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ASSESSING EXTERNAL EFFECTS OF CITY AIRPORTS: LAND VALUES IN BERLIN

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Assessing External Effects of City Airports: Land Values in Berlin*

Abstract: This paper employs a hedonic price model to explain standard land values in Berlin. Impact on land values is assessed for the two city airports situated in Berlin, Germany, Tempelhof and Tegel. Empirical results confirm expectations about the impact of various attributes on land values. Areas exposed to noise pollution of downtown airport Tempelhof sell at a discount of approximately 5-9% within a distance of 5000 m along the air corridor. No significantly negative impact was found for land values around Tegel Airport, which is located in a central, but less densely populated, area. Market access indicators created for all three Berlin airports in operation, including Berlin Schoenefeld International Airport, reveal clear location advantages in terms of accessibility of Tempelhof and Tegel compared to Schoenefeld Airport, where the new Berlin Brandenburg International Airport is about to be developed.

Keywords: Air Traffic, Land Values, Airport, Hedonic Regression, Berlin

JEL classification: R31, R42, R53

Version: April 2008

1 Introduction

While large cities depend on major airports carrying out hub functions to provide various international non-stop connections, smaller downtown business airports are much appreciated by businessmen due to their accessibility. Neighbourhood activists usually oppose these airports mainly because of extensive noise pollution and emissions. Opposition obviously becomes stronger the more central airports are located, since population density is typically found to be much higher in

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downtown areas. As a consequence, local authorities are confronted with two conflicting interests, emphasizing the role of downtown airports as a location factor to attract businesses on the one hand and the necessity of protecting local residents' living quality on the other. To make appropriate decisions, politicians have to rely on valid information about the extent to which residents are effectively exposed to the external effects mentioned. As attractiveness of real estate is immediately capitalized into prices, any considerable external impact of airports should be reflected in price differences. External effects being monetarily quantifiable, politicians may take into account wealth effects on local residents and consequently better determine feasible compensation.

Due to the importance of external effects of airports on affected residents, local authorities and real estate analysts, the impact of airports has attracted scholars' attention. BELL (2001) provides a survey on the impact on residents' physical condition and introduces effects on property prices. Most empirical studies available so far focus on North America (MIESZKOWSKI & SAPER, 1978; NELSON, 1979; UYENO, HAMILTON, & BIGGS, 1993) or United Kingdom, where Manchester Airport has attracted much attention (COLLINS & EVANS, 1994; PENNINGTON, TOPHAM, & WARD, 1990; TOMKINS *et al.*, 1998). Little evidence is available for continental Europe. Surveys on the empirical literature show that airports are clearly found to adversely affect property values (NELSON, 1980; VAN PRAAG & BAARSMA, 2005).

Besides being only the second analysis of a case in continental Europe, this study adds three new aspects to the existing literature: First, it analyses two airports, Tegel (IATA Code: TLX) and Tempelhof (IATA Code: THF) in one city. It addresses important dissimilarities between the airports: Tegel Airport presently handles ten times as many passengers a year as Tempelhof Airport. And building structure and land use of surrounding properties also differ considerably between the airports. While Tegel's air corridor covers large water space with an industrial area to the west and low-density residential areas to the east, Tempelhof Airport is embedded in a high-density residential area of 19th century five-storey buildings.

Comparing the effects generated by varying levels of air traffic on distinctly developed areas might provide valuable insights into the nature of the effects of noise on location attractiveness and capitalization into property prices.

Second, both Tegel and Tempelhof Airports are located relatively centrally and are surrounded by developed areas potentially adversely affected, whereas most airports in the studies mentioned above are outside city boundaries.

Third, this paper applies a hedonic model using highly disaggregated data of 15,937 official statistical blocks, the most disaggregated level available at the Statistical Office of Berlin. To analyse this highly disaggregated dataset we employ GIS tools and a projected GIS map of the official block structure including information on public infrastructure, such as schools, playgrounds and railway stations, enabling generation of impact variables.

The remainder of this article is organized as follows. In Section 2 we present Tegel and Tempelhof Airports in more detail while section 3 discusses the data. In Section 4 our empirical strategy is developed and results are presented in Section 5. The final section concludes the paper and provides an outlook for the future.

2 Berlin Airports Tegel and Tempelhof

The official inauguration of Tempelhof was in 1923. After complete redevelopment during the national socialist regime, Tempelhof was clearly Germany's most important air hub with a maximum capacity of 6 million passengers a year, exceeding the effective 1934 numbers by a factor of thirty.[1] These dimensions, the facility design and architectural and historical particularities have frequently been discussed (CARRÉ, 2000; DEMPS & PAESCHKE, 1998; MEUSER, 2000; SCHMITZ, 1997). Tempelhof later became internationally prominent as Berlin's most impor-

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[1] Facility extensions were designed by the architect Enst Sagebiel in 1934. Even by the end of WWII facilities had not been finished completely.

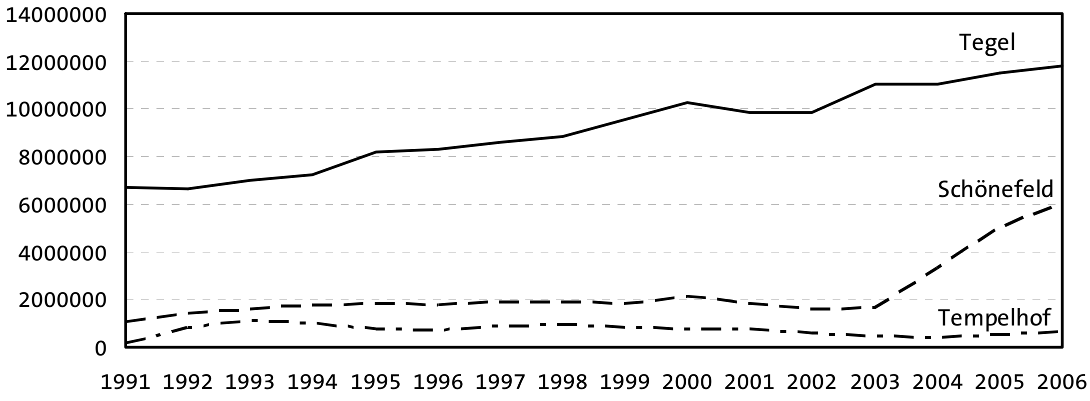
tant access point for the 1948-49 airlift established to supply West Berlin residents during the Berlin Blockade. To provide the necessary capacity, two more airports were conceptualised, one of which was Tegel Airport, jointly operated by the French since 1948.

By the mid 20th century, Berlin possessed a decent infrastructure for air traffic and was preparing itself to benefit from the rapidly growing market. However, Berlin soon lost its status as Germany’s pre-eminent hub, due to loss of market access following Germany’s division (REDDING, STURM, & WOLF, 2007). West Berlin became completely surrounded by the Soviet zone of occupation. While the most important West Germany counterpart of the airlift – Frankfurt – emerged as Germany’s new pre-eminent hub, generating more and more traffic and continuously expanding facilities, improvements in air traffic infrastructure in West Berlin remained relatively modest.

As no reserve space for extension of facilities was available in Tempelhof due to its downtown location, Tegel Airport was opened for civilian air traffic in 1960 to meet the demands generated by increasing national and international air traffic, and the fact that a flight connection was the only way of travelling between West Berlin and West Germany avoiding border controls. In 1974, a new civilian terminal in the south of Tegel airfield replaced the existing facilities which subsequently have been used for military and governmental purposes only.

Following the inauguration of the new Tegel Airport, Tempelhof Airport was closed until 1984 when it was reopened mainly for smaller airplanes utilized by business travellers. Despite minor extensions during the following decades, Tegel Airport kept moderate size. Even experiencing a considerable capacity overload (STEINKE, 2006), the number of served passengers at Berlin’s Tegel Airport has still not exceeded 12 million per year, a relatively small number compared to 52 million at Fankfurt or even over 67 million at London Heathrow in 2005. Figure 1 shows passenger traffic at Berlin airports since reunification in 1990.

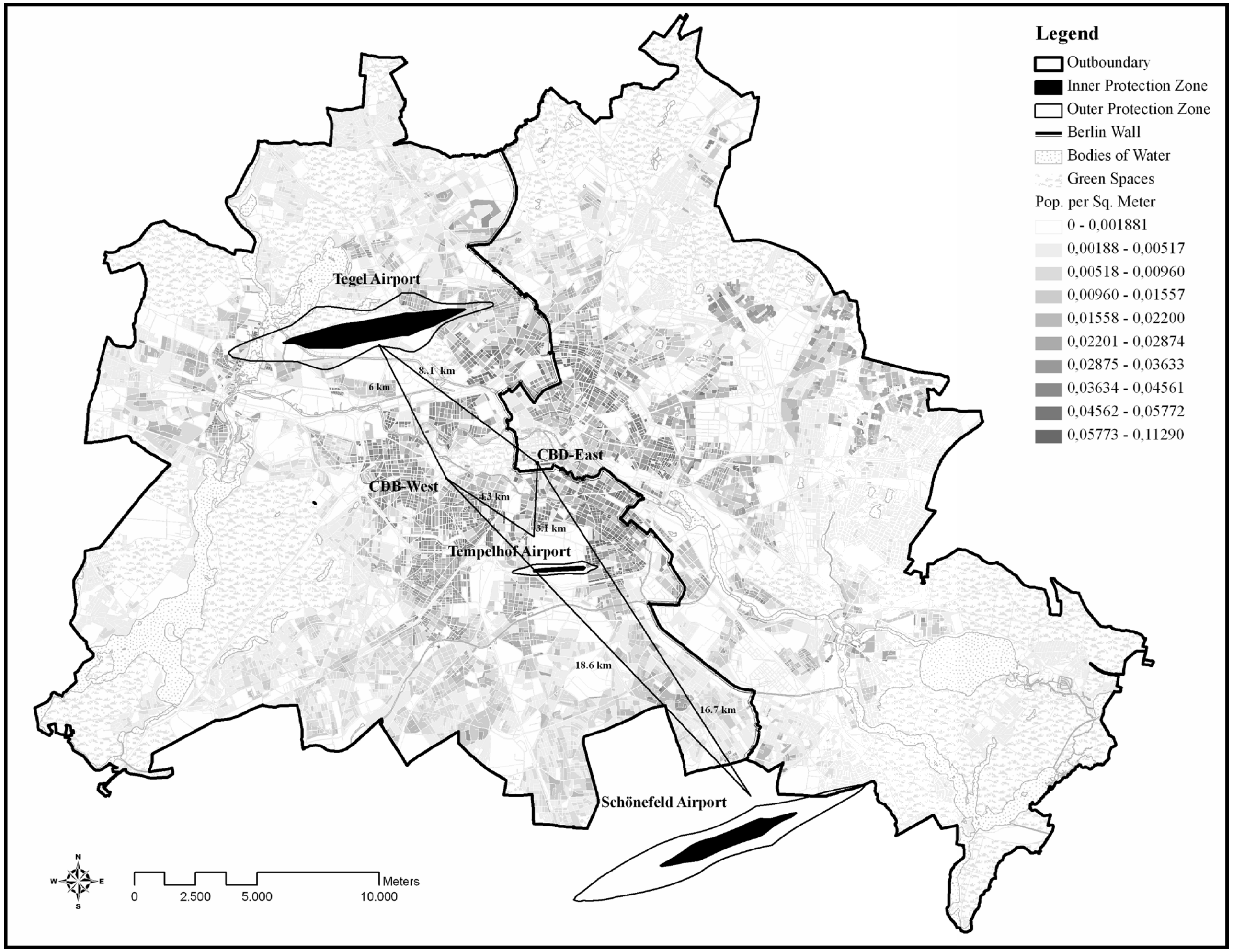
Fig. 1 Passenger Traffic at Berlin Airports



Source: German Airports Association. URL: http://www.adv-net.org/eng/gfx/index.php.

As noted above, the capacity of both airports is restricted by their central location and good accessibility. Figure 2 shows the location of the airports and the officially determined noise protection zones. Small noise protection zones reflect the relatively low air traffic at Tempelhof, which lies within an area of high population density. Compared to the city airports at Tegel and Tempelhof, the location of Schönefeld is remote. In recent years, Schönefeld, which will be redeveloped as the new Berlin Brandenburg International (BBI) Airport, has become much appreciated by low-cost carriers due to low operating costs. However, Tegel continues being the most important airport for business flights and the only airport in Berlin to offer intercontinental connections. Tempelhof, much smaller, is predominantly used by businessmen. Therefore, due to custom and connection to the central business district (CBD) areas, both city airports are particularly appreciated by the business community.

Fig. 2 Locations of Berlin Airports



Notes: This map was created on the basis of the "City and Environment Information System" (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2006b) of the Senate Department, Berlin.

While Tegel Airport will continue in operation until 2011, when the new BBI Airport is inaugurated, Tempelhof's closure has already been scheduled for October 31, 2008. The external effects of Tempelhof Airport are judged differently by citizens: Some neighbourhood activists' movements favour the final shutdown while the Interest Group of City Airport Tempelhof (ICAT) promisingly pleads for a referendum in favour of Tempelhof Airport remaining in operation. Tegel Airport, presently Berlin's largest airport, is foreseen to serve exclusively as a governmental airbase after 2011. Legal claims of airlines opposing Tegel's closure have been rejected by the administrative appeals tribunal responsible.

3 Data and Data Management

The study area covers the whole of Berlin, the capital city of Germany, which on July 30, 2006, had 3,399,511 inhabitants in an area of approximately 892 km^2. We use standard land values ("Bodenrichtwerte"), assessed by the local Committee of Valuation Experts ("Gutachterausschuss") as our primary endogenous variable. Standard land values are given in values per square meter for zones of similar use and valuation ("Bodenrichtswertszonen"), assessed by statistical evaluation (including elimination of outliers) of all transactions during the reporting period. Assessed values reveal market values for undeveloped properties within the zone of valuation and refer to typical density of a development provided in the form of a typical floor space index (FSI) value for the zone.[2] The FSI, also called floor space ratio (FSR), is the ratio of building total floor area to the area of the corresponding plot of land. Additionally, each standard land value is assigned to a class of land use, indicating whether the respective area is characterized by major retail and/or business activity, or industrial or residential use.

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[2] More information on data sources and the process of collection of standard land values is described in the Appendix.

The data refers to the 15,937 official statistical block structure, 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^2, approximately the size of a typical inner city block of houses. The mean population of the 12,314 populated blocks was 271 (median 135).[3] To analyse this highly disaggregated dataset we employed GIS tools and a projected GIS map of the official block structure including information on public infrastructure, such as schools, playgrounds and railway stations, enabling generation of impact variables, which are discussed in more detail in the section below.[4] Furthermore, we use population data at block level, including demographic characteristics from the Statistical Office of Berlin. All data used in this paper strictly refer to the end of 2005 with the exception of employment in the workplace which were only available at the Senate Department for the end of 2003.[5]

4 Empirical Strategy and Methodological Issues

4.1 Baseline Hedonic Modelling

We develop a hedonic pricing model to explain the present land value pattern in Berlin. We then extend the basic model by a set of variables capturing the impact of the airports on land values. Hedonic models are commonly applied in real estate and urban economics since they treat real estate commodities as bundles of attributes. Examples of hedonic pricing models in urban economic literature include construction of house indices (CAN & MEGBOLUGBE, 1997; MILLS & SIMENAUER, 1996; MUNNEKE & SLADE, 2001), impact assessment of quality of

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[3] There are much larger blocks, especially in the outer areas of Berlin. These typically cover recreational areas such as parks, forests and lakes, which are undeveloped and unpopulated and, therefore, omitted in the present study.

[4] All GIS maps were provided by the Senate Department of Urban Development (Senatsverwaltung für Stadtentwicklung) and are based on the “City and Environment Information System” (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2006b) of the Senate Department .

[5] Standard land values of 2006 are assessed on the basis of transactions from the reporting period year of 2005.

public services (BOWES & IHLANFELDT, 2001; GATZLAFF & SMITH, 1993), school quality (MITCHELL, 2000), group homes (COLWELL, DEHRING, & LASH, 2000), churches (CAROLL, CLAURETIE, & JENSEN, 1996), supportive housing (GALSTER, TATIAN, & PETTIT, 2004) and sports stadiums (AHLFELDT & MAENNIG, 2007; TU, 2005). Impact of aircraft noise has frequently been assessed using hedonic models (COLLINS & EVANS, 1994; MIESZKOWSKI & SAPER, 1978; NELSON, 1979; PENNINGTON, TOPHAM, & WARD, 1990; TOMKINS *et al.*, 1998; UYENO, HAMILTON, & BIGGS, 1993; VAN PRAAG & BAARSMA, 2005).

Following GALSTER, TATIAN & PETIT (2004), we assume that the characteristics of real estate can be described by their structural attributes [S], and a set of attributes capturing the effects of the neighbourhood [N] and local public services [L] (MUELLBAUER, 1974; ROSEN, 1974) as in the following equation:

$$H = f([S],[N],[L]) \tag{1}$$

H is the aggregated value of attribute characteristics, which translates into a market value or sales price (P) following a determined functional relationship:

$$P = g(H) \tag{2}$$

In urban and real estate economic literature, it is common to assume this relationship is log-linear, allowing for a non-linear relationship between price and attribute values and being more intuitively interpretable than other non-linear models. When interpreting regression results, the attribute coefficient gives the percentage impact of changes in attribute value on property value. For coefficient values smaller than 10%, this rule may also be applied to dummy variables (ELLEN *et al.*, 2001).[6] Following TU (2005), the relationships in (1) and (2) can be formulated more precisely in the regression equation

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[6] For larger coefficient values, a simple formula is strongly recommended, providing a much better approximation. For parameter estimate b, the percentage effect is equal to ($e^{b} - 1$) (HALVORSEN & PALMQUIST, 1980)

$$\ln(P) = \alpha + \beta_1 S_1 + \ldots + \beta_i S_i + \gamma_1 N_1 + \ldots + \gamma_j N_j + \delta_1 L_1 + \ldots + \delta_k L_k + \varepsilon \qquad (3)$$

where *i*, *j* and *k* represent the number of attributes, β, γ and δ represent the coefficients and ε is an error term.

In recent publications much attention has been paid to the characteristics of real estate units (ELLEN *et al.*, 2001; GALSTER, TATIAN, & PETTIT, 2004; HEIKKILA *et al.*, 1989; TU, 2005). To compare property transactions it is necessary to correct all transactions for a complete set of unit characteristics. Indeed, a feasible correction for unit characteristics enables reference to land values instead of property prices (HEIKKILA *et al.*, 1989). As we directly focus on land values as the endogenous variable, we can largely move away from unit characteristics and even the price-lot size relationship.[7] We focus on other factors and develop a model which describes Berlin's land value pattern through a comprehensive set of explanatory variables covering land use, accessibility indicators, natural endowments, public services provision and variables representing density and composition of neighbourhood populations.

We capture land use by dummy variables that identify blocks where considerable retail or business activity takes place or where the main use is industrial,[8] the remaining blocks representing residential areas. We use a variable representing the typical block FSI value, allowing for a quadratic term, since land value is expected to increase at a declining rate with increasing FSI.

Location characteristics are captured by a set of distance variables reflecting accessibility and proximity to amenities. Following VON THÜNEN (1826) and ALONSO (1964), the most important accessibility indicator is the distance to CBD

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[7] Lot size was typically found to have a concave functional impact on land values (COLWELL & MUNNEKE, 1997; COLWELL & SIRMANS, 1993). Later, a convex structure was indicated within the metropolitan area CBDs (COLWELL & MUNNEKE, 1999).

[8] The Committee of Valuation Experts provides information on land use for all land values. A detailed description of data sources is provided in the Appendix.

(CHESHIRE & SHEPPARD, 1995; DUBIN & SUNG, 1990; HEIKKILA *et al.*, 1989; ISAKSON, 1997; JORDAAN, DROST, & MAKGATA, 2004).

In contrast to the usual assumption of one single CBD, Berlin is characterised by duocentricity. This characteristic emerged during the 1920s and was strengthened during the period of division, 1949-1990 (ELKINS & HOFMEISTER, 1988). Modelling Berlin as a typical monocentric city could lead to biased estimates (DUBIN & SUNG, 1990). To deal with Berlin's duocentric structure we rely on the official definition of Berlin's Senate Department for Urban Development (SENATSVERWALTUNG FÜR WIRTSCHAFT ARBEIT UND FRAUEN, 2004). As a consequence, our main accessibility measure consists of distance to *either* CBD West *or* CBD East.[9] Figure 2 illustrates the straight line distances from Tegel, Tempelhof and Schönefeld Airports to CBD West and CBD East.

This is a valuable contribution to the land-gradient discussion since there is little empirical evidence available in European and in particular German cities.[10] Allowing land gradient to vary across land use further enriches our contribution. Of course, distance to CBD is only an approximation; the degree to which the local transportation infrastructure is developed may impact on accessibility. Impact of public transport on property prices has been investigated by GATZLAFF & SMITH (1993) and BOWES & IHLANFELDT (2001), who also discussed related sources of negative externalities. We capture the impact of the public transportation network on price pattern using distances to metro and suburban railway stations. To capture externalities created by railroad noise, which have a negative impact on property values (CHESHIRE & SHEPPARD, 1995; DEBREZION, PELS, & RIETVELD, 2006), we add distances to overground railways. In the same way, we consider the effects of proximity to bodies of water (lakes and rivers), natural amenities that are expected to be a major determinant for the emergence of high quality

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[9] We define CBD West as as having Breitscheidplatz as its centre. The centre of CBD East is defined as the crossroads between Friedrichstrasse and Leipzigerstrasse.

[10] Within the last three decades, the few exceptions are evidence from LEE (1993) for Duisburg and from MAENNIG & PFLEIDERER (2002) for Hamburg.

residential areas. We also include proximity to playgrounds and schools, providing information on the supply of public services.

As indicators of neighbourhood quality, we add population density and proportion of foreign residents (DUBIN & SUNG, 1990; TU, 2005). We also consider proportion of other potential low-income groups, such as people over the age of 65, and young professionals and students between the ages of 18 and 27. To assess any impact related to households with children, we use proxy variables of the proportion of the population in the following age classes: below 6; from 6 to 15; and from 15 to 18.

Recently, there have been attempts to control for location using large sets of dummy variables representing location fixed effects (ELLEN *et al.*, 2001; GALSTER, TATIAN, & PETTIT, 2004; GALSTER, TATIAN, & SMITH, 1999; TU, 2005). We use this concept to account for potential East-West heterogeneity by introducing a dummy variable for West Berlin, which we allow to interact with all explanatory variables to allow for heterogeneity of all implicit attribute prices.

Spatial dependence may lead to autocorrelation, leading to inefficient ordinary least squares (OLS) estimates and biased test scores. Intuitively, spatial dependence can be assumed to be the result of external effects of surrounding areas. One explanation for spatial dependence in property prices and rents is that the buyer and seller consider previous transactions that have occurred in the immediate vicinity. To deal with spatial dependence, CAN & MEGBOLUGBE (1997) used a spatial autoregressive explanatory variable representing a distance-weighted average of local sales prices occurring prior to the transaction.[11] To determine the value of the spatially lagged variable for block i, we weight the land value of neighbouring block j (P_j) with spatial weight

$$w_{ij} = (1/d_{ij}) / \sum_j (1/d_{ij}), \tag{4}$$

---

[11] Since assessed standard land values all refer to the same point in time, we do not define pre-transaction period.

where $(1/d_{ij})$ represents the inverse distance between the centroids of blocks *i* and *j*. The spatial lag value for block *i* takes the form

$$Spatial\_Lag_i = \sum_j [(1/d_{ij}) / \sum_j (1/d_{ij})] P_j \tag{5}$$

Having decided to use a spatial weight matrix, weighted by inverse distance, the spatial extent surrounding properties then needs to be defined. CAN & MEGBOLUGBE (1997) found a radius of 3000 m to be superior, taking into consideration only the three nearest properties. TU (2005) used a very similar distance of 1.8 miles. GALSTER, TATIAN & PETIT (2004) only tested the effectiveness of distinct-range specifications for a small subset of their transaction data. Goodness of fit (R^2) showed minimal impact and so they excluded the spatial lag term. To test which of the specifications proposed by CAN & MEGBOLUGBE (1997) best matched our requirements, we calculated the inverse distance matrices according to both specifications. Figure 2 shows Moran scatter plots for logarithms of land values for 2006. The plot based on a distance matrix capturing the three nearest blocks (Figure 2b) clearly exhibits a more linear relationship, better capturing spatial dependence. This is confirmed by a larger Moran's I coefficient.[12]

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[12] Comparing the effects of different spatial weight matrices on nominal values yields similar results. We provide scatter plots of logarithms since we use log values as endogenous variables.

Fig. 2a Spatial Dependence with 3,000 Meter Specification

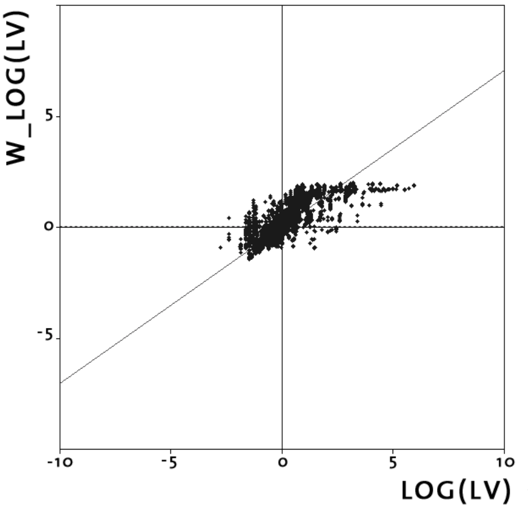
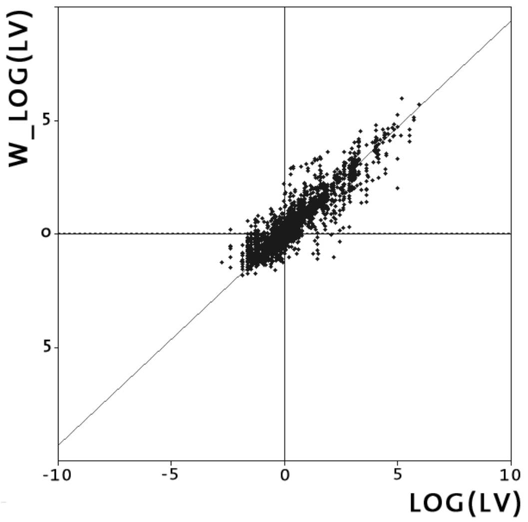


Fig. 2b Spatial Dependence with "3 Nearest Block" Specification



Notes: LOG(LV2006) is a natural logarithm of the standard land values of Berlin for 2006. W_LOG(LV2006) is the corresponding spatial lag value calculated on the basis of the spatial weight matrix. The corresponding Moran's I coefficient is 0.7051in Figure 2a and 0.9346 in Figure 2b.

Spatially lagged variables have positive effects on the explanatory power of models. This is the result of omitting attributes that are most likely to be correlated across space. Due to the large explanatory power of the spatial lag variable (i.e., Moran's I coefficient close to one), we emphasise that the explanatory power of our model depends only to a minor extent on the introduction of the lag term. In Table A2, we compare the performance of our final hedonic baseline regression (1) with performance when omitting the lag term (3). An R^2 of close to 0.9 indicates that our model performs well when neglecting spatial dependence.[13] However, the improvements in residuals following the spatial model extension are substantial. In Figure 3, the residuals corresponding to Table A1, Column (3), are plotted in a three-dimensional space.[14]

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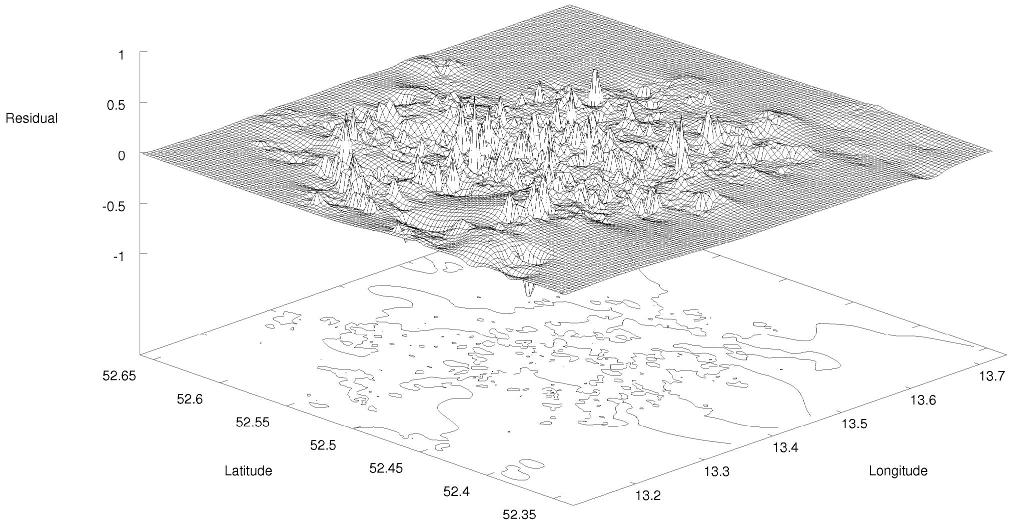
[13] To check for robustness, we consider numerous lag-term specifications, including the two, four, five and six nearest blocks as well as a specification considering all blocks within 1500 m. However, Moran scatter plots and R^2 both suggest that the final model is the best fit for capturing spatial dependence.

[14] These residual surfaces also serve as a useful tool to eliminate extreme values. The most western block, isolated and contiguous to Berlin's boundaries within a forest, has an extremely large residual. This indicates that our model, largely calibrated to inner-city areas, does not explain the valuation of an isolated area. Consequently, we omit this observation.

Figure 3 Gridded Residual Surface of Spatially-Extended Model



The full model specification can be expressed in the following way:

$$\begin{aligned}\ln(P) = {} & \alpha + \beta_1 Business + \beta_2 Industry + \beta_3 West \\ & + STRUCT\ a_1 + LOC\ a_2 + NEIGH\ a_3 \\ & + (Business \times STRUCT)\ b_1 + (Business \times LOC)\ b_2 \\ & + (Business \times NEIGH)\ b_3 \\ & + (Industry \times STRUCT)\ c_1 + (Industry \times LOC)\ c_2 \\ & + (Industry \times NEIGH)\ c_3 \\ & + (West \times SRUCT)\ d_1 + (West \times LOC)\ d_2 + (West \times NEIGH)\ d_3 \\ & + \gamma\ Spatial\_Lag + \varepsilon\end{aligned} \tag{6}$$

where ln(*P*) is the natural logarithm of standard land values; *Business*, *Industry* and *West* are dummy variables capturing land use and spatial heterogeneity; *STRUCT*, *LOC* and *NEIGH* are vectors of structural, locational and neighbourhood characteristics, respectively; and *Spatial_Lag* is the spatial autoregressive term from (4). α, β, γ and lower case letters represent the set of coefficients to be estimated and ε is an error term. In Table A1, in the Appendix, there is a detailed description of the components. Attribute variables interact with dummy variables to allow implicit values to vary across space and land use.

4.2 Modelling the Impact of Airports

We capture irregularities in land value pattern due to the airports by extending our baseline model with variables that attribute unexplained variation to zones of potential impact. Typically, externalities assessed in the urban economic literature can be assumed to spread evenly in all directions. Impact thus can be assessed using simple geometric forms like concentric rings and straight line distances to the potential sources of externalities (ELLEN *et al.*, 2001; GALSTER, TATIAN, & PETTIT, 2004; TU, 2005).

Assessing impact of noise generated by taking off and landing involves more complex forms, since sources of externalities move at high speed, thereby emanating noise over different locations at different altitudes. To account for the resulting sound pattern, we rely on officially determined protection zones which define areas being similarly affected by aircraft noise.[15] For each airfield there are two protection zones defined where the inner zone hardly exceeds the airport's territory. However, even outer zones describe areas still being exposed to aircraft noise. Since sonic sound does not halt at the borderline of a determined protection zone, we create larger zones capturing disturbance effects at larger distances. Borderlines of new zones are determined by proportional extension of officially-defined outer zones keeping zones centred on their geographic centroids. The resulting pattern can be interpreted as one of iso-noise lines representing areas similarly affected by noise disturbances. Figures 4 and 5 show the resulting pattern of officially-determined areas of noise protection (zone 1) and zones created by augmentation (zones 2–4) for Tempelhof and Tegel Airports. Zones 2-4 have each been enlarged stepwise by 4000 m on the horizontal diameter. Blocks are assigned to zones according to the location of geographic centroids.

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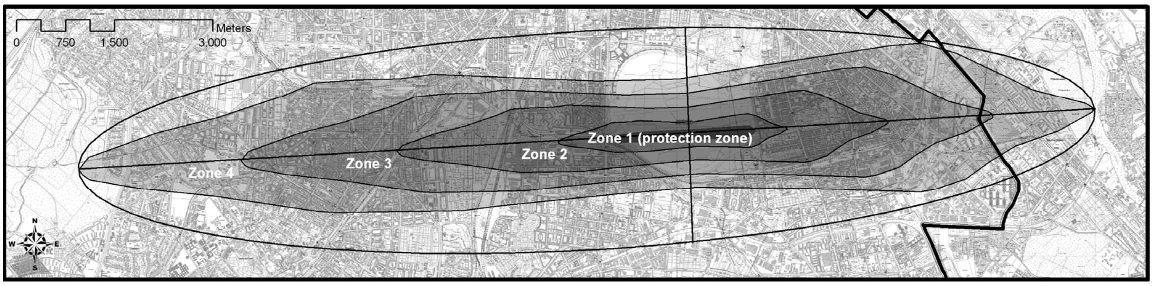
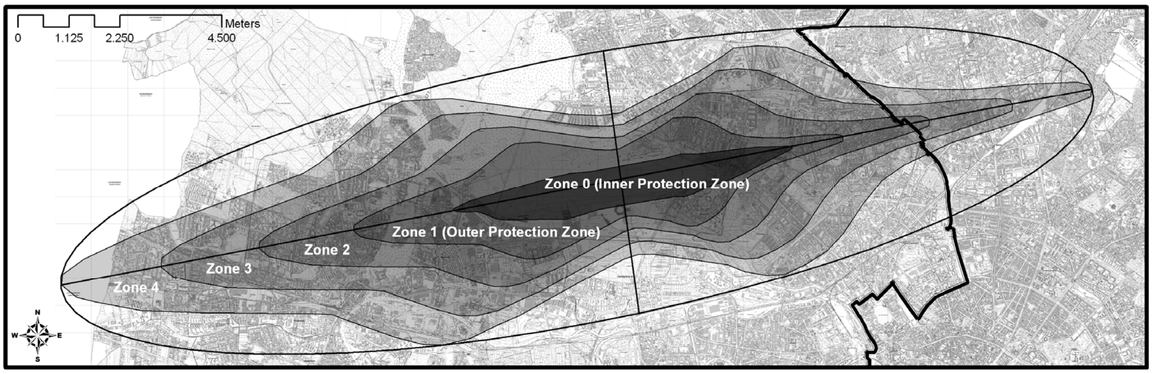
[15] Zones are determined on the basis of data on air traffic and define areas which are exposed to an equivalent continuous sound pressure level of more than 67 dB(A). Details are published in the Aircraft noise annual report available at the website of Berlin airports. URL: http://www.berlin-airport.de/EN/UeberUns/Umwelt/FlJahresbericht/Uebersicht.html.

Fig. 4 Tempelhof Noise Zones



Notes: This map was created on the basis of the "City and Environment Information System" (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2006b) of the Senate Department, Berlin.

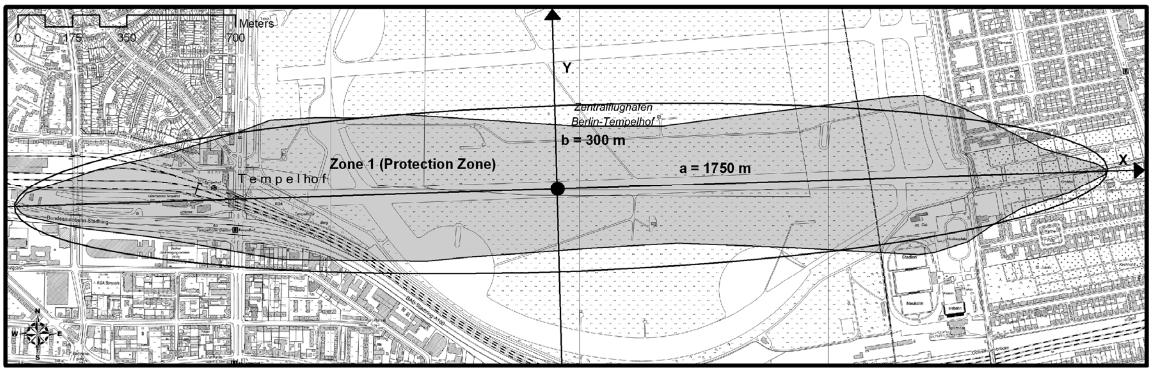
Fig. 5 Tegel Noise Zones



Notes: This map was created on the basis of the "City and Environment Information System" (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2006b) of the Senate Department, Berlin.

An alternative approach to attribute impact on land values to a potential source of external effects is to introduce distance of property to the location investigation. While this approach is straightforward when externalities can be assumed to spread concentrically, the application of straight line distances to airfield centres would necessarily lead to biased estimates. For instance, a distance of one kilometre to the runway along the air corridor might still be recognized as being close in terms of noise disturbance, while residents living at the same distance on the vertical centre line are likely to feel less perturbed by aircraft approaching and taking off. To deal with this particularity, we calculate equivalent distances in terms of noise perception, relying on simple geometry. We approximate the officially-defined outer protection zone by introducing a symmetric ellipse as exemplified for Tempelhof in Figure 6.

Fig. 6 Fitted Ellipse for Tempelhof Protection Zone



Notes: This map was created on the basis of the "City and Environment Information System" (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2006b) of the Senate Department, Berlin.

Fitting a coordinate system into the major and minor axes for airfield *j*, the ellipse is perfectly described by semimajor axis a_j and semiminor axis $b_{j,}$ since the ellipse is the locus of point *i* fulfilling the condition

$$\frac{x_{ij}^{\;2}}{a_j^{\;2}}+\frac{y_{ij}^{\;2}}{b_j^{\;2}}=1\,, \tag{7}$$

where x_{ij} and y_{ij} represent the coordinates of point *i* relative to the origin of coordinate system *j*.[16] Holding a_j and b_j constant, for every point *i* in coordinate system *j*, we obtain the value

$$c_{ij}^{\;2}=\frac{x_{ij}^{\;2}}{a_j^{\;2}}+\frac{y_{ij}^{\;2}}{b_j^{\;2}} \tag{8}$$

characterising the ellipse in terms of length of semiaxis relative to the original ellipse. Figure 7 compares the ellipse approximating the Tempelhof protection zone to corresponding ellipses for varying values of *c*. Larger values of *c* imply proportionally increasing semiaxes.

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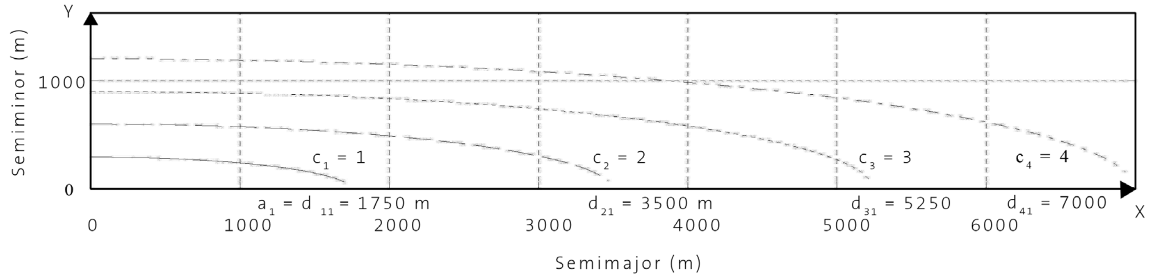
[16] For Tempelhof, *a* and *b* take the values of 1750 m and 500 m, respectively. The corresponding values for Tegel are 5000 m and 1000 m, respectively.

Fig. 7 Fitted Ellipse and Equivalent Distances



For each point *i* within the coordinate system, the length of the semimajor axis for the corresponding ellipse can be determined by multiplying the *c* value by semimajor axis parameter a_j of the original ellipse. Thus,

$$d_{ij} = a_j \times c_{ij} = \sqrt{x_{ij}^2 + \frac{a_j^2}{b_j^2} y_{ij}^2} \tag{9}$$

can be interpreted as point *i* equivalent distance to the centre of airfield *j* if it lies on the coordinate system's main axis corresponding to the air corridor. d_{ij} provides a comparable distance measure to the source of noise pollution.

5 Empirical Results

5.1 Baseline Hedonic Model

The baseline hedonic model (Table A2, Column (1)) fits satisfactorily with all coefficients showing the expected signs. The theoretically predicted negative distance-price relationship is much larger for West Berlin. The significantly negative coefficient for *West x Dist_Cent* can be interpreted as persistence of different spatial equilibriums emerged during the period of Germany's division. In East Berlin, no free markets being allowed, the usual theoretical prediction based on bid-rent theory (ALONSO, 1964) is not applicable. Land gradient varies across space and land use.

Composition and density of population affects land values more or less uniformly in both parts of the city. Population density has a negative impact on area valuation and the effect is significantly stronger within West Berlin. The coefficient for proportion of foreigners is also significantly negative, indicating that the foreign population indeed concentrates in areas of lower valuation, most probably due to lower incomes. This impact is similar in both parts of the city. The 18- to 27-year-olds also concentrate in areas of relatively lower valuation, probably since this group largely consists of trainees and students who have left home, thus being confronted with budget constraints. In contrast, people over 65 show no major concentration in economically deprived neighborhoods. The coefficient for the proportion of population below the age of six, a proxy for families with young children, is significantly positive.

Centrality is important, although the significantly positive coefficient for *Business x Dist_Cent* shows that the location premium that business users are willing to pay is not linked strongly to distance from CBD.

5.2 Empirical Impact of Berlin Airports on Land values

Figures 4 and 5 show four mutually exclusive zones for Tempelhof and Tegel Airports defined on the basis of official protection zones. Ellipses fitted around the boundaries of the outer zones define the general neighbourhoods. Fixed effect for these zones is captured by introduction of dummy variables denoting blocks whose centroids lie within these areas. Blocks lying within zones 1–4 are similarly represented by dummy variables capturing noise effects across space. The results of this basic impact model are presented in Column (1) of Table 2 for Tempelhof and Column (2) for Tegel.

Tab. 1 Empirical Results of Baseline Impact-Models

	(1) Land Value (Log)	(2) Land Value (Log)	(3) Land Value (Log)
Impact Area	Temepelhof	Tegel	Tegel (Residential)
Zone_1	-0.055132*** (0.019757)	0.030385*** (0.011541)	0.032781*** (0.010587)
Zone_2	-0.054069*** (0.013912)	0.018941* (0.01015)	0.023145** (0.009633)
Zone_3	-0.014747 (0.018981)	0.020979** (0.009703)	0.0248*** (0.009373)
Zone_4	-0.00172 (0.0162)	0.015574 (0.011103)	0.015622 (0.010852)
Neighbourhood	0.033983*** (0.010213)	-0.009387 (0.006503)	-0.011739* (0.006351)
Spatial Lag	Yes	Yes	Yes
Block Sample	Berlin	Berlin	Berlin
Observations	11,148	11,148	11,148
R-squared	0.966086	0.966016	0.96602

Notes: The basic model is the same as in Column (1) of Table A1. To reduce the table size we only display variables indicating impact of either Tempelhof or Tegel Airport. The log of standard land values is the endogenous variable in Models (1) – (3). Zones 1 – 4 are dummy variables, taking the value of 1 for blocks lying within the corresponding zone represented in Figures 3 and 4, and 0 otherwise. Neighbourhood is defined in a similar way, capturing general neighbourhood effects within the outer ellipses. In Column (3,) impact variables are interacted with a dummy variable denoting residential areas. Standard errors (in parentheses) are heteroscedastically robust. *Significance at the 10% level; **Significance at the 5% level; ***Significance at the 1% level.

Neighbourhood effects for Tempehof Airport are positive, indicating that properties sell at a location premium. Coefficient estimates for outer zones 3 and 4 are not significant at conventional levels reflecting that there are no additional location characteristics capitalized into prices. In contrast, coefficients for the two inner zones 1 and 2 have negative values of similar size and are statistically significant. These suggest a negative impact of 5.5% within an area of approximately 7.5 km in length and 1 km in width.[17]

Results for Tegel Airport are different and more surprising. While coefficients for the general neighbourhood and zone 4 are not statistically significant, results suggest a location premium of 2% for properties within zones 2 and 3, and up to

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[17] The area extends slightly more to the west (4 km) than to the east (3.5 km).

3% for zone 1. The Tegel air corridor, particularly the western wing, covers a large industrial area nerved by bodies of water. As land values within these areas may feasibly be assumed to react relatively inelastically to noise pollution, we repeat the estimation for Tegel Airport considering only impact on blocks exclusively used for residential purposes (Column (3)). However, the coefficients reveal the same picture.

Results so far suggest a significantly negative impact of airports on land values within zones 1 and 2 of Tempelhof Airport. To assess whether within these zones there is a clear relationship between impact and distance, we introduce equivalent distances as described in the methodological section. In Table 2 we capture the impact of Tempelhof by introducing a dummy variable denoting all blocks lying within zones 1 and 2 where impact was previously found to be significant. Also interacting this dummy variable with the equivalent distance variable (Column (1)) reveals a significantly positive distance-impact relationship.

Results suggest that along the air corridor impact diminishes from approximately 9% to 5% after 5 km, a distance corresponding to zone 2 of Tempelhof Airport. The same approach applied to Tegel Airport (Column (2)) reveals no distance-impact relationship significantly different from zero. Within zone 1, positive impact even increases with proximity (Column (3)), although the coefficient estimate is extremely close to zero. Results of Columns (1) and (3) are illustrated in Figure 8.[18]

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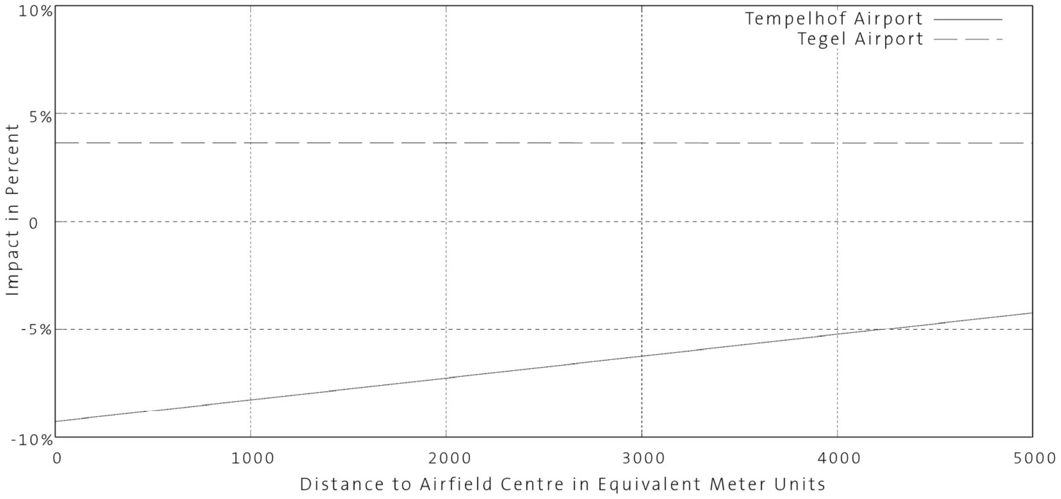
[18] In terms of equivalent distances, zone 1 of Tegel (5500 m) compares to zone 2 of Tempelhof (4500 m). We consequently choose to present impact based on the results of Table 3, Columns (1) and (2), for an equivalent distance range of 0–5000 m.

Tab. 2 Empirical Results of Estimates Based on Equivalent Distances

	(1) Land Value (Log)	(2) Land Value (Log)	(3) Land Value (Log)
Impact Area	Tempelhof	Tegel	Tegel (Residential)
Zone_1			0.036454**
			(0.016207)
Zone_1_2	-0.092752***	0.019905*	
	(0.019698)	(0.010427)	
Zone_1 x Eq. Distance			-0.00000002**
			0.00000001
Zone 1_2 x Eq. Distance	0.000010***	-0.000000010	
	(0.000004)	(0.000000006)	
Spatial Lag	Yes	Yes	Yes
Neighbourhood Effects	Yes	Yes	Yes
Block Sample	Berlin	Berlin	Berlin
Observations	11,184	11,184	11,184
R²	0.966087	0.966001	0.966003

Notes: The basic model is the same as in Column (1) of Table A2. To reduce the table size we only display variables indicating impact of Tegel or Tempelhof Airport. The log of standard land values is the endogenous variable as in Table 1 above. Zone_1 is defined as in Table 2. Zone_1_2 is a dummy variable denoting blocks lying either in zone 1 or 2. Eq. Distance is the equivalent distance from each block's centroid to the runway centre in equivalent meter units on the coordinates' main axes. Neighbourhood effects are defined as in Table 2. Standard errors (in parentheses) are heteroscedastically robust. *Significance at the 10% level; **Significance at the 5% level; ***Significance at the 1% level.

Fig. 8 Impact Tempelhof and Tegel Airports



Notes: Graphs displayed in this figure illustrate the coefficient estimates represented in Table 3, Columns (1) and (3).

Both approaches based on mutually exclusive zone dummy variables and equivalent distances basically yield the same results. These results are particularly surprising in the light of much larger aircraft taking off and landing at Tegel Airport and at much greater frequency compared to Tempelhof Airport. However, as noted above, building structure within the air corridors of Tempelhof and Tegel Airports differ substantially. This is reflected by an average population density of more than twice within zones 1 and 2 of Tempelhof Airport (0.025 inhabitants per square meter) compared to the corresponding zones of Tegel Airport (0.009).[19]

Our results suggest that owners of detached family houses in the vicinity of Tegel Airport react less sensitively to noise distortions than renters living in downtown apartments around Tempelhof Airport. These results are in line with previous findings indicating that prices of multistorey condominiums react more strongly to noise distortion generated by air traffic than those of detached houses (UYENO, HAMILTON, & BIGGS, 1993).

In the case of Berlin, this may partially be attributable to higher mobility of residents living in proximity to Tempelhof Airport. First, owners of detached family houses may be less free in choice of potential residence and less willing to move out of their homes. Secondly, as shown, residents living within the two inner zones of Tegel are older on average than those living within the corresponding zones of Tempelhof and may, therefore, be assumed to be less mobile.[20] Another explanation might be extra public payment for installation of passive noise protection leading to neutralization of distortions. Owners of detached family houses being immediately affected by aircraft noise in the vicinity of Tegel are more likely to install noise protection than landlords renting out apartments situated within the Tempelhof air corridor.

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[19] Median block population density differs even more substantially (0.0217 to 0.004).

[20] Comparing mean proportions of age groups within zones 1 and 2 of Tegel and Tempelhof Airports reveals that proportions are larger for all age groups below the age of 45 for Tempelhof while above 45 for Tegel.

Figure 1 shows the locations of Tegel and Tempelhof Airports and provides distances to CBDs as a simple accessibility indicator. We make use of highly disaggregated population and employment (at workplace) data to calculate more precise accessibility indicators for all three Berlin Airports. Following the tradition in economic geography, we represent airport accessibility *j* for residents by population potentiality PP_j, which is the distance-weighted sum of population of all instances of block *k* in Berlin (P_k).

$$PP_{ij} = \sum_k P_k \times \exp(-\alpha \times r_{jk}), \tag{10}$$

where α is the distance decay factor and r_{jk} is the shortest road distance between block *k* and airport main entrance *j*. α takes the value of 0.5, a typically applied value in the urban economic and economic geography literature (WU, 2000). Employment potential is calculated analogically using data on employment at workplace to reflect accessibility from businessmen's perspective. In terms of accessibility, Tempelhof Airport is clearly the most favourable from both a resident's (population potentiality) and a businessman's (employment potentiality) point of view. Just considering Berlin residents and employees, the location of Schönefeld/BBI Airport is remote compared to both city airports.[21]

6 Conclusion

This paper contributes to the assessment of external effects of airports by providing evidence for airports located in continental Europe where little evidence had been available. Focussing on two downtown airports, Tempelhof and Tegel, located in the same city, Berlin, but amid neighbourhoods characterized by distinctly different building structures, a negative impact was only found for the densely developed and populated areas within the Tempelhof air corridor where

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[21] The results for accessebility indicators for Tempelhof, Tegel and Schönefeld Airports are 121,497, 35,314 and 15,491 for population potentiality and 52,293, 14,458 and 1775 for employment potentiality, respectively.

land values are depreciated up to 9%, which is in line with the findings of COLLINS & EVANS (1994). Although there is evidence in the empirical literature for property prices within low density residential areas reacting less sensitively to aircraft noise (UYENO, HAMILTON, & BIGGS, 1993), the complete absence of negative impact of Tegel Airport on land values is somewhat unique.

Since 2003 Berlin has been experiencing a boom in air traffic largely driven by low-cost carriers with yearly growth rates in passenger numbers of 8–15%. With a growth rate of 8.5% from January to March 2007, passenger numbers are expected to exceed 20 million by the end of the year. Considering the recent boom in air traffic, it is likely that BBI immediately after inauguration will be undersized as the initial capacity will be limited to 22 million passengers. With regard to newly emerging discussion on the subject, our results suggest that taking social costs and benefits into account, suspension of the planned closure of Tegel airport might be justifiable.

Appendix: Data Collection

We collected data on standard land values, FSI values and land use as determined by zoning regulations from atlases of standard land valuation (Bodenrichtwertatlanten) (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2006a). The Committee of Valuation Experts in Berlin has published this data at intervals of one to four years, since 1967.

Data collection was conducted by assigning values represented in atlases of standard land valuation to the official block structure as defined in December 2005. If more than one value was provided by an atlas of standard land valuation for one particular block, the average of the highest and lowest values was used. Price data has been collected individually for blocks, not used for purely residential purposes. In contrast, for pure residential areas, data on land values at a lower level of disaggregation ("Statistische Gebiete") was used, since variation was typically much smaller. Since Berlin consists of 195 statistical areas ("Statistische Gebiete"), this ensured that price data for residential areas was sufficiently disaggregated to draw a comprehensive picture. Aggregation to statistical area level was by averaging the highest and lowest standard land values within the respective area. To guarantee that averages represented a feasible proxy of overall area valuation, a threshold for the ratio of maximum-to-minimum land value within a statistical area was introduced. If this ratio was > 2, then the extreme values were entered individually and averages were taken for the remaining blocks until the ratio fell below the threshold value. This had to be done in only very few cases, since generally maximum and minimum values were close.

Tab. A1 Description of Variables and Abbreviations

Variable	Description
	In Hedonic Regression
Business	Dummy variable: 1 for blocks where a considerable amount of retail and/or business activity takes place
Industry	Dummy variable: 1 for blocks where land is at least partially used for industrial purposes
West	Dummy variable: 1 for blocks lying within the area of former West Berlin
FSI	Floor space index: Quotient of full-storey area and plot area
FSI^2	Floor space index squared
Dist_Cent	Shortest great circle distance to CBD East or West in meters
Dist_Metro	Great circle distance to next metro station in meters
Dist_Suburban	Great circle distance to next suburban railway station in meters
Dist_Water	Great circle distance to next water space (lake or river) in meters
Dist_Schools	Great circle distance to next school in meters
Dist_Play	Great circle distance to next playground in meters
Dist_Rail	Great circle distance to overground railway tracks in meters
Pop_Prop_Sub6	Proportion of population below the age of 6
Pop_Prop_6_15	Proportion of population of age group of 6 to 15 years
Pop_Prop_15_18	Proportion of population of age group of 15 to 18 years
Pop_Prop_18_27	Proportion of population of age group of 18 to 27 years
Pop_Prop_65plus	Proportion of population above the age of 65
Pop_Density	Population density (inhabitants per square meter)
Prop_Foreigners	Proportion of foreign population
Prop_Male	Proportion of male population
Spatial_Lag	Spatial autoregressive term as described in the methodology section
STRUCT	Vector of structural characteristics including FSI and FSI^2
LOC	Vector of location characteristics including Dist_Cent, Dist_Metro, Dist_Suburban, Dist_Water, Dist_Schools, Dist_Play and Dist_Rail
NEIGH	Vector of neighbourhood characteristics including Pop_Prop_Sub6, Pop_Prop_6_15, Pop_Prop_15_18, Pop_Prop_18_27, Pop_Prop_65plus, Pop_Density, Prop_Foreigners and Prop_Male

Tab. A2 Baseline Empirical Results of Hedonic Analysis (1-3)

Variable	(1) Land Value (Log)	(2) Land Value (Log)	(3) Land Value (Log)
Intercept	1.419380***	1.409932***	4.770188***
	(0.067685)	(0.069337)	(0.013161)
Business	-0.476554***	-0.555828***	0.049848
	(0.178338)	(0.206850)	(0.226227)
Industry	-0.201496***	-0.659793***	-0.483550***
	(0.052465)	(0.184922)	(0.072417)
West	0.677466***	0.678161***	2.105208***
	(0.038296)	(0.041387)	(0.032986)
FSI	0.241159***	0.250090***	0.702962***
	(0.016054)	(0.015889)	(0.014560)
FSI^2	-0.025354***	-0.030463***	-0.056465***
	(0.005085)	(0.004964)	(0.005059)
Dist_Cent	-0.00000438***	-0.00000444***	-0.0000179***
	(0.000000587)	(0.000000599)	(0.00000084)
Dist_Metro	-0.00000211***	-0.000018***	-0.00000865***
	(0.000000625)	(0.000000659)	(0.00000118)
Dist_Suburban	-0.0000113***	-0.0000104***	-0.0000485***
	(0.00000341)	(0.00000362)	(0.00000392)
Dist_Water	-0.0000118***	-0.0000113***	-0.0000415***
	(0.00000201)	(0.000002)	(0.00000253)
Dist_Schools		0.000000299	
		(0.0000041)	
Dist_Play		-0.0000019	
		(0.00000302)	
Dist_Rail	0.0000122***	0.0000117***	0.0000468***
	(0.00000327)	(0.0000034)	(0.0000042)
Pop_Prop_Sub6	0.062190**	0.054859**	0.103997**
	(0.025417)	(0.025282)	(0.051869)
Pop_Prop_6_15		0.006943	
		(0.019842)	
Pop_Prop_15_18		-0.006325	
		(0.024015)	
Pop_Prop_18_27	-0.046841***	-0.040212**	-0.235991***
	(0.0057)	(0.019973)	(0.034376)
Pop_Prop_65plus		-0.026906**	
		(0.013406)	
Pop_Density	-0.737185***	-0.705164***	-0.846712***
	(0.0012)	(0.225787)	(0.253823)
Prop_Foreigners	-0.085958***	-0.059999*	-0.096806***
	(0.018556)	(0.035007)	(0.030934)
Prop_Male		0.006376	
		(0.017495)	
Business x FSI	0.355788***	0.371846***	0.138966
	(0.104214)	(0.110039)	(0.129089)
Business x FSI^2	-0.030011*	-0.027947*	0.024650
	(0.015922)	(0.016820)	(0.019060)
Business x Dist_Cent	0.0000499***	0.0000534***	0.0000783***
	(0.00000637)	(0.00000699)	(0.0000114)
Business x Dist_Metro	-0.0000304*	-0.0000435**	-0.000119***
	(0.0000161)	(0.0000167)	(0.0000187)

Tab. A2 Baseline Empirical Results of Hedonic Analysis (2-3)

Business x Dist_Suburban	-0.000064* (0.0000347)	-0.0000927* (0.0000532)	-0.000188*** (0.0000442)
Business x Dist_Water	0.0000402*** (0.0000127)	0.0000430*** (0.0000129)	0.0000240 (0.0000153)
Business x Dist_Schools		-0.00000580 (0.0000806)	
Business x Dist_Play		-0.0000188 (0.0000885)	
Business x Dist_Rail		0.0000512 (0.0000498)	
Business x Pop_Prop_Sub6		-0.235726 (0.202178)	
Business x Pop_Prop_6_15	-0.577296** (0.273710)	-0.476419 (0.315174)	-0.864808*** (0.256952)
Business x Pop_Prop_15_18		-0.105855 (0.353263)	
Business x Pop_Prop_18_27	-0.288284*** (0.102699)	-0.228749** (0.100348)	-0.421970* (0.244511)
Business x Pop_Prop_65plus		0.178150 (0.139387)	
Business x Pop_Density	-2.547692*** (0.907527)	-2.555855*** (0.882346)	-2.082144* (1.211372)
Business x Prop_Foreigners	0.188215*** (0.058839)	0.182792*** (0.068185)	0.360568*** (0.107345)
Business x Prop_Male		-0.014353 (0.089939)	
Industry x FSI		0.103909 (0.137109)	
Industry x FSI²		0.018786 (0.031367)	
Industry x Dist_Cent		0.0000161** (0.00000693)	
Industry x Dist_Metro		0.0000401 (0.0000285)	
Industry x Dist_Suburban	-0.0000862** (0.0000339)	-0.0000768* (0.0000456)	-0.0000303 (0.0000407)
Industry x Dist_Water		-0.00000984 (0.0000211)	
Industry x Dist_Schools	-0.000180* (0.000105)	-0.000111 (0.000107)	0.0000422 (0.000150)
Industry x Dist_Play	0.000354*** (0.000117)	0.000240* (0.000126)	0.000281* (0.000167)
Industry x Dist_Rail		0.0000387 (0.0000645)	
Industry x Pop_Prop_Sub6	0.780610** (0.352927)	0.530378 (0.361221)	0.204225 (0.408747)
Industry x Pop_Prop_6_15		0.050427 (0.390445)	
Industry x Pop_Prop_15_18		0.018953 (0.200147)	
Industry x Pop_Prop_18_27	0.344214** (0.352927)	0.312817** (0.129166)	0.469512*** (0.160178)
Industry x Pop_Prop_65plus		-0.098714 (0.126594)	

Tab. A2 Baseline Empirical Results of Hedonic Analysis (3-3)

Industry x Pop_Density		2.107667	
		(2.572701)	
Industry x Prop_Foreigners		-0.077971	
		(0.078824)	
Industry x Prop_Male		0.140772	
		(0.089877)	
West x FSI	-0.268710***	-0.263000***	-0.851855***
	(0.020125)	(0.020561)	(0.023213)
West x FSI^2	0.039513***	0.038739***	0.121320***
	(0.004624)	(0.004887)	(0.006546)
West x Dist_Cent	-0.0000317***	-0.0000319***	-0.000103***
	(-0.00000194)	(0.00000196)	(0.00000193)
West x Dist_Metro	0.0000236***	0.0000236***	0.0000727***
	(0.00000186)	(0.00000198)	(0.00000309)
West x Dist_Suburban	-0.00000769*	-0.00000815*	-0.0000322***
	(0.00000398)	(0.00000421)	(0.00000556)
West x Dist_Water	0.00000979***	0.00000963***	0.000038***
	(0.00000236)	(0.00000234)	(0.00000359)
West x Dist_Schools		0.00000277	
		(0.00000764)	
West x Dist_Play		0.0000497***	
		(0.00000863)	
West x Dist_Rail	-0.0000302***	-0.0000307***	-0.0000842***
	(0.00000430)	(0.00000445)	(0.00000682)
West x Pop_Prop_Sub6		0.032696	
		(0.052924)	
West x Pop_Prop_6_15		-0.028291	
		(0.034885)	
West x Pop_Prop_15_18	-0.156947***	-0.145205***	-0.432046***
	(0.040899)	(0.048004)	(0.093982)
West x Pop_Prop_18_27		-0.035878	
		(0.041474)	
West x Pop_Prop_65plus		0.020985	
		(0.024180)	
West x Pop_Density	-0.595791***	-0.549493*	-3.295263***
	(0.297937)	(0.302441)	(0.404408)
West x Prop_Foreigners		-0.032307	
		(0.041970)	
West x Prop_Male	-0.134591***	-0.141145***	-0.311987***
	(0.025066)	(0.032014)	(0.047581)
Spatial_Lag	Yes	Yes	
Block Sample	Berlin	Berlin	Berlin
Observations	11184	11184	11184
R^2	0.966127	0.966472	0.893846
Adjusted R^2	0.966002	0.966255	0.893465

Notes: Model (1) represents our baseline hedonic model, which we obtain after stepwise deletion of statistically insignificant variables of the full model specification (2). In (3) we repeat our baseline regression omitting the spatial lag-variable. The dependent variable is the natural logarithm of standard land values in all models. Independent variables are described in table 1. 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.

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