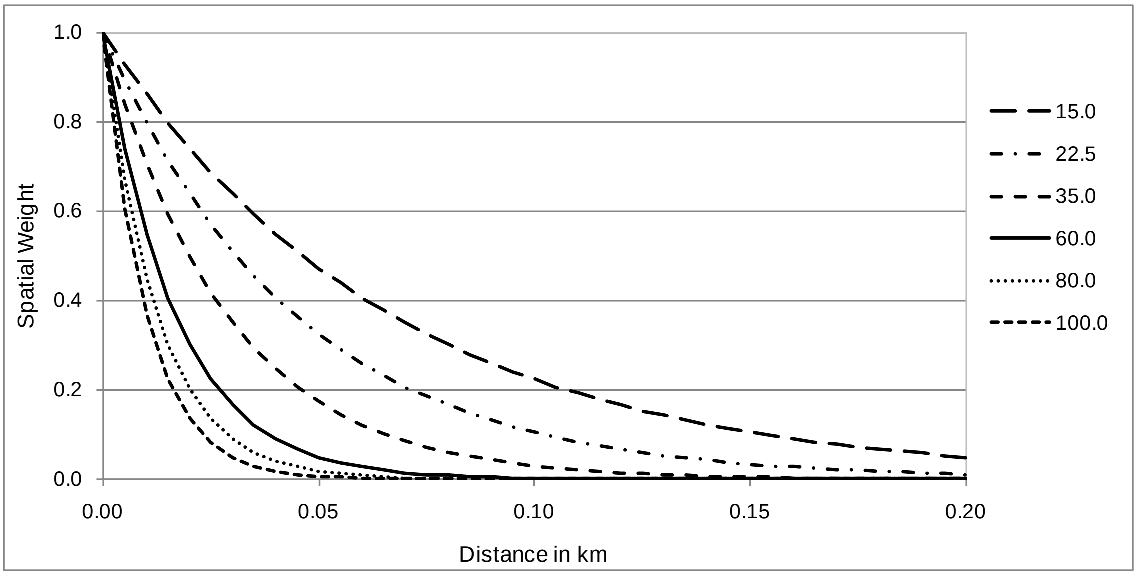
where ω is a vector of the coefficients to be estimated. *CHIME* is a vector of the two potentiality variables *CHIME_DAY_POTENTIALITY* and *CHIME_NIGHT_POTENTIALITY*, which, using exponential spatial weight functions, account for the marking of time of all church clock towers in Hamburg in relation to frequency, time of day and distance to the respective condominium. The variable *CHIME_DAY_INDEX* takes on the value 4 for church *j* if time is marked at quarterly intervals, or the value 2 if time is marked every half-hour, or the value 1 if time is marked hourly; otherwise the value is 0.

$$CHIME\_DAY\_POTENTIALITY_i = \sum_j CHIME\_DAY\_INDEX_j\; e^{-zd_{ij}} \tag{8}$$

For condominium *i* *CHIME_DAY_POTENTIALITY* corresponds to the sum of the *CHIME_DAY_INDEX* values of all Hamburg churches *j* weighted with the term exp(-zd_{ij}). d_{ij} is the distance between property *i* and church *j*, and *z* is a spatial weight used to weight the values of *CHIME_DAY_INDEX* in relation to d_{ij}. For the calculation of *CHIME_DAY_POTENTIALITY* *z* is considered to take on values from 15 to 100 (see also Fig. 2).[19]

[19] *CHIME_DAY_POTENTIALITY* and *CHIME_NIGHT_POTENTIALITY* were tested each with z = 15.0, 16.0, 17.0, 18.0, 20.0, 22.5, 25.0, 30.0, 35.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0.

Fig. 2 Selection of Estimated Spatial Weight Functions for Different *z (15.0 – 100.0)*



$$CHIME\_NIGHT\_POTENTIALITY_i = \sum_j CHIME\_NIGHT\_INDEX_j \, e^{-zd_{ij}} \quad (9)$$

The calculation of the variable *CHIME_NIGHT_POTENTIALITY* follows the same principle. For church *j CHIME_NIGHT_INDEX* is equal to the value of *CHIME_DAY_INDEX* when the marking of time occurs also at night (at least from 12:00 AM to 6:00 AM); otherwise the value is 0.

4 Results

About 87.2% of the variance of listing prices can be explained by the hedonic models used (Table 2).[20] This is an average value when compared to other hedonic housing price studies. Since White's test rejects homoscedasticity for all models, the standard errors were corrected using White's Correction. All control variables have the expected signs and are predominantly highly significant, yielding values that are plausible also in terms of their amounts.

[20] If the models are specified without the spatial lag term, the adjusted R^2 value is reduced by approx. 1.0%.

Table 2 Results

	Model 1	Model 2	Model 3	Model 4
CONSTANT	8.4549***	8.4323***	8.4384***	8.4445***
Property				
SIZE	0.0132***	0.0132***	0.0132***	0.0132***
SIZE_SQ	-0.000009***	-0.000009***	-0.000009***	-0.000009***
AGE	-0.0130***	-0.0129***	-0.0129***	-0.0130***
AGE_SQ	0.000098***	0.000097***	0.000098***	0.000098***
ROOMS	0.0267**	0.0268**	0.0267**	0.0265**
GARAGE	0.0328***	0.0334***	0.0334***	0.0347***
BALCONY	0.0592***	0.0583***	0.0574***	0.0571***
TERRACE	0.0396***	0.0395***	0.0401***	0.0399***
KITCHEN	0.0409***	0.0411***	0.0414***	0.0421***
POOL	0.0337	0.0357	0.0366	0.0366
FIREPLACE	0.0111	0.0104	0.0104	0.0099
GOODCOND	0.0503***	0.0507***	0.0504***	0.0504***
BADCOND	-0.1052***	-0.1057***	-0.1047***	-0.1049***
Neighborhood				
ELDERLYPOP	-0.0033***	-0.0034***	-0.0034***	-0.0034***
INCOME	0.0031***	0.0031***	0.0031***	0.0032***
FOREIGNPOP	-0.0057***	-0.0056***	-0.0058***	-0.0057***
SOCHOUSE	-0.0002***	-0.0002***	-0.0002***	-0.0002***
Access				
DIST_CENT	-0.0247***	-0.0245***	-0.0240***	-0.0242***
EMPGRAV	0.000002***	0.000002***	0.000002***	0.000002***
DIST_STAT	0.0374*	0.0394*	0.0395*	0.0343*
DIST_STAT_SQ	-0.0211**	-0.0215**	-0.0216**	-0.0195***
DIST_WATER	-0.0077***	-0.0076***	-0.0077***	-0.0076***
DIST_PARK	-0.0444***	-0.0444***	-0.0445***	-0.0446***
DIST_SCH	0.1598***	0.1557***	0.1577***	0.1572***
DIST_SCH_SQ	-0.1367***	-0.1292***	-0.1290***	-0.1304***
Noise exposure / visual intrusions				
WIDEROAD	-0.0460***	-0.0461***	-0.0470***	-0.0468***
NOISE_ROAD_SQ	-0.000019***	-0.000020***	-0.000020***	-0.000020***
NOISE_AIR	-0.0011***	-0.0011***	-0.0011***	-0.0011***
NOISE_RAIL	-0.0011***	-0.0011***	-0.0011***	-0.0011***
DIST_IND	0.0178*	0.0225**	0.0237**	0.0234**

Table 2 (continued)

	Model 1	Model 2	Model 3	Model 4
Place of worship				
POW_POTENTIALITY	0.000065***			
DIST_POW_100		0.0381	0.0384	0.0466
DIST_POW_100_200		0.0480**	0.0470**	0.0475**
DIST_POW_200_400		0.0262	0.0254	0.0259
DIST_POW_400_600		0.0090	0.0084	0.0093
DIST_POW_600_1000		0.0003	0.0019	0.0028
DIST_POW_100 x MOSQUE			0.0397	0.0292
DIST_POW_100_200 x MOSQUE			0.0383	0.0363
DIST_POW_200_400 x MOSQUE			0.0334	0.0325
DIST_POW_400_600 x MOSQUE			-0.0209	-0.0225
DIST_POW_600_1000 x MOSQUE			-0.0336	-0.0334
DIST_POW_100 x DECON			-0.0279	-0.0365
DIST_POW_100_200 x DECON			-0.0099	-0.0094
DIST_POW_200_400 x DECON			0.0059	0.0063
DIST_POW_400_600 x DECON			0.0214	0.0217
DIST_POW_600_1000 x DECON			-0.0966	-0.0961
CHIME_DAY_POTENTIALITY				0.1992
CHIME_NIGHT_POTENTIALITY				-1.6556
Number of observations	4,832	4,832	4,832	4,832
White's Correction	YES	YES	YES	YES
Spatial lag term	YES	YES	YES	YES
R^2	0.873	0.873	0.874	0.874
Adjusted R^2	0.872	0.872	0.872	0.872

Notes: The endogenous variable is the natural log of the last listing price of property. All models include yearly and seasonal dummy variables. * indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level.

Control variables

The coefficients estimated for *SIZE* and *SIZE_SQ* show the expected positive, but less than proportional effect of property size on condominium prices. The estimates of *AGE* and *AGE_SQ* indicate a quadratic influence for the property's age, with the lowest prices for condominiums that are 66 years old. Regarding the other condominium's physical characteristics, only a generally bad condition of the property (*BADCOND*) has a negative effect on condominium prices.[21] Among the neighborhood variables only the relationship between average income (*INCOME*) and condominium prices is positive. All other coefficients of

[21] The coefficients of dummy variables used in the semi-log form were transformed by (e^a - 1), where *a* is the estimated coefficient (Halvorsen and Palmquist 1980).

neighborhood indicators have negative signs. The coefficients of *DIST_STAT* and *DIST_STAT_SQ* show that the highest prices for properties can be found at a distance of approx. 900m from the next rail station. Also the estimates of *DIST_SCH* and *DIST_SCH_SQ* indicate a quadratic relation between distance from next school and housing prices. Coefficients of all other variables that measure distance from local amenities have the expected negative signs. Furthermore, access to jobs, measured by *EMPGRAV*, is seen as positive. While condominiums located next to a major road (*WIDEROAD*) experience price reductions of 4.6%, the coefficients of all traffic-noise indices (*NOISE_ROAD_SQ*, *NOISE_AIR*, *NOISE_RAIL*) are negative and statistically highly significant.

Impact of POWs

As mentioned above, tests with the potentiality variable *POW_POTENTIALITY* in Model 1 have shown that the spatial effect of places of worship is limited to around 1,000m. Model 2 now shows that the price premiums for the proximity to places of worship increase between 1,000m and 100m with declining distance, resulting in maximum premiums of 4.8% for locations between 100m and 200m from the nearest place of worship (*DIST_POW_100_200*). Compared to the property prices at a distance of more than 1,000m from the nearest place of worship, however, only premiums at a distance of 100m to 200m are significant. This result is plausible insofar as 200m also represents a plausible cutoff for a high visual perception of the buildings. In immediate proximity to places of worship, that is, at a distance of up to 100m (*DIST_POW_100*), price premiums are lower and not significantly different from residential property prices at a distance of more than 1,000m from the nearest place of worship. The lower premiums in close proximity to places of worship may result from noise pollution, for example, from community or cultural events, visitor traffic or church bell ringing. This topic will be further discussed when presenting the findings of Model 4. In summary, the estimated premiums near places of worship are comparable to previously reported premiums in the vicinity of churches that range from 3.1% (Carroll, Clauretie, and Jensen 1996) to 6.4% (Ottensmann 2000). Also, the estimated spatial extent of externalities of places of worship is comparable to the spatial effect of church buildings observed by Do, Wilbur, and Short (1994) and Ottensmann (2000). However, Carroll, Clauretie, and Jensen (1996) and Bielefeld et al. (2010) reported more far-reaching spatial effects.

In Model 3, the insignificant coefficients of the interactive vectors *DIST_POW* x *MOSQUE* and *DIST_POW* x *DECON* give rise to the conclusion that the condominium prices in Hamburg, either near mosques or in the vicinity of deconsecrated churches, do not differ significantly from property prices in the neighborhood of places of worship of other religions and/or in the vicinity of actively-used places of worship. Given the positive - albeit insignificant - coefficients of the interactive terms *DIST_POW_100* x *MOSQUE*, *DIST_POW_100_200* x *MOSQUE* and *DIST_POW_200_400* x *MOSQUE*, one could speculate that easy access to a place of worship matters more to Muslims than it does to believers of other religions. In fact, approx. 36% of Hamburg Muslims attend a mosque regularly (Ulrich 2010b), while, for example, only around 12% of Catholics in Hamburg attend church mass regularly (Ulrich 2010a). The fact that prices of residential properties near rededicated churches are not statistically different from prices in the vicinity of actively-used places of worship leads to the conclusion that, seemingly, the visual amenities of churches are key to price premiums, rather than easy access to church services and/or community and cultural events.

In Model 4, the potentiality variables *CHIME_DAY_POTENTIALITY* and *CHIME_NIGHT_POTENTIALITY* are calculated for z values from 15 to 100. For both variables the best fit is obtained for $z = 60$ (see also Fig. 2).[22] However, the coefficients of both variables are insignificant even for z = 60. Therefore, an effect of bell ringing on the prices of nearby residential properties cannot be proved. At least with respect to bell ringing at night, price reductions in the immediate neighborhood would have been expected. A weakness of the model is certainly that the level of noise exposure from church bells depends on further factors that the model does not control for. Thus, the volume of the bells of different churches

[22] Accordingly, the spatial effect of bell ringing is reduced by half approx. every 12m and is limited to a radius of approx. 80m (for $d_{ij} = 0.08$, the weight $\exp(-60d_{ij}) = 0.0082$).

can vary greatly. Many church towers still have steel bells from the post-war years. Their sound is rather shrill. By contrast, later cast steel bells and bronze bells tend to produce a warm sound. Furthermore, bells are suspended at different heights, which could result in different noise levels at the same distance from the nearest church tower. Although the model controls for the frequency and time of day of bell ringing as well as the distance from residential properties, the aforementioned constraints may lead to biased results. An interesting aspect is, however, that the coefficient of *DIST_POW_100* rises by almost a percentage point compared to Model 3 and is now more or less equivalent to the coefficient of *DIST_POW_100_200*. *DIST_POW_100* is now also significant at least at the 11% level. The lower price premiums reported for Models 2 and 3 in immediate proximity to places of worship, therefore, can largely be explained by the noise exposure to church bells even if the influence of the noise itself is not statistically significant.

5 Conclusions

Applying hedonic pricing techniques this study examines the impact of places of worship on residential property prices in Hamburg, Germany. Controlling for spatial dependence and employing potentiality variables places of worship are found to have positive external effects on neighboring condominium prices within a distance of approx. 1,000m. Compared to properties beyond this threshold, price premiums of 4.8% are obtained for condominiums at distances of 100m to 200m to the next place of worship. As a result of noise exposure, however, price premiums in immediate proximity to places of worship (≤ 100m) are lower and not significantly different from property prices at a distance of more than 1,000m from the nearest place of worship. Condominium prices in Hamburg, either near mosques or in the vicinity of deconsecrated churches, are not significantly different from prices in the neighborhood of places of worship of other religions and/or in the vicinity of actively-used places of worship. Thus, no price discounts for residential properties have been observed in the vicinity of mosques that would account for local residents feeling bothered by Islamic places of worship. The findings also imply that churches should be preserved as buildings, because they continue to have positive externalities on adjacent residential property prices even after they have been deconsecrated. The influence of church bell ringing on the prices of surrounding residential properties, however, could not be substantiated.

It should be noted, however, that the study was conducted in a metropolis known for its liberalism and open-mindedness. The findings may be different for conservative and/or rural regions. This warrants further research.

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Appendix

Table 3 Descriptive Statistics of POW Indicators

Denomination	Number of properties	Mean year of construction	Mean floor space	Mean *CHIME _DAY_INDEX*	Mean *CHIME _NIGHT_INDEX*	Mean *DIST_POW* (in kilometers)
Lutheran church	2,842	1922.2	483.4	1.40	0.72	0.467
Free church	716	1965.1	361.0	0.00	0.00	0.368
Catholic church	473	1934.7	699.3	0.21	0.00	0.388
Deconsecrated church	222	1931.7	615.9	0.85	0.00	0.354
Other church	212	1942.0	339.9	0.00	0.00	0.289
Mosque	186	1963.0	409.5	0.00	0.00	0.395
Buddhist center/temple	161	1974.8	176.9	0.00	0.00	0.421
Synagogue	17	1960.0	400.0	0.00	0.00	0.211
Hindu temple	3	1975.0	272.0	0.00	0.00	0.216
Total	4,832	1934.6	472.7	0.89	0.43	0.426

Table 4 Descriptive Statistics of POW Indicators for Property Portfolio

Denomination	Number of properties	Mean year of construction	Mean floor space	Mean *CHIME _DAY_INDEX*	Mean *CHIME _NIGHT_INDEX*	Mean *DIST_POW* (in kilometers)
Lutheran church	2,842	1922.2	483.4	1.40	0.72	0.467
Free church	716	1965.1	361.0	0.00	0.00	0.368
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Other church	212	1942.0	339.9	0.00	0.00	0.289
Mosque	186	1963.0	409.5	0.00	0.00	0.395
Buddhist center/temple	161	1974.8	176.9	0.00	0.00	0.421
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Hindu temple	3	1975.0	272.0	0.00	0.00	0.216
Total	4,832	1934.6	472.7	0.89	0.43	0.426

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