If Alonso was Right: Residual Land Price, Accessibility and Urban Attraction

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Abstract: This study investigates whether accessibility shapes the attractiveness of residential land as predicted by theory. A spatial hedonic analysis is conducted for the metropolitan area of Berlin, Germany, using a large set of georeferenced property transactions and micro-level data. We find that the nuclei of residential land price and employment density gradients are separated by approx. 10 km, which essentially contradicts theoretical implications. Also, environmental externalities arising from the residential composition or the building structure and density in the neighborhood are more important determinants than access to the city center, which, if at all, impacts negatively on residential land prices. Moreover, a new gravity-based accessibility indicator is employed that incorporates the effective distribution of employment as well as the rapid transit network architecture in order to disentangle the effects of proximity to employment opportunities from a more general urban attraction effect. After controlling for accessibility, we find a negative effect of urban attraction, respectively an effect of urban repulsion, indicating a relatively higher attractiveness of peripheral locations. This effect is partially counterbalanced by the benefits arising from access to employment opportunities that are, although relatively dispersed, more concentrated within downtown areas. In the tension between both forces, the land price gradient tends to be, if at all significant, positive. After all, we conclude that if transport costs are very low, commuting costs lose their role as the most striking determinant of land price. These results are robust to spatial dependency.

Keywords:Accessibility, gradient inversion, land price, urban attraction, Berlin

JEL classification: R23, R42, R52

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1 Introduction

Although the classical monocentric city model, arguably still the very core of urban economics, can hardly be ascribed to a single author, it seems fair to state that in terms of prominence and citation of his work, William Alonso still holds an outstanding position among the leading contributors. Therefore, and because the fundamentals of his model are quite similar to those of the other pioneering

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urban economists, his work might be regarded as exemplary for the early period of urban economics.[1] As one of the key features of the monocentric urban economy it is assumed that employment and population density as well as land price peak in one central urban core, which is the most attractive location in the city. With distance to the core, land price and intensity of land use continuously decline as transport costs to the exogenous center increase.

Of course, over the recent decades theoretical and empirical urban economic research has added substantially to this fairly simplistic framework. For instance, a broad range of amenities has been investigated that shape the value of urban land besides the compensations residents receive from reduced commuting (BRUECKNER, THISSE, & ZENOU, 1999; CHESHIRE & SHEPPARD, 1995). Recent theoretical models also address the key-weakness of the early models, which do not provide a comprehensive rationale for why city centers emerge. Accordingly, firms receive a production externality from neighboring firms that raises productivity and, hence, creates a strong incentive for agglomeration.[2] If the respective externalities are strong and localized and commuting costs are relatively low, then within a framework of abstract space the traditional "Mills map" will emerge (LUCAS & ROSSI-HANSBERG, 2002). Similar to the implications of the traditional monocentric theory, there is an economic core area predicted comprising all employment opportunities while residents trade the cost of commuting against the price of residential land along a (negative) central business district (CBD) gradient.

However, if transport costs are very low, other determinants of residential land prices will play an increasingly important role, possibly leading to a range of

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1 In the same breath as ALONSO (1964), the usual citations refer to MILLS (1972) and MUTH (1969). Important works sharing the same spirit, among others, include BECKMANN (1969) and SOLOW (1973). The respective history of thought at least dates back to VON THÜNEN (1826). In a recent survey, Alonsos' contribution featured within the group of the "path-breaking books in regional science" that received the most nominations by regional scientists. So far, more than 900 journal citations have been counted by the Institute of Scientific Information (ISI Web of Science) (WALDORF, 2004).

2 See for formal models BORUKHOV & HOCHMAN (1977), FUJITA & OGAWA (1982), LUCAS (2001), LUCAS & ROSSI-HANSBERG (2002), and TEN RAA (1984).

"irregular" gradient behaviors, e.g. land price gradients becoming insignificant, inverse or peaking at unexpected locations. In this analysis we empirically investigate the spatial structure of Berlin, Germany, using a large and comprehensive set of property transactions and highly disaggregated population and employment data, among data on additional location attributes. We relax a number of common assumptions, e.g. the featureless plain, perfect employment concentration, exogenous center as well as perfect substitutability between urban railway stations, in order to come closer to the effective pattern of accessibility and compare its role as a determinant of urban land price to other location characteristics. The metropolitan region of Berlin represents an interesting study area due to relatively low transport costs owing to a well-developed public transportation system and the absence of major problems of congestion.[3]

Our empirical strategy consists of four basic steps. First, we separate locational from non-locational property transaction characteristics in a hedonic analysis. In the second step, we compare the location of the endogenously identified nucleus of the land price gradient to the nodes of employment and population density gradients. In the third step, the role of the CBD land price gradient as a determinant of residential land gradient is investigated, including the sensitivity of the respective coefficient estimate to the introduction of a wide array of location controls. In the last step, we generate a more sophisticated accessibility indicator that helps to disentangle the pure employment accessibility effect from a more general effect of urban attraction, or repulsion, in order to reveal whether commuting costs feature as prominently as a determinant of location attractiveness as suggested by theory.

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[3] The major road and rail networks were designed during the pre World War II period, when Berlin counted almost 4.5 million inhabitants. Since then transport infrastructure has steadily improved while the population by the end of 2005 was below 3.4 million.

Data

Our sample of residential property transactions comprises 30,061 transactions which occurred between January 1, 2000, and December 31, 2007.[4] Transaction data provided by the COMMITTEE OF VALUATION EXPERTS IN BERLIN (2007) includes the usual parameters such as age, floor space, plot area and storeys as well as information on buildings' physical condition, plot shape, building type, location characteristics and contract details including information on buyers and sellers, among other things. Employing a GIS-environment, property transactions were geo-referenced based on geographic coordinates and merged with an electronic map of 15,937 officially defined statistical blocks, the highest level of disaggregation for which data is available at the statistical office. 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 at the end of 2006 was 271 (median 135). Referring to the framework of statistical blocks we obtain data on population, including such characteristics as age, origin and automobile registrations as well as data on employment at workplace.[5] Population data refer to the end of 2005. GIS content covering data on natural amenities like water and green spaces, urban railway stations and network is provided by the Senate Department (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2006).

2 Empirical Analysis

2.1 Generating Residual Land Price

We start from the basis assumption that the attractiveness of real estate commodities is fully capitalized into property prices in equilibrium real estate markets. The implicit prices of locational as well as non-locational factors can hence be revealed in a hedonic analysis using standard multiple regression

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[4] From the full record, approx. 1,800 observations had to be excluded due to missing values in relevant variables. We found no reason to believe in any type of sample selection bias.

[5] Data include all employees contributing to the social insurances in 2003.

techniques (MUELLBAUER, 1974; ROSEN, 1974). SIRMANS, MACPHERSON & ZIETZ (2005) provide a thorough review and meta-analysis of recent hedonic pricing studies.

Since the focus of our research lies on the price of urban land we use a strategy similar to PLAUT & PLAUT (2003) in order to separate the implicit price paid for locational attributes of a property from the non-locational characteristics. Employing the well-established log-linear specification we therefore regress the log of price of land in Euro per square meter of purchased land (*Price*) on a set of attributes characterizing the objects' physical attributes and contract details that potentially influence transaction price, as well as a set of location fixed effects that capture unobserved location characteristics.

$$\log(Price_i) = STRUCT_i\ a + \mu_i, \tag{1}$$

where $\mu_i = \theta_i + \varepsilon_i$,

STRUCT is a vector of non-locational characteristics, a is the respective set of coefficients, μ is a composite error term facilitating unobserved traffic cell (Verkehrszelle) fixed effects θ and ε is a random error term satisfying the usual conditions.[6] Since we cluster standard errors on traffic cells, our estimator addresses spatial autocorrelation in the error by allowing mean and variance to vary across space (DEHRING, DEPKEN, & WARD, 2007).

Results of hedonic analysis corresponding to equation (1) are presented in column (2) of Table A1 in the appendix. All models in Table A1 include year effects and monthly dummy variables. Column (1) shows results when location effects are omitted. These results are displayed for the sake of completeness only, allowing the interested reader to get an impression of the estimates' sensitiveness to the consideration of location and neighborhood characteristics. The following discussion refers to column (2) results, which are largely confirmed by the application of parametric location controls displayed in columns (3) and (4). As

[6] Our estimator coniders 303 out of 338 traffic cells.

expected, the floor space index (FSI), which is the ratio of total floor area to the area of the respective plot of land, significantly impacts on square meter land value. A respective increase in the FSI from, for example, 1 to 2 is accompanied by a corresponding increase in implicit land price of approx. 90%. With higher FSI values the effect slightly diminishes. Ceteris paribus, smaller plots and properties with more storeys tend to realize somewhat higher plot prices while properties with larger total floor space show the opposite effect. We also find the usual effect of property prices declining at a decreasing rate with age of the building structure. In addition, a particularly good or bad physical condition significantly impacts on sales price. Features like an extended flat, an elevator or a basement also raise transaction prices. Moreover, contract details significantly influence transaction prices. While properties where housing associations or public authorities are sellers, sell at a discount, the opposite is true for private juristic persons. Also, properties that are free of charge for local public infrastructure, not occupied by renters or possess a low share of secondary structures at sales price realize significant premiums.

From the effective plot price per square meter, the non-locational property characteristics and the estimated attribute coefficients, the residual land price (*RES*) can be inferred:

$$RES_i = \exp\left(\log(Price_i) - STRUCT_i\ \hat{a}\right) \qquad (2)$$

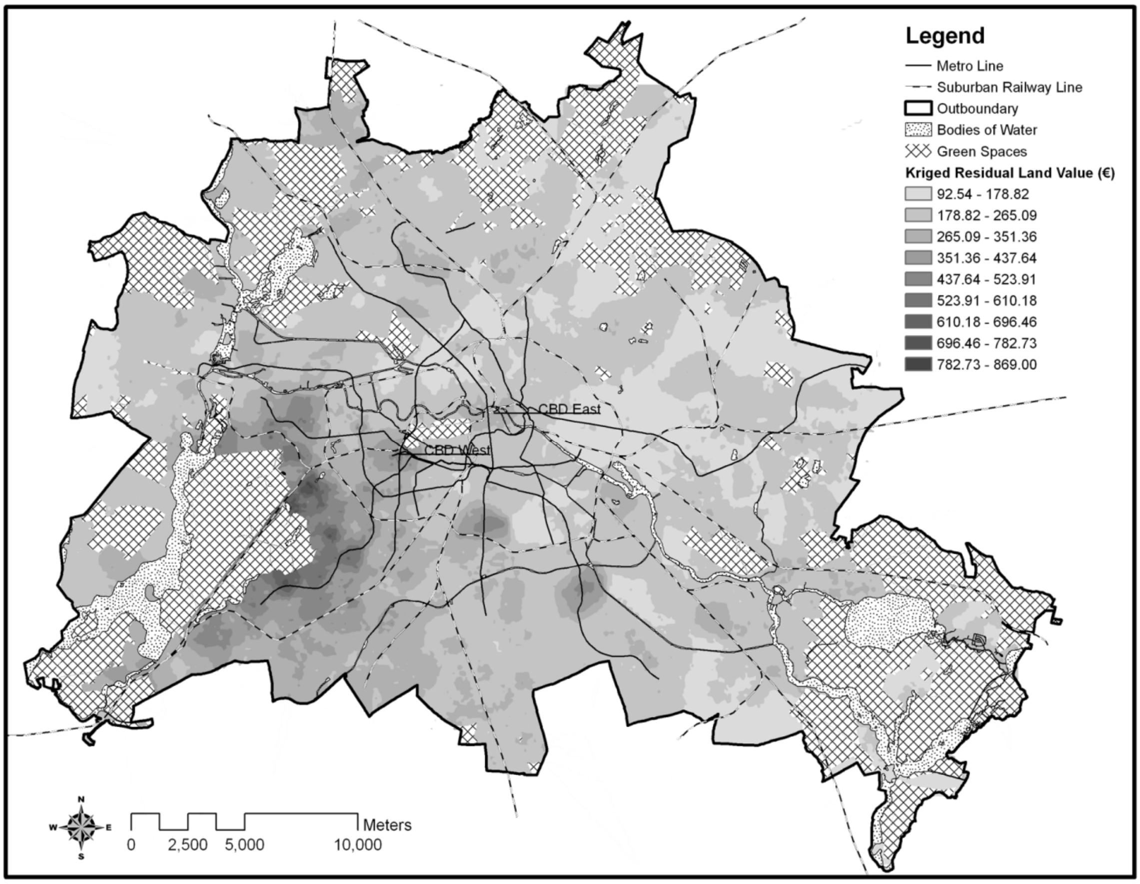
Assuming that there are no relevant omitted property characteristics, these residual land prices reveal the premium that buyers were implicitly willing to pay for a square meter of land at a given location. As long as omitted structural attributes are not correlated across space, we can at least rule out a systematic deviation from the implicitly perceived value of land.

Estimated residual land price is visualized in Figure 1 employing standard spatial interpolation techniques.[7] Following Alonso's basic assumptions underlying the

[7] We use ordinary kriging with a spherical semivariogram model.

monocentric theory, we would expect the highest implicit land price to be located within the downtown areas of Berlin, continuously declining as distance to the city center increases. However, besides a general east-west heterogeneity, which might be attributable to some form of market segmentation due to city's particular history, a notable concentration of higher valued areas is instead observable in the south-west of Berlin.

Fig. 1 Residual Land Prices



Notes: Kriging is ordinary with spherical semivariogram model. Kriged land values are given in Euro per square meter. Classes are defined according to the JENKS (1977) algorithm.
Source: Urban and Environmental Information System of the Senate Department Berlin (2006).

2.2 Gradient Nodes

The standard monocentric model of an urban economy assumes that land price and various density gradients take a negative convex form, all emerging from a single "nucleus", "node" or "pinnacle", which is the city center. Assuming the location of the CBD to be known *a priori*, gradients are usually described by a negative exponential function of distance to the CBD (*distCBD*). Our residual land prices would accordingly be described by the following function.

$$RES_i = \alpha_0 + \alpha_1 \exp(-\alpha_2\ distCBD) + \varepsilon_i \quad (3)$$

Employment and population density gradients may be modeled in the same way. In order to empirically reveal whether the residential land price gradient as well as the population and employment gradients all emerge out of one common nucleus, the assumption of an *a priori*-known CBD location has to be relaxed. As suggested by PLAUT & PLAUT (1998) we therefore substitute distance to the CBD by a function of CBD coordinates relative to location *i*.

$$RES_i = \alpha_0 + \alpha_1 \exp(-\alpha_2\ ((X^C - X_i)^2 + (Y^C - Y_i)^2)^{0.5}) + \varepsilon_i \quad (4)$$

where X^c (east/west) and Y^c (north/south) describe the location of the CBD by coordinates given in units of projected km and X_i and Y_i are the same referring to transaction *i*. Table 1 shows parameter estimates corresponding to equation (2) estimated by the use of non-linear least squares (NLS).

Tab. 1 Land Price and Employment Gradient

	(1) (NLS)	(2) (NLS)	(3) (NLS)
α_0	177.306*** (0.8734)	0.00083*** (0.000149)	-0.00359*** (0.00106)
α_1	649.664*** (22.3781)	0.03493*** (0.001930)	0.02865*** (0.000793)
α_2	0.373*** (0.0087)	0.518*** (0.0273)	0.086*** (0.0072)
X^c	14.398*** (68.969)	22.983*** (87.495)	23.780*** (110.146)
Y^c	16.051*** (43.715)	20.236*** (86.958)	19.036*** (116.714)
Obs.	30,061	15,937	15,937
R squared	0.173	0.053	0.155

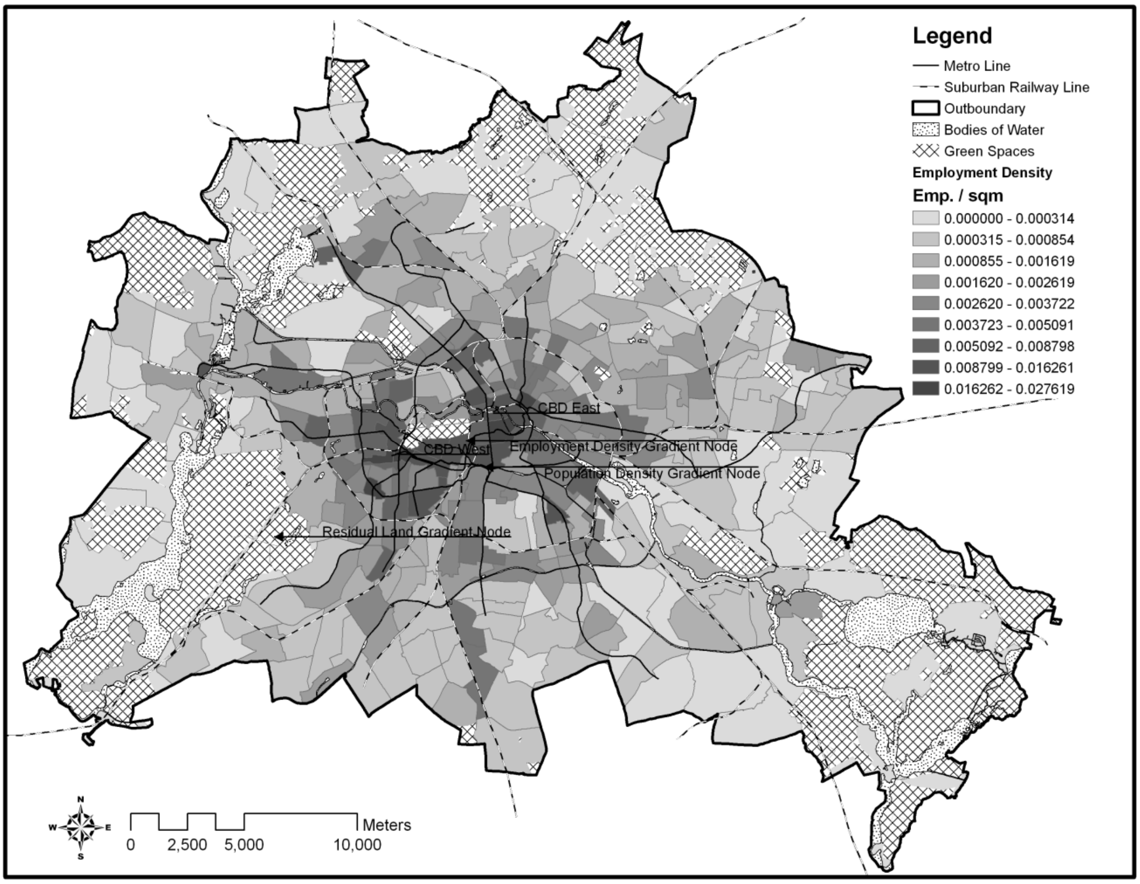
Notes: Endogenous variable is residual land price per sqm. (*RES*) in model (1), employment per sqm in model (2) and population per sqm in model (3). * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Estimated employment and population density nodes both lie within the major downtown area of Berlin, separated only by approx. 1.5-km. In contrast, the respective residential land price gradient node is located in the middle of the forest Grunewald, one of the major recreational areas in Berlin. This location is clearly outside the suburban railway ring, which represents an important demarcation line for the inner-city areas of Berlin. It is separated by roughly 10 km from the estimated employment and population density nodes. Figure 2 illustrates the locations of estimated gradient nodes on the background of employment density.

The negative intercept value for population density displayed in column (3) of Table 2 appears somewhat distracting. However, our estimates effectively imply that the population density diminishes to zero after 24.275km from the population density gradient node, which roughly corresponds to the radius of a circle touching the city's boundaries at the outmost point.

Table 1 results, as well as Figure 1 and 2, strongly indicate that access to the CBD is not the most important determinants of residential land price in Berlin. Also, access to employment does not seem to play the predominant role in intra-city choice of location, given that employment density is highest within the downtown area. Residents potentially sort spatially according to preferences for a broader range of location and neighborhood characteristics, rather than with respect to accessibility to employment and other amenities that are concentrated in the urban core. This outcome, which essentially contradicts the implications of Alonso's monocentric city model, could be facilitated by relatively low transport costs due to a well-developed system of public transport and the absence of considerable problems of congestion, which would raise the opportunity cost of traveling by private transport. Alternative determinants of residential land price are subject to further investigation in the following sub-section.

Fig. 2 Employment Density and Gradient Nodes



Notes: Employment density is given in employment per square meter. Classes are defined according to the Jenks (1977) algorithm. For better visibility display employment density referring to the framework of 338 traffic cells instead of 15,937 statistical blocks.

Source: Urban and Environmental Information System of the Senate Department Berlin (2006).

2.3 Determinants of Residual Land Price

Standard hedonic price estimates explaining estimated residual land prices (*RES*) by a number of location attributes using multiple OLS regression are presented in Tables 2.

$$\log(RES_i) = LOC_i\, b + \varphi_i \tag{5}$$

where *LOC* is a vector of variables, which covers distance to the employment center as well as other location characteristics such as building structure, spatial amenities and neighborhood composition, and *b* is the respective set of coefficients to be estimated. However, due to the spatial nature of the data, a spatial structure in the error term φ is likely to arise, which can be addressed by employing spatial autoregressive models (SAR). Following the standard procedure, we decide for a spatial error correction model to account for error terms and omitted variables that are correlated across space (ANSELIN, 2003; ANSELIN & BERA, 1996; ANSELIN & FLORAX, 1996).[8] We choose a row-standardized weights matrix (W), where transactions within a distance band of 350 meters are treated as neighbors.[9] Formally, the spatial autoregressive (SAR) model that we estimate employing a maximum likelihood estimator corrects for the spatial structure of the error term φ in equation (5) as follows:

$$\varphi = \lambda W \varphi + \varepsilon, \qquad (6)$$

where ε is a usual independent and identically distributed vector of error terms. Table 3 presents SAR estimates analogical to Table 2.

In column (1) of Table 2, we show results for OLS regression of residual land price (*RES*) on distance to the employment center estimated in Table 1. In order to account for possible market segmentation as a persistent effect of the city's division during the 20th Century, we include a dummy denoting all transactions that took place within the formerly western part of the city (*West*). Throughout all estimations conducted in the course of this analysis, we find a robust price differential between the formerly separated parts of the city. Accordingly, land in the western part of the city during our period of observation was valued as on average roughly 20% - 25% higher.[10] At the same time, the positive and highly statistically significant coefficient on the distance to the employment center in column (1) confirms that proximity the CBD does not raise the price of residential land as is predicted by theory.

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[8] Another form of spatial dependency emerges from the fact that sales prices are endogenous to neighboring transactions. This dependency can be dealt with by the application of a spatial lag model. Methodological aspects of spatial error and spatial lag models are covered by ANSELIN (1988) and ANSELIN & BERA (1998).

[9] This weights matrix provides the best fit compared to alternative specifications and minimizes the Akaike and Schwarz criteria.

[10] For dummy-variables the percentage impact in semi-log models corresponding to a parameter estimate *b* may be approximated by (exp(*b*) – 1)*100 (HALVORSEN & PALMQUIST, 1980).

Tab. 2 Determinants of Residual Land Price (OLS)

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)
Distance (km) to Employment Center	0.00467*** (0.000577)	-0.0143*** (0.000792)	0.0282*** (0.00176)	-0.0212*** (0.000821)	-0.0102*** 0.00191
West	0.210*** (0.0059)	0.184*** (0.0059)	0.196*** (0.00625)	0.224*** (0.0074)	0.227*** (0.00783)
PBS: Prefabricated 1950s		-0.0870*** (0.0253)			-0.0637** (0.0251)
PBS: Low Density Wilhelminian Style		-0.0121 (0.0136)			0.0416*** (0.0139)
PBS: High Density Wil. Style with Mod.		-0.176*** (0.0164)			-0.0528*** (0.0171)
High Density Wil. Style		-0.232*** (0.0104)			-0.0209 (0.0143)
PBS: Post-War Villas		0.338*** (0.0144)			0.266*** (0.0145)
PBS: Low Density Early 20th Cent.		0.0864*** (0.0082)			0.0307*** 0.00845
PBS: Low Density 1990s		0.207*** (0.0164)			0.223*** 0.0171
PBS: High Density Post-War		-0.0195 (0.0313)			0.0673** 0.0314
PBS: Village-like		-0.144*** (0.0272)			-0.199*** 0.0281
PBS: Post-War Villas		0.130*** (0.0189)			0.0680*** 0.0189
PBS: Block Dev. 1920s and 1930s		0.183*** (0.0191)			0.196*** 0.0189
PBS: Prefabricated 1980s / 1990s (East)		0.251*** (0.0626)			0.337*** 0.0627
PBS: High Density 1990s		-0.0535* (0.0282)			0.00234 0.0294
Distance to Nearest Water Space (km)			-0.0029 (0.0022)		-0.0196*** 0.00225
Distance to Nearest Green Space (km)			-0.0160*** 0.00162		-0.0048*** 0.0016
Distance to Nearest Station (km)			-0.0677*** (0.0033)		-0.0700*** 0.00338
Population Density (Inhabitants/sqm)				-3.640*** (0.2870)	-3.018*** (0.3650)
Proportion (%) Pop. under 18 Years Old				0.0017*** (0.0005)	0.0021*** (0.0005)
Proportion (%) Pop. 18 – 27 Years Old				-0.0052*** (0.0007)	-0.0058*** 0.0007)
Proportion (%) Pop. 65 Years and Older				0.0029*** (0.0004)	0.0022*** (0.0004)
Proportion (%) Foreign Population				-0.0071*** (0.0004)	-0.0072*** (0.0004)

Tab. 2 (Continued)

	(1)	(2)	(3)	(4)	(5)
Automobile Reg. per Capita				0.0561**	0.0722***
				(0.0246)	(0.0245)
Constant	4.997***	5.207***	5.012***	5.351***	5.361***
	(0.0078)	(0.0121)	(0.0086)	(0.0249)	(0.025)
Obs.	30,061	30,061	30,061	30,061	30,061
R-squared	0.037	0.094	0.050	0.102	0.137

Notes: Endogenous variable is log of residual land price per square meter in all modes (*RES*). PBS variables capture the predominant building structure. Heteroscedasticity robust standard errors are in parenthesis. * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Column (2) of Table 3 reveals the robustness of this result, although the significance level of the coefficient is slightly affected. Given that employment is not particularly concentrated at the city fringe, besides generally low commuting costs, these findings indicate the presence of either perceived amenities in the periphery or disamenities in the core. So far, there is still relatively little evidence available on land price gradients becoming positive, and those who have investigated gradient inversion did so mainly for the city of Chicago (MCDONALD & BOWMAN, 1979; MCDONALD & MCMILLEN, 1990; MCMILLEN, 1996). One of the few exceptions are PLAUT & PLAUT (2003), who document a gradient inversion for Haifa, Israel, by the mid-1980s. They attribute the inversion to a dramatic increase in car ownership, which led to the CBD losing its comparable advantages in terms of accessibility. Other common explanations for gradient inversion refer to aging and deterioration of downtown housing stock or the socioeconomic traits in inner-city neighborhoods. In columns (2) – (5) of Tables 2 and 3, we address some potential explanations for the relative attractiveness of peripheral locations in Berlin. Since age and physical condition of properties were already accounted for when generating residual land values, we use a set of dummies describing an area's typical building structure in order to capture the related external effects on location desirability (column 2). In column (3) we add geographic distance variables addressing availability of rail-based public transport as well as natural amenities. Neighborhood composition, including car ownership per capita, which presumably captures both an income and accessibility effect, is investigated in column (4). In column (5) we explain residual land price by the full set of locational attributes. The positive (inverted) land price gradient disappears (SAR) or even becomes negative (OLS) in columns (2), (4) and (5). These results point to a significant spatial correlation between building structure and neighborhood characteristics with land price as well as with distance to the employment center. For instance, results suggest an amenity effect related to less intensely developed and populated areas, potentially covering the effects of lower congestion and a peaceful atmosphere. Moreover, car ownership is significantly positively related to land price. Since automobile density is also positively correlated with distance to the employment center, the significant price effect possibly reflects preferences of high income households for peripheral areas and the necessity to improve effective accessibility by having cars. Proximity to spatial amenities like green spaces and bodies of water as well as railway stations also impacts positively on the price of land, although their contribution – the explanation of the positive land gradient – is limited compared to the alternative sets of location variables.

The results described above are generally robust both within and between Tables 2 and 3. Comparison of column (5) in Table 2 to column (3) in Table A1 also reveals that results remain qualitatively unchanged when using prices per square meter and the full set of structural attributes instead of residual land prices.

Tab. 3 Determinants of Residual Land Price (SAR)

	(1) (SAR)	(2) (SAR)	(3) (SAR)	(4) (SAR)	(5) (SAR)
Distance (km) to	0.00432*	-0.00068	0.02806***	0.00322	0.0145
Employment Center	(0.002091)	(0.00226)	(0.00589)	(0.002324)	(0.00568)
West	0.213***	0.212***	0.203***	0.215***	0.211***
	(0.021)	(0.0202)	(0.0217)	(0.0205)	(0.0212)
PBS: Prefabricated		-0.019			-0.004
1950s		(0.0193)			(0.0197)
PBS: Low Density		0.002			0.013
Wilhelminian Style		(0.0161)			(0.0169)
PBS: High Density		-0.069***			-0.055***
Wil. Style with Mod.		(0.0175)			(0.0184)
High Density		-0.058***			-0.039***
Wil. Style		(0.0118)			(0.0140)
PBS: Post-War Villas		0.059***			0.055***
		(0.0182)			(0.0182)
PBS: Low Density		0.032***			0.029***
Early 20th Cent.		(0.0100)			(0.0101)
PBS: Low Density		0.104**			0.113**
1990s		(0.0472)			(0.0471)
PBS: High Density		0.057*			0.082**
Post-War		(0.0338)			(0.0341)
PBS: Village-like		-0.051			-0.052
		(0.0369)			(0.0368)
PBS: Post-War Villas		0.017			0.018
		(0.0225)			(0.0215)
PBS: Block Dev.		0.057***			0.063***
1920s and 1930s		(0.0178)			(0.0184)
PBS: Prefabricated		0.389***			0.396***
1980s / 1990s (East)		(0.0692)			(0.0692)
PBS: High Density		0.042			0.047
1990s		(0.0390)			(0.0392)
Distance to Nearest			-0.011		-0.0159**
Water Space (km)			(0.0075)		(0.0071)
Distance to Nearest			-0.016***		-0.013**
Green Space (km)			(0.0054)		(0.0050)
Distance to Nearest			-0.0640***		-0.069***
Station (km)			(0.0109)		(0.0104)
Population Density				-0.723**	-0.452
(Inhabitants/sqm)				(0.3290)	(0.3907)
Proportion (%) Pop.				0.0019***	0.0018***
under 18 Years Old				(0.0005)	(0.0005)
Proportion (%) Pop.				-0.0011*	-0.0014**
18 – 27 Years Old				(0.0007)	(0.0007)
Proportion (%) Pop.				0.0006	0.0006
65 Years and Older				(0.0004)	(0.0004)
Proportion (%)				-0.182***	-0.178***
Foreign Population				(0.0005)	(0.0005)

Tab. 3 (Continued)

	(1)	(2)	(3)	(4)	(5)
Automobile Reg.				0.099***	0.097***
per Capita				(0.0192)	(0.0192)
Constant	4.993***	5.04058***	5.013***	5.032***	5.076***
	(0.0286)	0.02936	(0.0297)	(0.0351)	(0.0357)
λ	0.769***	0.76132***	0.765***	0.758***	0.747***
	(0.006)	0.0064779	(0.0064)	(0.0065)	(0.0068)
Obs.	30,061	30,061	30,061	30,061	30,061
R-squared	0,345	0,347	0,346	0,346	0.348

Notes: Endogenous variable is log of residual land price per square meter (*RES*) in all models. PBS variables capture the predominant building structure. SAR models use a weight matrix that treats properties within 350 m as neighbors. Standard errors (in parenthesis) are robust for heteroscedasticity and spatial dependency. * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

2.4 Accessibility and Urban Attraction

Despite the theoretical prominence, our results so far provide surprisingly little evidence for accessibility representing a major determinant for attractiveness of urban location, at least when the monocentric city model is the considered reference. Very limited accessibility effects on house prices have frequently been found in hedonic analyses (ADAIR *et al.*, 2000; CHESHIRE & SHEPPARD, 1997; HENNEBERRY, 1998).

Nevertheless, some of the results presented in the above sub-section indicate that residents indeed take into account effective accessibility in their choice of location. The positive relationship between car ownership, distance to the employment center and the price of residential land indicates that the cost of remoteness is relatively lower for households that are willing and able to have cars, resulting in a potential outbidding of low-income households in suburban locations. Also, the estimated positive price effect of proximity to urban railway stations clearly indicates that residents value an increase in effective accessibility derived from the metrorail system. According to our robust estimates, implicit land prices are raised by approximately 7% for a 1km reduction in distance to the nearest station, which lies within the range of estimates provided in the literature (GIBBONS & MACHIN, 2005). Hence, the non-significant or even positive coefficient estimates for distance to the employment center presented in Tables 2 and 3 do not necessarily imply the absence of significant accessibility effects. More likely, the underlying assumptions of the monocentric urban economy are too rigid and inadequate to capture the effective spatial structure of Berlin. In particular, the assumption of perfectly concentrated employment opportunities within the urban core seems rather questionable. As advocated by ADAIR *et al*. (2000), more complex gravity-based accessibility indicators may come closer to reality by allowing the respective spatial pull to originate from distinct locations. Using such a measure, OSLAND & THORSEN (2008), studying a monocentric region in Norway, disentangle the impact of employment accessibility on housing prices from a more general effect of urban attraction, which they attribute to urban amenities that are concentrated in the core region. Considering these results, the absence of a significantly negative land price gradient (to the employment center) by no means connotes that residents do not value access to employment opportunities. On the one hand, the employment distribution might simply be too dispersed in order to be well reflected by the distance to the employment centre. On the other hand, the observed land price gradient is likely to reflect a net effect of access to employment and a broader centrality effect, whereas in contrast to OSLAND & THORSEN (2008) we may observe an effect of urban repulsion instead of attraction.

We therefore generate a gravity-based accessibility measure building on the basic hypothesis that larger numbers of employment opportunities, which are accessible within a reasonable amount of time, increase the number of households bidding for living space at a given location and, hence, equilibrium land prices. The point of departure is a HANSEN (1959) type accessibility measure which represents employment potentiality (*EP*) at location *i* as distance-weighted sum of employment (*E*) at locations *j*. Such potentiality measures have a long tradition in economic geography, dating at least back to HARRIS (1954).

$$EP_i = \sum_j E_j \exp\left(-\delta \times t_{ij}\right) \quad (7)$$

where t_{ij} is the effective travel time between location of transaction *i* and the controid of statistical block *j* and δ is the decay parameter determining the spatial discount according to the standard exponential cost function. If employment were concentrated in one single location, let's say the urban core, and the price of land was assumed to be a linear function of *EP*; δ would roughly correspond to the land gradient parameter estimated in commonly employed log-linear specifications.

Ideally, the impact of employment potentiality on location attractiveness would be estimated on the basis of a full travel-time matrix individually connecting the 30,061 property transactions considered in our analyses to the 15,937 statistical blocks for which employment data is available within our study area. Instead, we use a shortcut that allows us to reduce the computation requirements without much loss of generality and precision. GIBBONS & MACHIN (2005) find that the catchment area of urban railway stations hardly exceeds a range of 2km, a range that roughly corresponds to a maximum walking distance. This result, derived for London, should be feasibly applicable to Berlin. Building on this finding we aggregate employment within the catchment area of railway stations using the standard potentiality form and a decay parameter of a equal to 2. Fig A1 in the appendix shows the corresponding spatial decay function that flats out approximately after 2km, allowing for a small proportion to walk even further distances. Station employment potentiality (*SEP*) takes the following form for station s:

$$SEP_s = \sum_j E_j \exp(-a \times d_{sj}) \tag{8}$$

where d_{sj} is the distance between station s and the centroid of block j. The catchment area of station s is constituted by all statistical blocks j for which station s is the nearest station. Assuming that residents travel longer distances by rail-based public transport, we substitute employment by station potentiality in equation (7) in order to obtain railway employment potentiality (*REP*). *REP* represents the total employment weighted by the travel time residents at location i have access to by use of urban rail transport.[11]

[11] The combined Berlin metro and suburban railway network consists of 275 stations and has a length of 475-km. Yearly passenger numbers add to approximately 790 million (2006).

$$REP_i = \sum_s SEP_s \exp(-\delta \times t_{is}) \text{ , if s} \neq \text{m} \quad (9)$$

For the generation of travel time t_{is} between location *i* and station *s* we assume an average train velocity of 33km/h, which is determined on the basis of an evaluation of the timetables of Berlin's metro and suburban railway lines. Furthermore, we assume a walking speed to the station of 4km/h and an average waiting time of 2.5 minutes at the station of departure.[12] Station potentiality of station *m* located closest to location *i* remains unconsidered since no train ride is involved in a journey to blocks belonging to the respective catchment area. Instead we assume that a location is endowed with an employment potentiality within walking distance (*WEP*), which does not depend on railway infrastructure.

$$WEP_i = \sum_j E_j \exp\left(-a \times d_{ij}\right) \quad (10)$$

where d_{ij} is the distance between centroids of blocks *i* and *j*. We use a basic concept of empirical economic geography (CRAFTS, 2005; KEEBLE, OWENS, & THOMPSON, 1982) to determine block internal distances and self-potential on the basis of blocks' surface area (*A*).

$$d_{ii} = \frac{1}{3}\sqrt{\frac{A_i}{Pi}} \quad (11)$$

Total employment potentiality at block *i* hence consists of employment potentiality within walking distance (*WEP*) and rail employment potentiality (*REP*). Similar to OSLAND & THORSEN (2008), our employment accessibility indicator enters the regression equation logarithmized so that the extended version of equation (5) consequently takes following form:

$$\log(RES_i) = LOC_i\, b + \beta_1 \log\left(WEP_j + \sum_j SEP_j \exp\left(-\beta_2 tt_{ij}\right)\right) + \varepsilon_i \quad (12)$$

The respective results are displayed in column (1) of Table 4.

12 A 2.5 minitues waiting time was chosen on the basis of a train frequency of 5 minutes, which should represent a feasible average for Berlin. A walking speed to the station of 4 km/h corresponds to what GIBBONS & MACHIN (2005) consider to be a maximum feasible walking time to a station (up to 30 minutes) and their estimate of a 2-km catchment area.

Tab. 4 Residual Land Price and Employment Accessibility

	(1) (NLS)	(2) (NLS)	(3) (SAR)	(4) (SAR)
β_1	11.064*** (0.7161)	8.534*** (1.1768)	2.787** (1.2940)	2.859** (1.4253)
β_2	0.0014*** (0.00015)	0.0015*** (0.00025)		
log(*WEP*)		0.052* (0.0059)		0.005 (0.0149)
Distance (km) to Employment Center	0.0237*** (0.00312)	0.0211*** (0.00315)	0.0235*** (0.00703)	0.0222*** (0.0076)
West	0.244*** (0.0078)	0.234*** (0.0078)	0.214*** (0.0211)	0.212*** (0.0211)
PBS: Prefabricated 1950s	-0.067*** (0.0188)	-0.073*** (0.0189)	-0.004 (0.0197)	-0.004 (0.0197)
PBS: Low Density Wilhelminian Style	0.029** (0.0140)	0.015 (0.0142)	0.013 (0.0169)	0.012 (0.0169)
PBS: High Density Wil. Style with Mod.	-0.114*** (0.0184)	-0.068*** (0.0183)	-0.058*** (0.0185)	-0.056*** (0.0185)
High Density Wilhelminian Style	-0.0615*** (0.0137)	-0.0328** (0.0137)	-0.040*** (0.0140)	-0.039*** (0.0140)
PBS: Post-War Villas	0.271*** (0.0152)	0.257*** (0.0153)	0.056*** (0.0182)	0.055*** (0.0182)
PBS: Low Density Early 20th Cent.	0.043*** (0.0087)	0.037*** 0.0087	0.030*** (0.0101)	0.029*** (0.0101)
PBS: Low Density 1990s	0.231*** (0.0350)	0.251*** (0.0352)	0.115** (0.0472)	0.1141** (0.0477)
PBS: High Density Post-War	0.058** (0.0273)	0.058** (0.0274)	0.083** (0.0341)	0.082** (0.0341)
PBS: Village-like	-0.183*** (0.0311)	-0.195*** (0.0312)	-0.052 (0.0378)	-0.052 (0.0368)
PBS: Post-War Villas	0.079*** (0.0206)	0.065*** (0.0207)	0.018 (0.0215)	0.018 (0.0215)
PBS: Block Dev. 1920s and 1930s	0.194*** (0.0163)	0.179*** (0.0163)	0.063*** (0.0184)	0.063*** (0.0184)
PBS: Prefabricated 1980s / 1990s (East)	0.297*** (0.0541)	0.330*** (0.0543)	0.394*** (0.0692)	0.396*** (0.0692)
PBS: High Density 1990s	-0.0074 (0.03579)	-0.0039 (0.0359)	0.046 (0.0392)	0.046 (0.0392)
Distance to Nearest Water Space (km)	-0.0169*** (0.00228)	-0.0176*** (0.00230)	-0.0147** (0.00708)	-0.0154** (0.00711)
Distance to Nearest Green Space (km)	-0.0060*** (0.00154)	-0.0067*** (0.00155)	-0.0128** (0.00501)	-0.0128** (0.00504)
Distance to Nearest Station (km)	0.1483*** (0.0198)	0.1294*** (0.0200)	-0.0147 (0.0271)	-0.0068 (0.0326)
Population Density (Inhabitants/sqm)	-2.647*** (0.3494)	-3.009*** (0.3498)	-0.487 (0.3908)	-0.461 (0.3912)
Proportion (%) Pop. under 18 Years Old	0.334*** (0.0522)	0.231*** (0.0519)	0.185*** (0.0536)	0.180*** (0.0537)

Tab. 4 (Continued)

	(1)	(2)	(3)	(4)
Proportion (%) Pop.	-0.470***	-0.617***	-0.142**	-0.144**
18 – 27 Years Old	(0.0627)	(0.0622)	(0.0652)	(0.0652)
Proportion (%) Pop. 65	0.265***	0.190***	0.060	0.0577
Years and Older	(0.040)	(0.0401)	(0.0414)	(0.0414)
Proportion (%) Foreign	-0.811***	-0.759***	-0.185***	-0.180***
Population	(0.0363)	(0.0363)	(0.0467)	(0.0467)
Automobile Reg.	0.084***	0.086***	0.096***	0.098***
per Capita	(0.0190)	(0.0191)	(0.0192)	(0.0193)
Constant	-137.421***	-105.059***	-30.894*	-31.809*
	(9.2637)	(15.2044)	16.702	(18.3837)
λ			0.745***	0.746***
			0.0068	(0.0068)
Obs.	30,061	30,061	30,061	30,061
R-squared	0.1464	0.1420	0.3477	0.3477

Notes: Endogenous variable is log of residual land price per square meter (*RES*) in all models. PBS variables capture the predominant building structure. SAR models use a weight matrix that treats properties within 350 m as neighbors. Heteroscedasticity robust standard errors are in parenthesis. Model (3) and (4) standard errors are robust for spatial dependency. * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Robust estimates employing a SAR specification, which is set up as in the section above, are displayed in column (3) of the same Table. Therefore, a linearized version of equation (12) is used where we take the estimated coefficient β_2 from column (1) as given. We also estimate an alternative specification where we allow the log of employment potentiality within walking distance to enter the specification as a separate term in order to allow for a different marginal value of employment opportunities that can be accessed by walking or public mass transport (columns 2 and 4). While the overall pattern of results proves to be very robust to this model alteration, employment opportunities in the immediate vicinity play only a very limited role as a determinant of land price. In contrast, both key coefficients of interest β_1 and β_2 show the expected sign and are statistically significant, indicating that access to employment is a significant determinant of land price if the effective distribution is accounted for. However, the magnitude of the transport coefficient β_2 is very small compared to the results provided by OSLAND & THORSEN (2008), which supports the notion of relatively low transport cost within the metropolitan area of Berlin.

At least two more features in Table 4 results deserve closer attention. First, the coefficient on distance to the nearest railway station becomes insignificant in the SAR and even positive and significant in the NLS models. The definition of this variable imposes the usual, but somewhat rigid, assumption of perfect substitutability of urban railway stations, independently from the hierarchy that stations enjoy within the network. This assumption is relaxed by our accessibility indicator as it takes into account both the distance to a nearest station as well as the number of jobs that can be accessed by the use of the network, weighted by distance. This measure also captures services like, for example, shopping opportunities that are likely to be correlated with employment in urban space. The simple distance measure being rendered insignificant by the introduction of the gravity-based accessibility measure indicates that the standard hypothesis of urban railway stations representing perfect substitutes should be rejected in favor of more complex concepts, which allow the perceived accessibility effect to vary across stations.[13] In the second striking effect of the introduction of the employment potentiality variable(s) we note that *Distance to Employment Center* is now significant, even though controlling for spatial dependency. The notable increase in the CBD gradient following the introduction of the decentralized employment accessibility measure highlights the importance of distinguishing between a labor market accessibility effect and the effect of urban attraction, which was proposed by OSLAND & THORSEN (2008).[14] However, contrary to their results our estimates suggest a negative urban attraction effect. Both studies share the commonality that the gravity-based accessibility measures contribute only limitedly to the explanatory power of the model.

Given that job opportunities are more concentrated in downtown compared to peripheral areas, our results also suggest that without the spatial pull originating

[13] The pattern of results remains almost unchanged if *Distance to Nearest Station* is omitted.

[14] As a robustness check we estimate a linerized version of Table 4, column (2) specification using the effective price per sqm of land and the full range of locational and non-locational attributes. Results, which are displayed in column (4) of Table A1 in the appendix, remain qualitatively unchanged.

from commuting costs there would be a significantly positive land price gradient in Berlin. This result could partially be attributable to the relevant urban amenities being dispersed and highly correlated with employment across space rather than concentrated in the city center. However, whether our indicator captures non-employment effects or not, our results clearly indicate that there is, if any, a negative effect of urban attraction. Such an effect of urban repulsion may reflect residents' preferences for some kind of environmental externalities emanated by amenities in the urban periphery. These amenities might be particularly appreciated, given a relatively well-developed transport infrastructure and the absence of major problems of congestion that keep transport costs relatively bearable within almost our entire study area. In the same vein, the qualitative difference to the positive urban attraction effect estimated by OSLAND & THORSEN (2008) might be at least partially attributable to the different geographic scale of their study. Within the area of the Federal State of Berlin considered in this analysis all residential areas locate closer than 25km to the urban core. In contrast, within the Norwegian region of Rogaland investigated by OSLAND & THORSEN (2008) there are respective distances of more than 80km, potentially increasing the perceived cost of remoteness and, hence, the urban attraction effect.

3 Conclusion

If Alonso was right in his fundamental assumptions about the spatial structure of cities and the underlying mechanisms, we would expect employment and population density as well as residential land price gradients to emerge from one singe core and a precise negative CBD land price gradient to be the most striking, if not the only significant determinant of land price. Not least, we should be able to establish a significant relationship between access to employment and the price of residential land. With the exception of the last point, our results, which are based on highly disaggregated data and are robust for spatial dependency, clearly indicate that these hypotheses have to be rejected in the case of Berlin.

Employing residual land prices generated from detailed transaction data in hedonic analysis, we find that the nucleus of residential land price gradient lies within a recreational area southwest of the Berlin downtown area. This surprisingly remote location is roughly 10 km away from the respective nodes of the population and employment density gradients. Further investigation indicates that a) distance to the city center itself exhibits a non-significant or even positive impact on the value of residential land and b) residential composition, including age, origin and car ownership together with environmental externalities related to building structure and density as well as the presence of natural amenities explain much of the relative attractiveness of peripheral locations. Specifically for Berlin, there is a robust price differential of up to approx. 25% between properties selling within the formerly separated eastern and western parts of the city. Apparently, there are still two segmented markets that tend very slowly, if at all, towards an integrated equilibrium, indicating high transactions costs associated with spatial arbitrage.

Since the basic monocentric city framework apparently inadequately captures the perceived accessibility of residential locations in Berlin, we develop a new type of gravity-based accessibility measure that relaxes both the common assumptions of perfectly concentrated employment as well as perfect substitutability among urban railway stations. Our results suggest an indicator that also takes into account the network architecture as well as the effective distribution of employment to be superior to a standard “distance to nearest station” measure. We therefore recommend further research on transport infrastructure to address network externalities, which increase the effective accessibility effect of stations that enjoy a higher rank within the network hierarchy. In comparison to the recent analysis by OSLAND & THORSEN (2008), which was conducted on a more regional scale, our results derived for the metropolitan area of Berlin indicate very low commuting costs. Moreover, after controlling for accessibility, we find a robust positive land gradient implying that there is a clear tendency for residents to prefer peripheral locations on average, and hence, a negative urban attraction effect.

After all, we conclude that the standard theoretical frameworks may become unsuited to explain the spatial structure of cities and metropolitan regions, if, among other reasons, transport costs are sufficiently low. Agglomeration economies due to information and human capital spillovers, particularly in services, largely depend on face-to-face contacts. Therefore the geographic scope of production externalities arising from spatial interaction between firms is limited and a concentration of economic activity will, to some degree, even occur in cases where transport costs are very low. Within residential areas surrounding the economic cores, under these circumstances commuting considerations may be dominated by other location factors in households' residential choice. In the case of Berlin, the benefits of locating close to employment opportunities do not lead to a negative residential CBD price gradient as predicted by theory. Effectively, the respective utilities seem to be only strong enough to keep the land gradient from inverting.

Appendix

Tab. A1 Structural Attributes

	(1) (OLS)	(2) (OLS+FE)	(3) (OLS)	(4) (OLS)
Floor Space Index (FSI)	0.960*** (0.0234)	1.008*** (0.0488)	0.980*** (0.0222)	0.980*** (0.0222)
FSI squared	-0.109*** (0.00444)	-0.108*** (0.00906)	-0.107*** (0.00413)	-0.107*** (0.00413)
Plot Area (m²)	-3.64e-05*** (4.31e-06)	-3.93e-05** (1.58e-05)	-3.38e-*** (4.18 e-06)	-3.31e-05*** (4.12e-06)
Plot Area (m²) squared	3.85e-10*** 0	3.67e-10** (1.44e-10)	3.39e-10*** 0	3.21e-10*** 0
Property Located at Frontage	0.0617** (0.0252)	-0.00628 (0.0376)	-0.0132 (0.0246)	-0.0126 (0.0245)
Property Located at Corner	0.0927*** (0.0263)	0.00245 (0.0381)	0.0044 (0.0256)	0.00428 (0.0255)
Property Located at Multiple Frontages	0.167*** (0.0311)	0.0662 (0.0561)	0.0586* (0.03)	0.0506* (0.0299)
Demoted Property	0.0129 (0.0323)	-0.0895** (0.0426)	-0.0707** (0.0319)	-0.0765** (0.0316)
Backyard Property	0.121*** (0.0272)	0.0249 (0.0419)	0.0253 (0.0265)	0.0253 (0.0264)
Small House	0.224*** (0.0794)	0.240** (0.101)	(0.264***) 0.0782	0.245*** (0.0763)
One/Two Family House	0.542*** (0.0725)	0.429*** (0.0908)	0.516*** (0.0713)	0.500*** (0.0693)
Townhouse	0.985*** (0.0766)	0.954*** (0.105)	1.143*** (0.0782)	1.090*** (0.0766)
Villa	0.933*** (0.0769)	0.556*** (0.0928)	0.830*** (0.0757)	0.807*** (0.0737)
Multi Family House	0.206*** (0.0731)	0.138 (0.0883)	0.164** (0.0719)	0.142** (0.0699)
Multi Family House with Commerce	0.286*** (0.0732)	0.222** (0.0881)	0.257*** (0.0718)	0.229*** (0.0699)
Floor Space (m²)	1.11e-05*** (3.34e-06)	1.99e-05* (1.10e-05)	1.03e-05*** (3.3e-06)	1.09e-05*** (3.29e-06)
Floor Space (m²) squared	-1.17e-10*** 0	-1.51e-10** (7.65e-11)	-9.66e-11*** 0	-8.84e-11*** 0
Storey	-0.0149*** (0.00558)	-0.0163* (0.00930)	-0.00805 (0.00535)	-0.00951* (0.00539)
Age (Years)	-0.00457*** (0.000330)	-0.00919*** (0.000770)	-0.00734*** (0.000347)	-0.00719*** (0.000344)
Age (Years) squared	1.69e-05*** (2.49e-06)	4.21e-05*** (5.54e-06)	3.56e-05*** (2.58e-06)	3.28e-05*** (2.56e-06)

Tab. A1 (Continued)

	(1)	(2)	(3)	(4)
Condition: Good	0.363***	0.278***	0.346***	0.347***
	(0.00912)	(0.0205)	(0.00921)	(0.00916)
Condition: Bad	-0.491***	-0.395***	-0.397***	-0.396***
	(0.00972)	(0.0284)	(0.0106)	(0.0105)
Flat Roof	0.0455***	0.0353	0.0149	0.0356***
	(0.0128)	(0.0238)	(0.0123)	(0.0122)
Pent Roof	0.128***	0.0508	0.110***	0.138***
	(0.0173)	(0.0331)	(0.0167)	(0.0166)
Span Roof	-0.0269**	0.00167	-0.0295***	-0.00828
	(0.0113)	(0.0189)	(0.011)	(0.0109)
Berlin Roof	-0.117***	-0.0704**	-0.0745***	-0.0408***
	(0.0108)	(0.0335)	(0.0125)	(0.0127)
Hipped Roof	0.0977***	0.0530**	0.0689***	0.0883***
	(0.0138)	(0.0211)	(0.0131)	(0.0131)
Mansard Roof	0.0607***	0.0400*	0.0424***	0.0651***
	(0.0169)	(0.0213)	(0.016)	(0.0161)
Domed Roof	0.0884***	0.0739*	0.0998***	0.125***
	(0.0242)	(0.0390)	(0.0232)	(0.0231)
Extended Flat	0.119***	0.105***	0.106***	0.108***
	(0.00666)	(0.0133)	(0.00638)	(0.00634)
Elevator	0.204***	0.0404	0.148***	0.0960***
	(0.0213)	(0.0304)	(0.0211)	(0.0221)
Basement	0.202***	0.119***	0.161***	0.158***
	(0.0106)	(0.0301)	(0.0104)	(0.0104)
Underground Car Park	0.333***	0.124	0.262***	0.234***
	(0.102)	(0.101)	(0.0885)	(0.0869)
Seller: (Public) Authority	-0.0663***	-0.150***	-0.0673***	-0.0739***
	(0.0184)	(0.0238)	(0.0174)	(0.0172)
Seller: Housing Association	-0.0239**	-0.134***	-0.0483***	-0.0532***
	(0.0113)	(0.0307)	(0.0105)	(0.0105)
Seller: (Private) Juristic Persion	0.0822***	0.0586***	0.0896***	0.0868***
	(0.00781)	(0.0173)	(0.00755)	(0.00753)
Buyer: (Public) Authority	0.0914	0.0770	0.122	0.126
	(0.106)	(0.115)	(0.0988)	(0.0977)
Buyer: Housing Association	-0.225***	-0.131	-0.121**	-0.135**
	(0.0593)	(0.162)	(0.0564)	(0.0563)
Buyer: (Private) Juristic Persion	0.125***	0.116***	0.125***	0.122***
	(0.00928)	(0.0160)	(0.00897)	(0.00894)
Charge for Local Public Infrastructure	-0.144***	-0.0533**	-0.112***	-0.109***
	(0.00736)	(0.0218)	(0.00763)	(0.00759)
Property is not Occupied by Renter	0.164***	0.0787***	0.0776***	0.0711***
	(0.00821)	(0.0165)	(0.00838)	(0.00836)
Share (%) Secondary Structure at Sales Price	-0.028***	-0.021***	-0.0220***	-0.022***
	(0.362)	(0.425)	(0.349)	(0.339)

Tab. A1 (Continued)

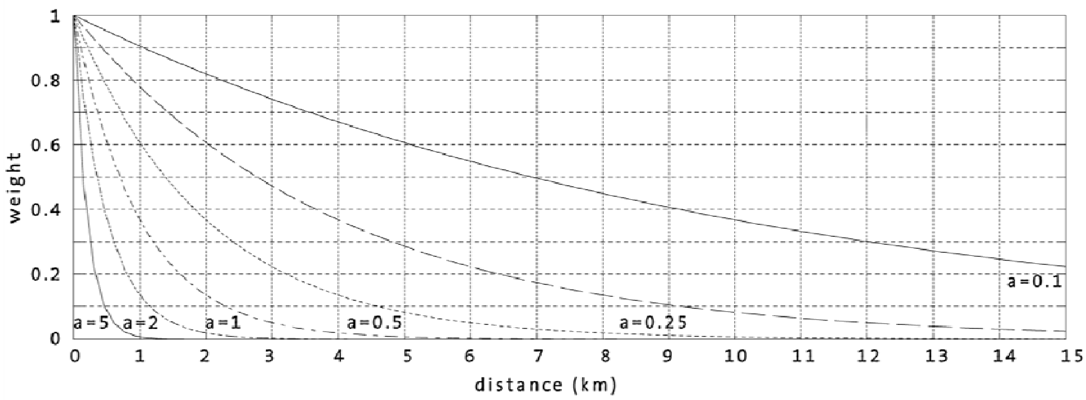
	(1)	(2)	(3)	(4)
West			0.240*** (0.00987)	0.256*** (0.00991)
PBS: Prefabricated 1950s			-0.0818*** 0.0238	-0.0881*** (0.0237)
PBS: Low Density Wilhelminian Style			0.0345** (0.0149)	0.0279* (0.0148)
PBS: High Density Wil. Style with Mod.			0.0582*** (0.0178)	-0.108*** (0.0175)
High Density Wil. Style			-0.0339** 0.0142	-0.0633*** (0.0141)
PBS: Post-War Villas			0.213*** (0.0149)	0.212*** (0.0148)
PBS: Low Density Early 20th Cent. Detached			0.0318*** (0.00882)	0.0331*** (0.00877)
PBS: Low Density 1990s			0.218*** (0.0186)	0.216*** (0.0194)
PBS: High Density Post-War			0.03887 (0.029)	0.0338 (0.0289)
PBS: Village-like			-0.197*** (0.0295)	-0.178*** (0.0285)
PBS: Post-War Villas			0.0539*** (0.01918)	0.0600*** (0.0190)
PBS: Block Development 1920s and 1930s			0.0939*** (0.01562)	0.0856*** (0.0157)
PBS: Prefabricated 1980s / 1990s (East)			0.1242*** (0.0420)	0.0920** (0.0430)
PBS: High Density 1990s			0.0249 (0.0286)	0.0120 (0.0288)
Distance to Nearest Water Space (km)			-0.0187*** (0.00224)	-0.0174*** (0.00224)
Distance to Nearest Green Space (km)			-0.0013 (0.00162)	-0.0016 (0.00161)
Distance to Nearest Station (km)			-0.0587*** (0.00329)	0.1620*** (0.0145)
Population Density (Inhabitants/sqm)			-1.883*** (0.3963)	-1.161*** (0.398)
Proportion Pop. under 18 Years Old (%)			0.0017*** (0.0006)	0.0025*** (0.0006)
Proportion Pop. 18 – 27 Years Old (%)			-0.0054*** (0.0007)	-0.0046*** (0.0007)
Proportion Pop. 65 Years and Older (%)			0.0016*** (0.0004)	0.0018*** (0.0004)
Proportion Foreign Population (%)			-0.0070*** (0.0004)	-0.0074*** (0.0004)

Tab. A1 (Continued)

	(1)	(2)	(3)	(4)
Automobile Registrations per Capita			0.0917*** (0.0248)	0.100*** (0.0240)
Distance (km) to Employment Centre			(-0.0102)*** (0.00207)	0.02155*** (0.00293)
Log(*EP*)				11.21*** (0.725)
Constant	4.810*** (0.0810)	4.786*** (0.124)	5.104*** (0.0842)	-139.5*** (9.353)
Location Effects		Yes		
Obs	30,061	30,061	30,061	30,061
R squared	0.668	0.753	0,695	0.699

Notes: Endogenous variable is log of plot price per square meter. All models include year effects and monthly dummy variables. Model (2) also includes 303 traffic cell effects. PBS denotes the predominant buildings structure. Heteroscedasticity robust standard errors are in parenthesis. Model (2) standard errors are clustered on 303 traffic cells. * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Fig. A1 Decay Parameters and Spatial Weight Functions



Notes: Own illustration.

Literature

ADAIR, A., MCGREAL, S., SMYTH, A., COOPER, J., & RYLEY, T. (2000). House Prices and Accessibility: The Testing of Relationships within the Belfast Urban Area *Housing Studies, 15*(5), 699-716.

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

ANSELIN, L. (1988). *Spatial Econometrics: Methods and Models*. Dordrecht: Kluwer.

ANSELIN, L. (2003). Spatial Externalities. *International Regional Science Review, 26*(2), 147.

ANSELIN, L., & BERA, A. K. (1996). Simple Diagnostic Tests for Spatial Dependence. *Regional Science & Urban Economics, 26*(1), 77.

ANSELIN, L., & BERA, A. K. (1998). Spatial Dependency in Linear Regression Models with an Introduction to Spatial Econometrics. In A. ULLAH & D. E. GILES (Eds.), *Handbook of Applied Economic Statistics* (pp. 237-289). New York: Marcel Dekker.

ANSELIN, L., & FLORAX, R. J. G. M. (1996). Small Sample Properties of Tests for Spatial Dependency in Regression Models: Some Further Results. In L. ANSELIN & R. J. G. M. FLORAX (Eds.), *New Directions in Spatial Econometrics* (pp. 21-74). Berlin: Springer.

BECKMANN, M. J. (1969). On the Distribution of Urban Rent and Residential Density. *Journal of Economic Theory, 1*(1), 60-67.

BORUKHOV, E., & HOCHMAN, O. (1977). Optimum and Market Equilibrium in a Model of a City without a Predetemined Center. *Environment and Planning A, 9*(8), 849-856.

BRUECKNER, J. K., THISSE, J.-F., & ZENOU, Y. (1999). Why Is Central Paris Rich and Downtown Detroit Poor? An Amenity-Based Theory. *European Economic Review, 43*(1), 91-107.

CHESHIRE, P. C., & SHEPPARD, S. (1995). On the Price of Land and the Value of Amenities. *Economica, 62*(246), 247-267.

CHESHIRE, P. C., & SHEPPARD, S. (1997). Welfare Economics of Land Use Regulation. *Research Papers in Environmental and Spatial Analysis, 42*.

COMMITTEE OF VALUATION EXPERTS IN BERLIN. (2007). *Compilation of Purchasing Price Data*. Berlin.

CRAFTS, N. (2005). Market Potential in British Regions, 1871-1931. *Regional Studies, 39*(9), 1159-1166.

DEHRING, C. A., DEPKEN, C. A., & WARD, M. R. (2007). The Impact of Stadium Announcements on Residential Property Values: Evidence from a Natural Experiment in Dallas-Fort Worth. *Contemporary Economic Policy, 25*(4), 627-638.

FUJITA, M., & OGAWA, H. (1982). Multiple Equilibria and Structural Transition of Non-Monocentric Urban Configurations. *Regional Science and Urban Economics, 12*(2), 161-196.

GIBBONS, S., & MACHIN, S. (2005). Valuing Rail Access Using Transport Innovations. *Journal of Urban Economics, 57*(1), 148-169.

HALVORSEN, R., & PALMQUIST, R. (1980). The Interpretation of Dummy Variables in Semilogarithmic Equations. *American Economic Review, 70*(3), 474-475.

HANSEN, W. G. (1959). How Accessibility Shapes Land Use. *Journal of the American Institute of Planners, 25*, 73-76.

HARRIS, C. D. (1954). The Market as a Factor in the Localization of Industry in the United States. *Annals of the Association of American Geographers, 44*(4), 315-348.

HENNEBERRY, J. (1998). Transport Investment and House Prices. *Journal of property investment & finance, 16*(2), 144-158.

JENKS, G. F. (1977). *Optimal Data Classification for Choropleth Maps, Occasional Paper, No. 2*. Kansas: Lawrence.

KEEBLE, D., OWENS, P. L., & THOMPSON, C. (1982). Regional Accessibility and Economic Potential in the European Community. *Regional Studies, 16*(6), 419-431.

LUCAS, R. E., JR. (2001). Externalities and Cities. *Review of Economic Dynamics, 4*(2), 245-274.

LUCAS, R. E., JR., & ROSSI-HANSBERG, E. (2002). On the Internal Structure of Cities. *Econometrica, 70*(4), 1445-1476.

MCDONALD, J. F., & BOWMAN, H. W. (1979). Land Value Functions: A Reevaluation. *Journal of Urban Economics, 6*(1), 25-41.

MCDONALD, J. F., & MCMILLEN, D. P. (1990). Employment Subcenters and Land Values in a Polycentric Urban Area: The Case of Chicago. *Environment and Planning A, 22*, 1561-1574.

MCMILLEN, D. P. (1996). One Hundred Fifty Years of Land Values in Chicago: A Nonparametric Approach. *Journal of Urban Economics, 40*(1), 100-124.

MILLS, E. S. (1972). *Studies in the Structure of the Urban Economy*. Baltimore: Johns Hopkins Press.

MUELLBAUER, J. (1974). Household Production Theory, Quality, and The "Hedonic Technique". *American Economic Review, 64*(5), 977-994.

MUTH, R. F. (1969). *Cities and Housing: The Spatial Pattern of Urban Residential Land Use*. Chicago: University of Chicago Press.

OSLAND, L., & THORSEN, I. (2008). Effects on Housing Prices of Urban Attraction and Labor-Market Accessibility. *Environment and Planning A, 40*, 2490-2509.

PLAUT, P. O., & PLAUT, S. E. (1998). Endogenous Identification of Multiple Housing Price Centers in Metropolitan Areas. *Journal of Housing Economics, 7*(3), 193-217.

PLAUT, P. O., & PLAUT, S. E. (2003). The Inversion of the Land Gradient in the Inner City of Haifa, Israel. *Journal of Real Estate Research, 25*(4), 557-576.

ROSEN, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy, 82*(1), 34-55.

SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN. (2006). *Urban and Environmental Information System*. Berlin.

SIRMANS, G. S., MACPHERSON, D. A., & ZIETZ, E. N. (2005). The Composition of Hedonic Pricing Models. *Journal of Real Estate Literature, 13*(1), 3-43.

SOLOW, A. R. (1973). On the Equilibrium Models of Urban Location. In M. PARKIN (Ed.), *Essays in Modern Economics*. London: Longman.

TEN RAA, T. (1984). The Distribution Apprach to Spatial Economics. *Journal of Regional Science, 24*(1), 105-117.

VON THÜNEN, J. H. (1826). *Der Isolierte Staat in Beziehung Auf Landwirtschaft Und Nationalökonomie, Oder Untersuchungen Über Den Einfluss, Den Die Getreidepreise, Der Reichtum Des Bodens Und Die Abgaben Auf Ackerbau Ausüben*. Hamburg: Perthes.

WALDORF, B. S. (2004). Path-Breaking Books in Regional Science. *Papers in Regional Science, 83*(1), 59-89.