

**Gabriel M. Ahlfeldt**

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Gabriel M. Ahlfeldt\*

# Rail Mega-Projects in the Realm of Inter- and Intra-City Accessibility: Evidence and Outlooks for Berlin

**Abstract:** This article resumes and complements recent quantitative research on the impact of the Berlin railway system on the urban economy. Evidence suggests that access to intra-city rail lines has had a considerable impact on the value of urban land since at least the late 19<sup>th</sup> century. Since then, access to the intra-city rail network has remained a significant determinant of urban land value, although the marginal impact has decreased over time. In contrast, the post-unification realignment of Berlin's inter-city rail system has had, if any, only a weak impact on real estate markets. Micro-level simulations indicate that the new central station's connection to the urban railway network is likely to have more pronounced, although relatively localized impacts, raising the question of how to balance the cost for infrastructure among landlords and society.

**Keywords:** *Rail mega-projects, accessibility, land value, Berlin*

**JEL classification:** *R21, R40, R53*

**Version:** *December 2010*

FORTHCOMING IN **BUILT ENVIRONMENT**

## 1 Introduction

The recent decades, both in the U.S. as well as in Europe, have brought forth a range of urban (re)development and revitalization initiatives for urban areas in need of external stimuli. Some of the most striking and ambitious urban (re)development policies have been implemented in the course of rail mega-projects with new, extended, or renewed railway stations as focal nodes. Recent mega-projects like King's Cross & St. Pancras in London, the new Vienna main station or Stuttgart 21 are hybrids of urban planning strategies and transport infrastructure policies. Unlike other (public) facilities, rail stations potentially exhibit a strong direct influence on the local urban economy in their function as central nodes of inter- and intra-city transport.

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\* LSE, Department of Geography & SERC, Houghton Street, London WC2A 2AE, g.ahlfeldt@lse.ac.uk, www.ahlfeldt.com

The impact of such large-scale rail projects therefore attracts the attention of various scientific disciplines, including economics which has recently rediscovered the dimension of space. Empirical research has exploited rail transport innovations as local shocks to intra-city accessibility (Ahlfeldt & Wendland, 2009, 2010; Gibbons & Machin, 2005), inter-city accessibility (Ahlfeldt & Feddersen, 2010; Coffman & Gregson, 1998) or intra-city access to inter-city rail lines (Ahlfeldt, 2010c). Local economic stimuli, thereby, are not only expected from a pure welfare effect of a reduction in physical transport costs, but – similarly importantly – from bringing economic agents closer together and intensifying spatial interactions that give rise to productivity gains. Naturally, results of empirical analyses on the impact of transport innovations not only serve as a basis for the evaluation of various theories of urban and regional economics, but also qualify as a benchmark for expectations on the economic impact of rail mega-projects more generally. By providing direct access to other cities' and regions' economies, central rail stations – theoretically – qualify as a city's natural center of gravity. On the other hand, facilities and track beds occupy much of a city's most productive space where economic activity usually reaches the highest densities. The economic rationale for either extensive land consumption or expensive construction work for tunnels in order to shift facilities and lines below ground level therefore depends on the existence of sizable accessibility effects. If there are localized benefits, in turn, the natural question arises of how to balance the respective costs between benefiting landlords and society.

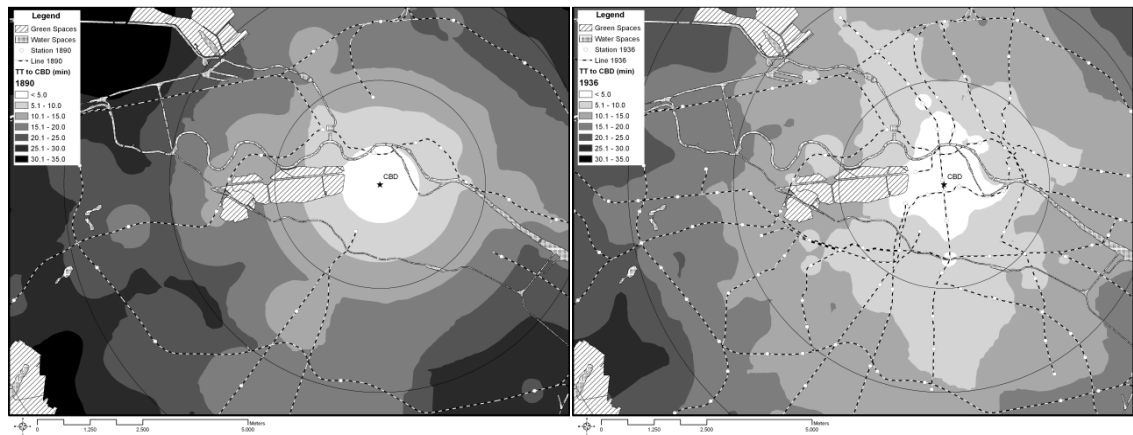
This article condenses and complements recent empirical evidence on the (urban) economic impact of large-scale rail projects in Berlin, Germany. It covers two core periods of railway reorganization. First, the late era of industrial revolution where Berlin became the capital of the German Reich and was one of the most dynamic cities in Europe, an equal to the leading metropolises in terms of population, economic and cultural prosperity and technological innovations that also comprised new rapid transit systems. The emerging underground and suburban railway network represented a major shock to the spatial equilibrium of the city and promoted development alongside lines and hub-stations, first of all within the area that is known today as the "City West". The second focus is on the period after the unification of Berlin, when the city once again underwent major political, economical and cultural changes. The early 90s, when Berlin was chosen to become the capital of unified Germany and economic prospects were regarded very positively, was a time for extraordinary urban development projects like the new Government district or the office and shopping areas at Potsdamer Platz and Frie-

drichstrasse, among others. A new mainline concept was implemented to connect Berlin to the German railway network. The plans encompassed the construction of a new north-south track, including a tunnel for the downtown section, a new central station as well as the construction or extension and modernization of three additional mainline stations. The new mainline concept has been in operation since 2006 and has completely reshaped the pattern of intra-city access to inter-city rail connections. However, the new central station has yet to be fully connected to the underground rail network, which is expected to have an additional impact on the city structure.

## **2 The Early Days**

### **2.1 Citywide Effects**

By the end of the 19<sup>th</sup> century, Prussia in general and Berlin in particular had entered the second phase of industrialization, a period of rapid technological progress and economic growth. Berlin evolved from a relatively small area with only 913,984 inhabitants in 1871 to a metropolis with 4,338,756 within an area of 87,810 ha in 1939 (Statistisches Amt der Stadt Berlin, 1970, 1988). The evolution of the public railway network decisively stimulated the reorganization of spatial patterns. The 1870s marked the starting point of the emergence of Berlin's intra-urban railway system, when the circular line (1877) was built to connect the termini of former regional lines, thereby transforming regional connection networks into systems of inner-city mass transportation. In 1882, the east-west connection joined several inner-city stations with the circular line and up to 1890 a huge area of Berlin and its surroundings was served (Borchert, Starck, Götz, & Müller, 1987). It was, however, not until the subsequent decades that gradually added stations created a highly developed and very dense network that fundamentally changed the pattern of urban accessibility. The suburban railway network was complemented by the inauguration and further development of the underground railway, which started in 1902 and was to reach a total length of about 80 km and 103 stations by 1939. By that time, the combined rapid transit network had reached a size close to that of present-day Berlin. As shown by Ahlfeldt & Wendland (2010), the newly developed rapid transport network led to an asymmetric evolution of travel time to the city center (see Figure 1) breaking up the previous almost concentric accessibility pattern.

**Fig. 1** Travel Time to the CBD in 1890 and 1936

Source: Ahlfeldt & Wendland (2010).

It is evident that in terms of CBD accessibility areas along the emerging network benefited, in relative terms, at the expense of those that remained unconnected. If classic rent theory holds, the decline in opportunity costs of travel time should have led to an attraction of residents and firms and a demand-driven increase in land value until, in equilibrium, the rise in land value fully compensated for the travel time savings. More generally, the decline in effective commuting costs should have promoted urban decentralization as the cost of remoteness was considerably reduced along the new network.

Following the approach by Ahlfeldt & Wendland (2010), it can be demonstrated that these theoretical expectations were met by reality. Over the period 1890 to 1936, the marginal price effect of a 1 km reduction in distance to the city center declined from as much as 78% to about 40%, reflecting that peripheral locations gained considerably in valuation relative to the city's core area. No clear trend, though, is evident if accessibility to the city center is considered in terms of travel time and the evolution of the railway network is accounted for. The marginal effect of a 1-minute reduction in travel time scatters around 15% during the whole period (see Table 1). An interpretation of this pattern is that the opportunity cost of traveling remained roughly constant over time, but as the average velocity increased due to transport innovations, residents and firms were willing to bid higher prices for properties at larger distances to the center. It can be concluded that without the evolution of the network, decentralization would have hardly exceeded the 1900 level. In particular prior to 1900, however, alternative explanations account for a considerable proportion of the observed decentralization. Possible factors include improvements in the network of buses and streetcars, a gradual increase in availability of individual transport, and not least, urban development policies. The so-called Hobrecht-Plan

combined the intensification of residential density surrounding the CBD with a concept of mixed-use development, which facilitated residential decentralization and a redistribution of market opportunities for businesses.

**Tab. 1 Marginal Land Price Effect of CBD Accessibility 1890-1936**

	Marginal Price Effect (Relative to Initial Period in Parentheses)						
	1890	1896	1900	1904	1910	1929	1936
1 km Reduction in Distance	77.5% (1)	58.3% (0.75)	52.0% (0.67)	50.9% (0.66)	45.3% (0.58)	40.5% (0.52)	39.7% (0.51)
1 min Reduction in Travel Time	17.5% (1)	15.0% (0.86)	12.8% (0.73)	14.0% (0.80)	12.4% (0.71)	15.6% (0.89)	15.3% (0.87)

Notes: Own calculations. Estimates obtained from OLS regressions of (log) land values in RM/sqm on distance or travel time to the CBD. All estimates satisfy significance criteria at the 1% level. See Ahlfeldt & Wendland (2010) for a data description and CBD definition.

## 2.2 Localized Effects

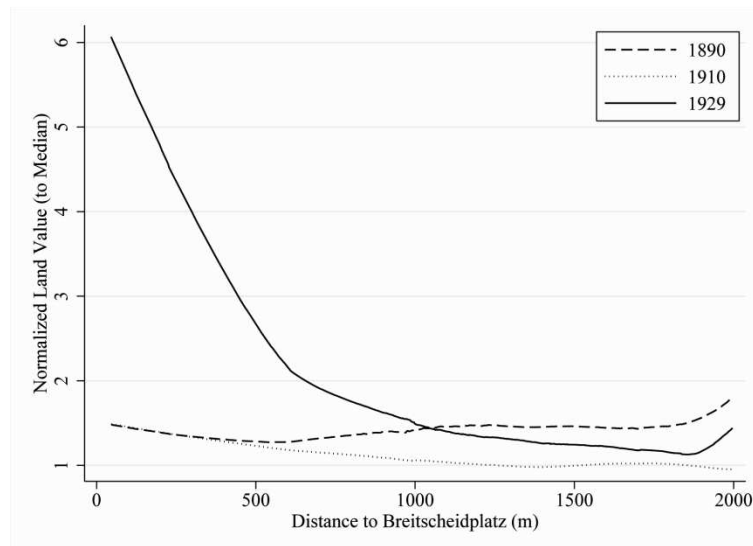
The new transport network not only impacted on the city structure in terms of raising the attractiveness of the urban periphery relative to the core, but also had significant local impacts in proximity to the newly inaugurated rail stations. Residents and firms trade the price of land not only against the distance to the city center, but also against distance to nearby railway stations whose value consequently capitalize into prices. Ahlfeldt & Wendland (2009), controlling for the overall decentralization process, show that over the period 1890-1936 land values significantly increased when the distance to the nearest rail station was reduced as the network became denser. They find that the value of land increased by up to 2.5% for a 100 m reduction in distance to a railway station.

Of the localized changes occurring around new rail stations, the western downtown area around Kurfürstendamm and Tauenzienstrasse certainly underwent the most striking development during that time. This area represents an early example for how a considered urban development strategy embedded into a large-scale infrastructure project may promote the rapid transformation from an almost undeveloped area into a dense cluster of economic and cultural activity. The roots of the emergence of this (sub-)center lie in the 1870s when it was Bismarck's explicit wish and plan to transform the Kurfürstendamm, a corduroy road connecting the historic center with the Grunewald hunting lodge, into a representative boulevard.

Figure 2 provides a non-parametric locally weighted regression estimate of the unknown non-linear relationship between normalized land value (to the median) and the distance to Breit-

scheidplatz the location of the Kaiser Wilhelm Memorial Church. It is evident that a substantial increase in area valuation occurred between 1910 and 1929 and that by 1929 the area had emerged as a strong sub-center with proximity effects capitalizing into land prices up to a distance of 1 km at least. The sub-center over the considered period not only gained in attractiveness relative to its immediate surroundings, but also in comparison to the historic center. Table 2 compares peak land values at Breitscheidplatz with those at Friedrichstrasse along the road stretch from Unter den Linden (U.d.L.) to Leipziger Strasse, which exhibited the highest land values during the observations period. While peak values at Friedrichstrasse increased by about one half, the respective increase at Breitscheidplatz amounted to as much as a factor of 10, with the largest gains occurring between 1910 and 1929.

**Fig. 2** “City West” Gradients



Notes: Own calculations. Results obtained from locally weighted regression of normalized (to median) land value on distance to Breitscheidplatz (m). See Ahlfeldt & Wendland (2010) for a data description.

**Tab. 2** Peak Land Values at Friedrichstrasse and Kurfürstendamm

	Peak Land Value (Relative to Initial Period in Parentheses)						
	1890	1896	1900	1904	1910	1929	1936
Friedrichstrasse	1700	1825	1895	1920	2235	2000	2500
(U.d.L. – Leipziger Str.)	(1)	(1.1)	(1.1)	(1.3)	(1.3)	(1.2)	(1.5)
Kurfürstendamm	120	192.5	302.5	372	475	1200	1250
(Breitscheidplatz)	(1)	(1.6)	(2.5)	(3.1)	(4.0)	(10.0)	(10.4)

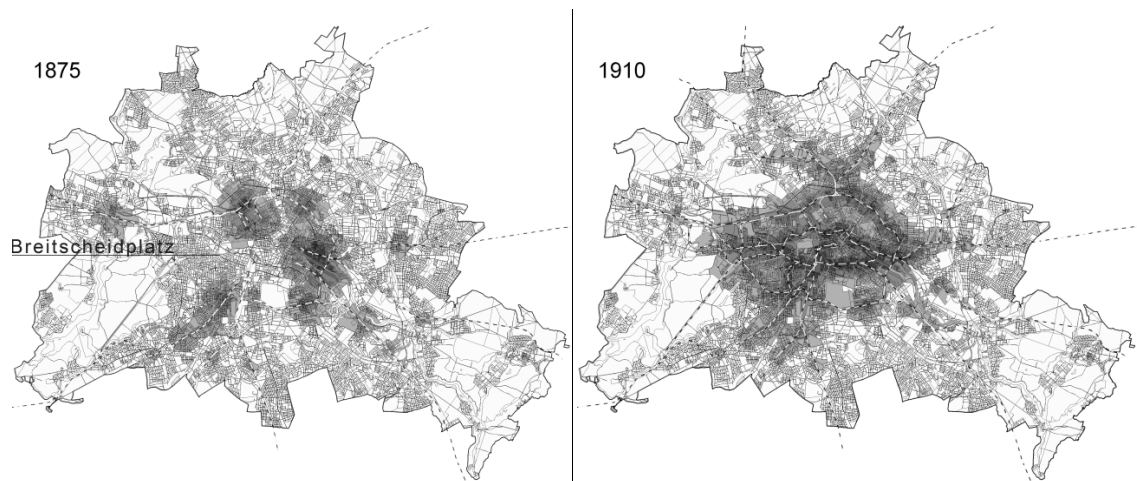
Notes: Own calculations. Land values are given in nominal RM/sqm. See Ahlfeldt & Wendland (2010) for a data description.

The impressive upgrade of the Kurfürstendamm area has to be considered alongside the background of the evolution of the rail network architecture discussed above. Even before road

works along the Kurfürstendamm were completed, Bahnhof Zoo, which lies adjacent to Breitscheidplatz and later became the central station of the city during the period of division, was connected to the major east-west rail line in 1882. Ten years later, Bahnhof Zoo was served by 7 streetcar lines, although the development of residential buildings had just begun. Another 10 years later, in 1902, the first underground railway line connected the area to the city center and even the second railway line, inaugurated in 1905, ran through the area. Although the area still exhibited a residential character, it had evolved to being the by far most important transport node outside the city's core region.

Ahlfeldt & Wendland (2008) employ a refined multi-level market potential indicator in order to assess the centrality of each of Berlin's 15,937 housing blocks with respect to the population of all other housing blocks in account of the rail network architecture. As a key innovation, this accessibility indicator facilitates distinct transport costs for walks to and from stations and rides on the rail network. Figure 3 visualizes centrality as represented by this accessibility indicator for 1875 and 1910. It reveals that, by 1910, in terms of network centrality, the area around Breitscheidplatz had become one of the leading city regions, years before the attraction of economic and cultural activity began.

**Fig. 3 Rail Market Potential 1875 and 1910**



Source: Ahlfeldt & Wendland (2008).

Table 3 shows how the network-based access to city markets at Breitscheidplatz evolved in relation to the crossroads of Friedrichstrasse and Unter den Linden during the period 1875-1935. Most interestingly, besides a long-term catching-up process, it turns out that from 1910 to 1920 the area, in these terms, even outperformed the traditional center. Notably, this was



precisely the decade that preceded the “golden era” of Kurfürstendamm during the 1920s. The decline in relative accessibility after 1920 mainly reflects the inauguration of two new north-south underground lines crossing the historic center.

**Tab. 3      Relative Rail Market Potential 1875 – 1935**

Rail Market Potential of Breitscheidplatz relative to Unter den Linden / Friedrichstrasse											
1875	1880	1885	1890	1895	1900	1905	1910	1920	1925	1930	1935
0.1%	0.5%	23%	28%	36%	48%	99%	126%	119%	68%	61%	60%

Notes: Own calculation. See Ahlfeldt & Wendland (2008) for details on the data and the generation of the rail market potential.

Clearly, the early investments into the connectivity of the Kurfürstendamm area are hardly explainable by passenger demand only. Intuitively, one would expect the focal node of a transport network to be within the existing core of economic activity. From the historical center, the other major sub-centers, Hermannplatz and Bernauer Strasse, could also have been more easily connected. The selection of the first underground rail paths was clearly determined exogenously to the distribution of urban economic activity and was a result of a mixture of political interest in urban development and private economic interests like real estate speculation (Erbe, 1987). The declared intention of planners and property developers was to promote further investments and building (Bohm, 1980) and evidence, by and large, indicates that these objectives have been achieved.

## 3 The Present Day

### 3.1 City Wide Effects

After the re-unification of the city, the city’s transport networks were in need of substantial modernization. While the modernization of the intra-urban rail system was mainly a task of re-integration and renovation, at the beginning of the 1990s it was decided that the mainline rail system had to be entirely reorganized. The key element of the new concept was the development of a new north-south railway track, including a tunnel for the downtown section. The intersection of the new north-south with the old east-west track was chosen to be the location of Berlin’s new central station, which was timely inaugurated for the FIFA World Cup in 2006. The station was designed by the prominent architecture firm GMP and involved investments that amounted to approximately €1 billion for facilities and feeder lines. In total, the modernization of Berlin’s railway tracks cost over €4 billion (Hops & Kurpjuweit, 2007). The new central

station “Hauptbahnhof” – representing one of Europe’s largest and most modern interchange stations – and the huge investment amounts stand exemplarily for the post-unification euphoria at the beginning of the Nineties when Berlin’s economic perspectives were still very positively regarded. Two more mainline stations were developed along the new railway track at the intersections with the inner ring line: “Gesundbrunnen” in the north and “Südkreuz” in the south. Moreover, at the western periphery of Berlin, “Bahnhof Berlin-Spandau” was considerably extended and modernized. The new stations along the north-south track were to provide additional transport capacities in order to disburden the existing mainline stations “Bahnhof Zoo” and “Ostbahnhof”, which had served as central stations within the formerly separated parts of the city. In particular Bahnhof Zoo, which after unification became Berlin’s most frequented station due to its proximity to the West-Berlin core area around Kurfürstendamm and its good connections to the urban railway network, was considered to be undersized in light of only three platforms and a total of 150,000 passengers served per day. Due to the characteristic configuration formed by the north-south, east-west and the northern ring track, the new transport plan was named the “mushroom” concept.

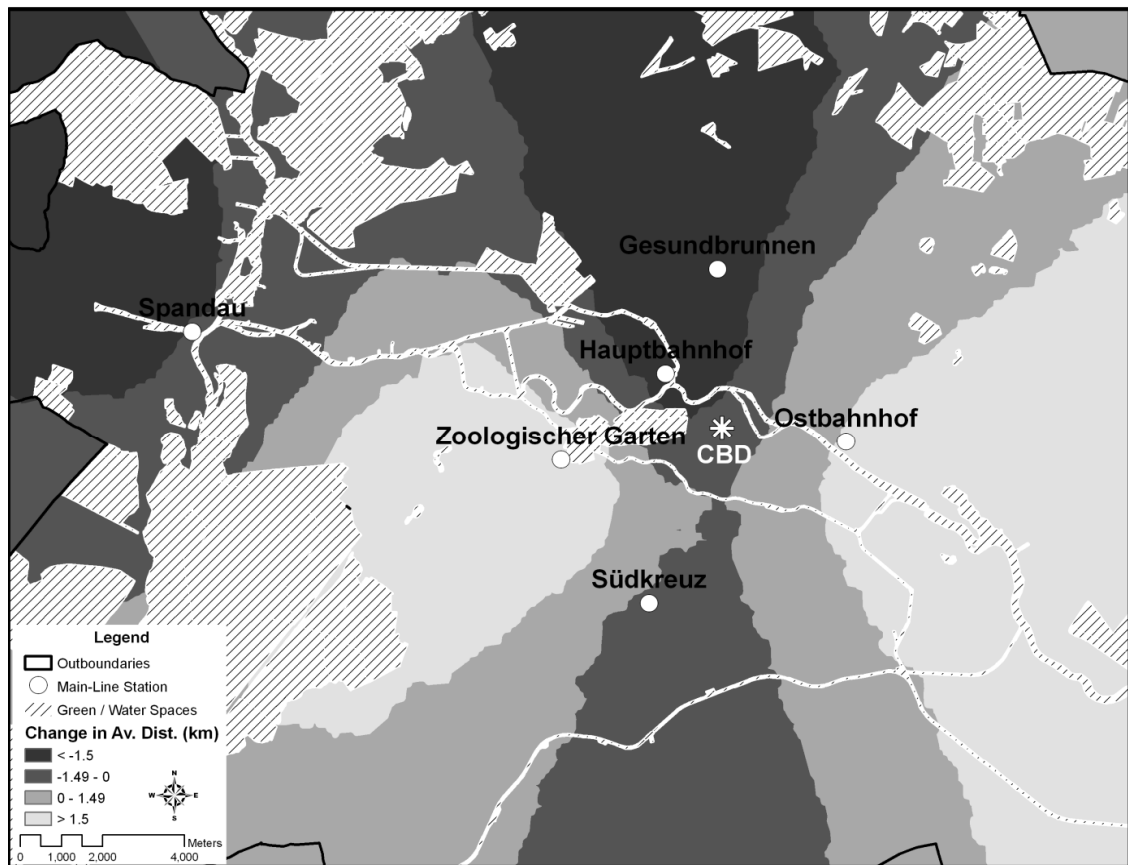
At the beginning of July 2005, however, the rail carrier Deutsche Bahn AG quite unexpectedly announced that instead of allocating transport capacities more or less equally among the two mainlines the vast majority of long-distance trains would cross Berlin on the newly developed north-south line after the implementation of the new transport plan on March 28, 2006. Even more surprisingly, it was decided that the remaining trains approaching and leaving the new central station via the east-west track would no longer stop at Bahnhof Zoo, thereby reducing its significance to a regional dimension (Hasselmann, 2005). This decision elicited strenuous protests from various business and passenger lobbies. Given the unexpected loss in accessibility to regional markets, which at least to the effective degree were unexpected, and the strong opposition of business lobbies, one would have expected a considerable impact on location desirability within the catchment area of Bahnhof Zoo, which, in turn, should have led to a significant downward adjustment in real estate prices. Similar adjustments should have taken place in the vicinity of Ostbahnhof, which was also affected adversely by the new transport plan, and – in the opposite direction – within the catchment area of stations benefiting from the reorganization.

Hence, if real estate markets traded the value of urban land against mainline accessibility, we would have expected a significant increase in the value of location within areas that were positively affected compared to those that were adversely hit. Identifying positively and negatively affected areas, however, is not straightforward due to the relatively complex reorganization of the network architecture. As proposed by Ahlfeldt (2010c), the complementary relationship between mainline stations can be dealt with by assuming that residents use the nearest mainline station for all connections served by that station and the next rail hub, which offers access to all connections, for the remaining proportion. Note that both Bahnhof Zoo and Ostbahnhof need to be treated as central rail hubs during the period prior to the network reorganization, while in the post-period only Hauptbahnhof holds this status. Building on this rationale, the weighted average distance to all mainline connections can be computed based on the share of total connections provided by the nearest rail station and the distances to this station as well as the nearest rail hub.<sup>1</sup> If the nearest station is a rail hub, the average distance necessary collapses to the unweighted distance to this station.

Figure 4 shows the location of the relevant stations against the background of spatially interpolated changes in average distances to mainline connections. As expected, areas that experienced the strongest decline in access to mainlines are around the formerly most important stations Bahnhof Zoo and Ostbahnhof, particularly extending to the west and east (light shaded). Central areas and areas to the north, south and north-west benefit from the new stations Hauptbahnhof, Gesundbrunnen and Südkreuz and the extension of Spandau, which at least partially compensates western areas for the closure of Bahnhof Zoo.

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<sup>1</sup> Formally, the average distance ( $AD_{it}$ ) to all mainline connections at location  $i$  and time  $t$  takes the following form :  $AD_{it} = n_{it}/N_t \times DSTATION_{it} + (1 - n_{it})/N_t \times DHUB_{it}$ , where  $n$  is the number of connections offered at the nearest station,  $N$  is the total number of connections in the city,  $DSTATION$  is the distance to the nearest station and  $DHUB$  is the same for the nearest rail hub.

**Fig. 4** Change in Average Distance to Inter-City Connections

Source: Own illustration.

Having identified these positively and negatively affected areas, the relative change in area valuation that came with the implementation of the new plan can be identified in a difference-in-difference setup, i.e. by differentiating prices over time (before/after) and area (positive/negative). As an indicator of land value we use property transaction prices per square meter of land, adjusted for structural characteristics and aggregated to the level of traffic cells (Verkehrszellen). The isolation of the (residual) price paid for land from the price paid for the structure and its various characteristics as well as general time trends is achieved in a hedonic regression analysis as described in Ahlfeldt (2010c). All property transactions are considered that fall into the periods from October 1, 2002, to June 30, 2005 (before), and April 1, 2006, to December 31, 2008 (after). These observation periods are symmetric with respect to the transaction volumes. The period between July 1, 2005, and March 30, 2006, is excluded in order to prevent anticipation effects of the announcement capitalizing into the “before” or “after” period. Again, a full record of all the property transactions of developed properties is used for the statistical analysis. Table 4 compares the situation before announcement and after

implementation of the new transport plan on the basis of 293 out of 338 traffic cells (Verkehrszellen) where sufficient transactions occurred in both periods.

**Tab. 4 Average Distances and Land Prices**

	Full sample		Positive		Negative		Estimate
	Before (1)	After (2)	Before (3)	After (4)	Before (5)	After (6)	DD (7)
Mean distance	7.00	7.41 (5.9%)	7.69 (-18.1%)	6.30	6.52 (25.3%)	8.17	-3.05***
Mean land price (€/m <sup>2</sup> )	430.84	420.17 (-2.5%)	403.50 (-0.5%)	401.50	449.27 (-3.7%)	432.50	15.15
Sample	293		118		175		293

Notes: Own calculation. Percentage changes between periods are in parentheses. Average distances to mainline stations and land prices and are aggregated to traffic cells. Positive (negative) is the group of traffic cells that experiences a reduction (increase) in average distance between the periods before and after the intervention. The periods before (after) range from October 1, 2002 (April 1, 2006), to June 30, 2005 (December 31, 2008).

One of the first natural questions to ask in any quasi-experimental work is whether the treatment did what we expected it to do, namely reduce the mean distance to stations within areas that were positively affected and increase the distance in areas that were negatively affected. Based on the figures presented in Table 4 this notion can be affirmed. Mean distance to a mainline connection decreased from 7.69 km to 6.30 km within a sample of 118 traffic cells that were positively affected. In percentage terms this corresponds to a reduction of about 18.1% (3 and 4). In contrast, as much as 175 traffic cells were worse off with the new network structure, experiencing an increase in mean distance from 6.52 km to 8.17 km, which corresponds to a relative increase of 25.3% (5 and 6). The difference in mean distances between the two groups increases by as much as 3.05 km (7). A regression based *t*-test clearly points to high statistical significance. In terms of average mainline accessibility it is further notable that the “positive” sample switches from being relatively disadvantaged to being advantaged compared to the “negative” sample, and the other way round. At the city level the new transport plan has led to an overall decline in average accessibility as suggested by the relatively large number of traffic cells in the “negative” group and the increase in mean distance from 7.0 to 7.41 km, which correspond to an increase of 5.9%, for the whole sample (1 and 2).

The second row of Table 4 shows changes in mean prices in both groups. There is a modest reduction in mean price for the “positive” group of about €2 per square meter or 0.5% (3 and 4). Although the “negative” group continues to be – on average – higher valued than the “positive” group, the decline in mean price of about €17 per square meter or 3.7% is relatively large

compared to the “positive” group (5 and 6). Relative to the “positive” group, the “negative” group experiences a decline in land price per square meter of about €15 (7), which appears quite substantial in relation to an average land price of around €400 per square meter. It has to be noted, however, that a regression-based *t*-test does not reject this effect from being zero at conventional significance levels. Evidence for an impact of mainline accessibility on land prices, hence, is very weak at best. It should be noted that no significant mainline accessibility effects could be found when establishing a relationship between changes in prices and changes in average distances to mainlines (Ahlfeldt, 2010c).

One possible explanation for the weak market reaction could be that markets had anticipated the new mainline plan before the official communication. As discussed, the final announcement was clearly perceived as a surprise in the media and wider public, leading to strenuous protests from business and passenger lobbies following the communication. It was argued that the degree of reallocation, and in particular the complete disconnection of Bahnhof Zoo, was not reasonable from a transport economics perspective. Accordingly, the heavy decline in access to the inter-city lines within the Bahnhof Zoo catchment area, including a decline in access for hundreds of thousands of residents, could hardly be justified by a 4-minute reduction in travel time for passengers departing from the eastern parts of the city in a western direction (Ataman, 2005). Since one would expect a major rail carrier to act rationally from a transport economics perspective, evidence in support of the “irrationality” argument of opponents would also support the notion that the final transport plan could hardly be foreseen and anticipated.

Table 4 suggests an overall decline in mainline accessibility in terms of affected traffic cells. Since population and employment are not necessarily distributed evenly across traffic cells, this does not necessarily imply an effective reduction in accessibility from the perspective of residents and employees. In Table 5, therefore, the groups of positively and negatively affected areas are expressed in terms of population (2005) and employment at workplace (2003).<sup>2</sup> Again, the figures support the fact that the vast majority of the population and employees became worse off by the network reorganization. As shown in the first row, there are almost 800,000 inhabitants (3) and almost 200,000 employees (6) more within the “negative”

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<sup>2</sup> All employees who contributed to social insurances are considered.

group than in the “positive” group, which means that approximately 60% of residents and employees now have larger average distances to mainline connections. This figure even increases to about 64% if mainline accessibility is expressed in terms of average travel time along the rapid transit network (U- and S-Bahn) and corresponding walks to stations.

**Tab. 5      Affected Population and Employment**

Change in average	Population			Employment		
	Positive (1)	Negative (2)	Net (3)	Positive (4)	Negative (5)	Net (6)
distance (km)	1,269,680 (38.1%)	2,065,432 (61.9%)	-795,752 (-23.9%)	388,137 (40.1%)	580,095 (59.9%)	-191,958 (-19.8%)
travel time (min)	1,188,177 (35.6%)	2,146,935 (64.4%)	-958,758 (-28.7%)	352,754 (36.4%)	615,478 (63.6%)	-262,724 (-27.1%)

Notes: Own Calculation. Percentages of total population and employment are in parenthesis. Travel time refers to combined walks to nearest rapid transit station and shortest train ride along the network. See for a more detailed description Ahlfeldt (2010).

These findings support the argumentation of numerous opposition groups that the access to main lines has become inferior for the majority of residents as a result of the new transport plan and that the situation has been unnecessarily aggravated by the complete disconnection of Bahnhof Zoo. It also highlights that, in terms of maximizing access to customers, the new transport plan is not very efficient and that real estate markets were therefore unlikely to anticipate the final adjustment. One of the possible explanations frequently quoted by the opponents of the new transport plan was that the Deutsche Bahn AG aimed at concentrating passengers at the new central station Hauptbahnhof in order to promote its success as one of Berlin’s major shopping malls, with more than 15,000 square meters of shopping area.

### 3.2 Localized Effects

As discussed, among the changes scheduled in the new transport plan the closure of Bahnhof Zoo for main lines induced particularly heavy protests. It was argued that the area around the station would suffer considerably as accessibility to main lines was vital to the role of the “City West” as a center for business, retailing and tourism. More generally, one could argue that even though it might be difficult to prove significant mainline accessibility effects on a city wide scale, property market reactions in proximity to mainline stations should be particularly strong and, thus, easier to detect. Building on Ahlfeldt (2010c), such real estate price reactions may be isolated in a quasi-experimental strategy by comparing price trends within a narrower sphere of influence of a main station to a control group formed by the rest of the city. Follow-

ing Gibbons & Machin (2005) the threshold distance around a station to distinguish between the station neighborhood and the control group is set to 2 km. Our identification strategy basically estimates the difference in mean (log) prices (in €/m<sup>2</sup>) between the station neighborhood and the control group on a quarterly basis and thus provides an index of market performance within the station neighborhood relative to the rest of the city. Prices are adjusted for observable property and location characteristics, unobservable time-invariant location characteristics, general time trends and broad changes to the urban structure that are unrelated to station effects, e.g. a general adjustment in the core-periphery structure of the city.<sup>3</sup>

The resulting hedonic indices (in log differences) based on the full set of all transaction of developed properties in Berlin from January 1, 2000, and December 31, 2008 are displayed in Figure 5 for the station neighborhoods of Bahnhof Zoo and Hauptbahnhof. While there is a continuous downward trend within the catchment area of Bahnhof Zoo, no particular adjustment in the trend is evident around the crucial period between the announcement and implementation of the new transport plan (July 2005 to March 2006). To the contrary, evidence suggests a recovery of the area after 2007, indicating that any adverse real estate price effects of the closure of Bahnhof Zoo, if existent, were dominated by alternative forces. Similarly, there is no upward adjustment in price trends around 2006 within the catchment area of Hauptbahnhof. Figure 6 shows smoothed (relative) trends for all mainline stations affected by the new transport plan. Again, the pattern is not very persuasive with regard to mainline effects. Between the time of announcement and inauguration, no consistent price adjustment could be found for stations that benefited (Gesundbrunnen, Hauptbahnhof, Spandau, Südkreuz) or suffered from the new transport plan (Bahnhof Zoo, Ostbahnhof). If at all, the positive trend around Bahnhof Gesundbrunnen as well Bahnhof Spandau could be interpreted as weak evidence of a long-run adjustment process, which, however might be driven by the extension of facilities and inclusion of services like retailing rather than the (expected) increase

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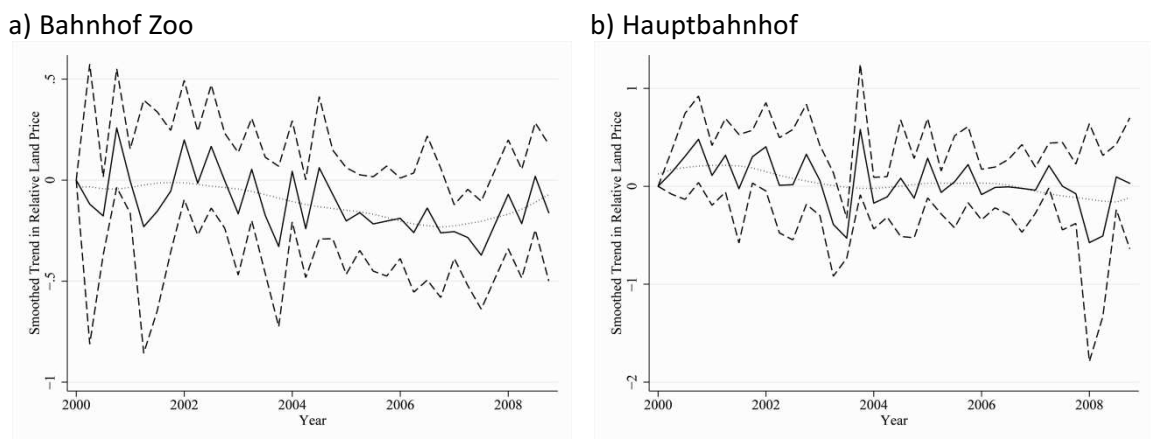
<sup>3</sup> Formally, the estimation equation takes the following form:  $\log(P_{it}) = \sum_n \beta_n S_{ni} + \sum_t (\gamma_t SD_i \times \varphi_t) + \sum_m \sum_t (\delta_{mt} L_{mi} \times \varphi_t) + \vartheta_j + \varphi_t + \varepsilon_{it}$ , where  $P_{it}$  is the price of a property  $i$  at time  $t$ ,  $S_n$  is a vector of structural property characteristics,  $SD$  a dummy variable denoting the circular 2km impact area around a mainline station,  $L_m$  is a vector of observable location characteristics with time-variant effects,  $\vartheta_j$  is a set of traffic cell fixed effects capturing time-invariant location characteristics,  $\varphi_t$  a set of quarterly time effects,  $\varepsilon_{it}$  is an error term and all other Greek letters stand for parameters to be estimated.



in accessibility. Note that for all other stations, no support for the presence of anticipation effects can be found, even if tracking the evolution of prices back as far as to 1993 (Ahlfeldt, 2010c).

From the identification strategy discussed above it is not possible to reject a significant impact of the mainline reorganization on property prices. It is virtually not possible in practice to perfectly separate property price effects arising from the realignment from all other (unobservable) changes occurring in the neighborhood of stations. It is, however, possible to conclude that the localized impact on property prices arising from the *pure* change in mainline accessibility seems to be relatively small in relation to the overall neighborhood changes occurring around stations. Based on this evidence, the concerns of business lobbies about the Zoo area experiencing a major decline in attractiveness following the disconnection of the station seem unjustified from an ex-post perspective.

**Fig. 5 Relative Price Differentials within Station Neighborhoods (I)**



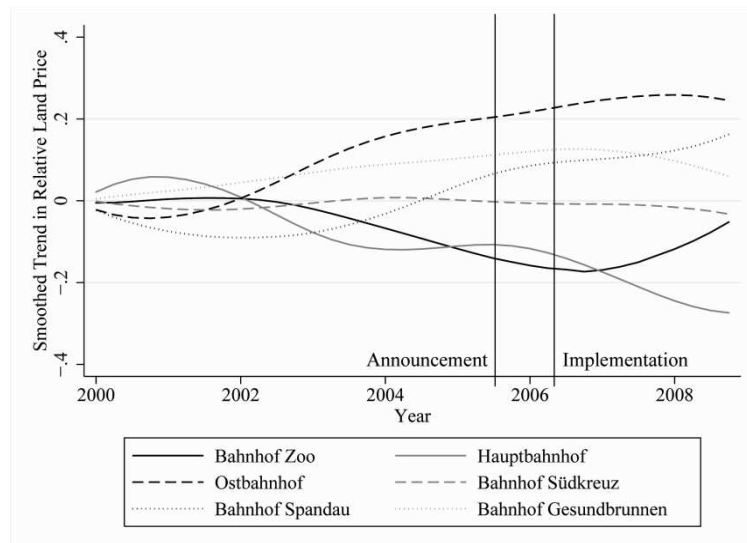
Notes: Own calculations. Solid lines are indices of relative land prices (log differences). Dashed lines show 95% confidence intervals. Dotted lines represent smoothed trends generated by the use of locally weighted regressions (bandwidth is 0.5). See Ahlfeldt (2010c) for details on data and methods.

One natural question to ask is whether the apparently small rail accessibility effects are a general phenomenon of the study period or specific to main lines. After Berlin's reunification, major investments were not only necessary into the mainline network but also into the urban and regional rail networks. First, network links and temporary improvements facilitated the first joint transport network since 40 years. Second, rail links between West-Berlin and the hinterland had to be fully recovered, which after 30 years out of traffic effectively meant the construction of new tracks, electric plants and stations (Book, 1995). Mainly due to the improve-

ments made to the underground network in West-Berlin during the post-war period, the network with 275 stations and 475 km of overall network length had considerably grown compared to pre-war Berlin.<sup>4</sup> This relative increase in the network size potentially induced an increase in network externalities and, hence, a rise in the value of having a station in close proximity. On the other hand, the broad availability of individual transport as an alternative transport mode should have reduced the relative importance of the rapid transport network. Also, the addition of stations to an already well-developed network potentially reduces the marginal value of having a station close by. Comparing the estimates of Ahlfeldt (2010b) to Ahlfeldt & Wendland (2009), the latter effect seems to be clearly dominating. Accordingly, the marginal price effect of a 100 m reduction in the distance to the nearest urban rail station fell from as much as 2.5% to about 0.4%. This effect, however, is still highly statistically significant and relatively large compared to the impact of other location attributes, e.g. natural amenities like green and water spaces or public facilities like schools. The absence of statistically measurable rail accessibility effects discussed in this section is thus a specific result for main lines and does not generalize to other rail systems. One natural explanation is the, on average, lower frequency of usage of main lines compared to urban and regional rail systems, which among other reasons, are used for commuting, shopping and entertainment purposes.

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<sup>4</sup> The combined length of the metro and suburban railway network added up to more than 410 km, including 222 stations in 1939.

**Fig. 6** Relative Price Differentials within Station Neighborhoods (II)

Notes: Own calculations. Smoothed trends generated by the use of locally weighted regressions (bandwidth is 0.5) as in Figure 5. See Ahlfeldt (2010c) for details on data and methods.

### 3.3 The Outlook

Having engaged with the impact of rail mega-projects in Berlin during two pioneering periods of rail network (re-)development, some words are due on future developments of rail infrastructure. Clearly, the euphoria from the early days after the city's reunification has made way for a considerable economic disillusion. The probably most important extension to the existing network still emerges out of the need to connect the new central station Hauptbahnhof to the existing urban railway network. Placed on a strip of land close to where the Berlin Wall stood, the station, despite its geographic centrality, was built into a largely undeveloped area, only connected to the urban railway network through the suburban east-west railway track. Two major railway network extensions are currently being considered. First, a northern connection to the circular line of the suburban railway system of approx. 1.7 km length is scheduled. According to the current plans, this extension would not be accompanied by the inauguration of new stations. The second promising project is the eastern connection to the metro line 5 (U5) at Alexanderplatz via "Brandenburg Gate" and the Boulevard "Unter den Linden". The first section from Hauptbahnhof to "Brandenburg Gate" has recently been inaugurated, temporarily labeled U55. As a further extension, this line may continue westwards through the residential area of the Moabit district until connecting to the suburban circular line at the station

“Jungfernheide”.<sup>5</sup> Following these plans, the metro line 5 would be extended in total by approximately 9 km and 10 stations, of which 8 would be completely new.

Especially in light of the limited evidence of economic stimuli of mainline connectivity it is an interesting question how the development of Hauptbahnhof to an intra-urban rail hub would influence location attractiveness. As discussed, empirical evidence suggests that urban rail stations – in Berlin and elsewhere – exhibit a pronounced, although localized impact on property prices. As demonstrated by the case of Kurfürstendamm during the 1920s, intra-urban rail hubs may foster the agglomeration of urban economic activity.

This issue is addressed by Ahlfeldt (2008), who develops a quantitative model that connects the 15,937 city blocks on the basis of the metro- and suburban railway network in order to predict the impact of network alterations on the value of urban land. In line with existing evidence, the model predicts a significant and localized impact around the newly developed rail stations. Furthermore, the model predicts the impact will considerably spread along the existing network, reflecting increasing demand for land where passengers save travel time by adjusting their routes to the newly available alternatives. Figure 7 shows the outcome of the micro-level simulation in terms of predicted changes in standard land values (Bodenrichtwert) in €/m<sup>2</sup> for a scenario with the north-, west- and eastbound extensions. Clearly, the model predicts the largest impact within the business areas in the historical city center, in particular along the Boulevard Unter den Linden. Selected properties may experience an increase in standard land value of up to 120 €/m<sup>2</sup>. As expected, the model also predicts a considerable relative increase in land value around Hauptbahnhof of up to more than 10%. Since land values, however, are generally lower than in the core city areas, the increase in absolute terms is more moderate.

From the model results presented above, it is possible to infer on the aggregated value added to landlords owning about 557,000 registered properties in Berlin (2007). Based on the area covered by these properties, the total value added in aggregate amounts to slightly more than

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<sup>5</sup> The structure plan also considers an extension of the line to Tegel Airport and further northwards. However, due to the scheduled closure of Tegel Airport this extension has become unlikely and will not be further considered. Effectively, even the westward extension from central station is seriously being questioned.

€175 million. More interestingly, it can be shown that the distribution of this increase in wealth is highly localized. Based on the predicted values of Ahlfeldt (2008), a Lorenz curve can be calculated to visualize the percentage of total value added for a given percentage of developed land area (see Figure 8). The Lorenz curve (solid line) has a clearly convex shape, revealing the inequality in the distribution, which becomes particularly apparent in comparison to the line of equality (dashed line). For instance, one half of the total value added capitalizes into less than 16% of total property area. Similarly, a quarter of the total value added capitalizes into less than 4% of total property area. Owners of the respective properties clearly benefit disproportionately from the transport innovation. Since only a limited fraction of the affected areas is publically owned, a relatively small number of private landlords will benefit disproportionately from the largely publically financed improvement of rail infrastructure.

**Fig. 7** Predicted Change in Land Value

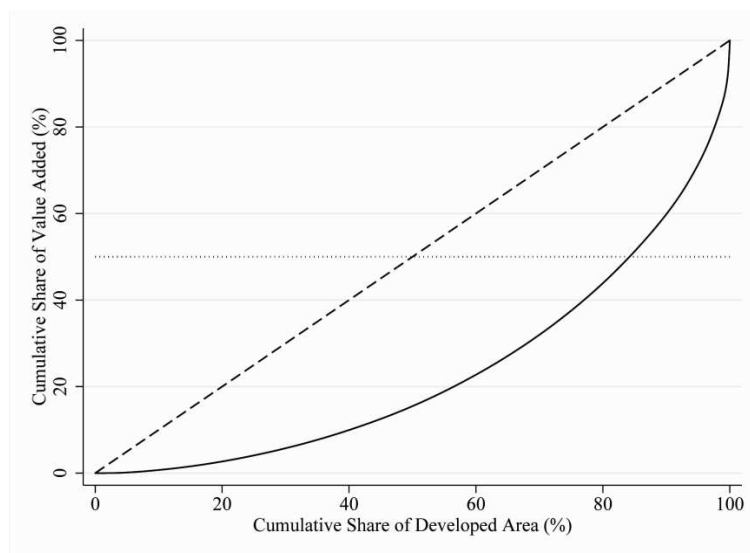


Notes: Own illustration on the basis of the results of Ahlfeldt (2008).

Put in other words, (public) costs are equally distributed across the society while there is a striking imbalance in the benefits. This imbalance further increases if one considers that a large fraction of public expenditures is paid out of federal funds and that there is not only an inequa-

lity in the distribution between landlords, but also between landlords and renters. Increasing demand for living space following infrastructural improvements leads to an upward adjustment in rent level that – in equilibrium – compensates for the utility arising from travel time saving. While renters in the long run expect a constant net-utility at best, private landlords receive a positive externality from a public investment they have only marginally contributed to.<sup>6</sup> From a welfare economics perspective, therefore, monetary compensations by the benefited landlords would be justified. In practice, the magnitude of compensations should be, of course, assessed upon a statistical ex-post evaluation. Model predictions as discussed above, however, potentially represent a useful tool for planning authorities since they allow the assessment of the potential contribution to financial viability in cost-benefit analyses, which is particularly valuable in times of budget scarcity.

**Fig. 8 Lorenz Curve**



Notes: Own calculation and illustration on the basis of the results of Ahlfeldt (2008). Solid line is the Lorenz curve. Dashed line is the line of equality.

<sup>6</sup> Following Ahlfeldt's (2010a) argument renters may be even worse off in the new equilibrium as they had opted, with respect to their preferences, towards accessibility. The increase in equilibrium rents driven by new residents with a high willingness to pay for accessibility potentially overcompensates for the utility gains from improved access to the rail network.

## 4 Conclusion

This article condenses and complements the results of a series of empirical research on the impact of rail mega-projects on the urban economy of Berlin during the late era of industrial revolution and the period after unification. Evidence suggests that intra-urban rail stations exhibit a significant impact on demand for land, although the effect is relatively localized and diminishes slightly over time as the availability of individual transport increases. As demonstrated by the case of the Kurfürstendamm area during the 1920s, intra-urban rail hubs – at least if embedded into an urban development strategy – exhibit a potential to foster urban economic development and to promote the agglomeration of urban economic activity. In comparison, the effects of large-scale inter-city rail projects are less striking. Even the fundamental reorganization of the inter-city rail network in post-unification Berlin has had, if any, only a weak impact on property prices, both within the station neighborhoods as well as at the city level. This is remarkable given that the realignment has had an adverse effect on the majority of the city area, population and employment, which was hardly foreseeable in its final form and was strongly opposed by various business and passenger lobbies.

Productivity gains arising from inter-city connectivity as suggested by various agglomeration theories apparently do not capitalize strongly into real estate prices. Economic agents seem to discount the value of inter-city rail stations weakly on distance, most likely due to the relatively low frequency of usage. Given this rather global character of rail stations, two conclusions for planning authorities emerge. First, the limited direct impact on the urban economy may justify a relatively peripheral location of the station in order to make available the spaces occupied by facilities and feeder lines, which often cover much of a city's most productive space. Relocation may be a feasible alternative if expensive tunnel constructions are not financially viable. Second, the availability of access to main lines by itself is unlikely to induce considerable stimuli on a neighborhood. At least, effects are small compared to many other influencing factors. Authorities carrying out urban development policies in the course of rail mega-projects should therefore develop strategies that go beyond the scope of an efficient transport concept.

Regarding future developments of rail infrastructure, a considerable impact on the local economy is to be expected from the improvements in the connectivity of Berlin's new central station to the metrorail network. In line with empirical evidence, simulations predict significant, but localized effects. Monetary compensations by landlords, who disproportionally benefit

from the externalities related to the investment project, would therefore be justified in welfare economic terms. With empirical methods, looking at, among others, those discussed in this article, the degree to which private landlords benefit from public investment can be identified. Micro-level simulations, as shown, facilitate the prediction of the expected impact, enabling authorities to define priorities, develop viable financial concepts and, not least, assess the potential for compensations by private landlords.



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