Spatial Determinants of CBD Emergence: A Micro-level Case Study on Berlin

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Abstract: Over the recent decades, scholars and planning practitioners have developed strategies for directed urban decentralization, which aim at the optimization of urban commuting patterns by allowing households to locate closer to job opportunities. However, given ongoing changes in the socio-economic framework, households are becoming less likely to choose their residences with respect to location of the workplace. In order to optimize trip patterns with respect to public transport and to simultaneously promote sustainable urban growth, we therefore suggest a strategy of *Directed Urban Concentration*, which purports the generation of very strong (employment) sub-centers, if not multiple central business districts (CBDs), as a complementary strategy to established approaches of mixed and multifunctional land use. In an empirical analysis we show that in the case of Berlin, Germany, the emergence of the second CBD during the first half of the past century was largely driven by market access generated by rail-based public transport. Our results suggest that city planners could successfully promote the emergence of new urban economic cores with focal transport nodes that are equivalently well-connected to their hinterlands as well as to the existing CBD.

Keywords: Directed urban concentration, urban transport, market access, urban planning, Berlin
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1 Introduction

One of the key urban planning challenges of the 21st century towards sustainable urban growth is the reduction of the overall length of urban residents' trip patterns and a more prominent role for public transport in the modal split. During

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the second half of the last century, the traditional monocentric city gradually disappeared in many developed parts of the world while sub-centers and edge cities increasingly account for employment opportunities and provision of retailing and entertainment services. While on one hand the maintenance of compact economic activity clusters, as provided by organically grown CBDs, is vital for further economic growth, on the other hand traffic congestion within overcrowded central areas still imposes high social cost in the form of increased commuting costs, higher energy consumption and ongoing social exclusion.

While most economists tend to focus on weighing the benefits of agglomeration economies against the cost of congestion, disregarding the numerous implications for social and urban life-style, various city planners concentrate on the development of decentralized, safe, attractive and lively areas with a slighter business density. Choosing an interdisciplinary perspective, we suggest a concept of *Directed Urban Concentration* that combines both perspectives and puts as equivalent objectives economic growth as well as sustainable development and livable urban environments on the planning agenda.

We exploit a unique natural experiment to investigate how areas in immediate proximity to new major transport nodes may become subject to initial advantages whereupon agglomeration forces and cumulative causation lead to the emergence of strong activity clusters, or even alternative CBDs. Berlin, Germany, represents a frequently cited example of a large European metropolis suffering only to a minor extent from problems related to traffic congestion.[1] While in Berlin there is a relatively high proportion of mixed use (SENATSVERWALTUNG FÜR STADTENTWICKLUNG BERLIN, 2007) which, according to the relevant planning theories, might prevent excessive concentration of economic activity, there is another striking particularity that accounts for the relaxed traffic situation: a nearly perfect duo-centricity.[2] We conduct a detailed micro-level case study focus-

[1] Relevant information available at www.stadtentwicklung.berlin.de

[2] In terms of employment, cultural and retailing activity, the Senate Department Berlin considers the two major downtown areas in the districts Charlottenburg and Mitte to be of equivalent importance (SENATSVERWALTUNG FÜR WIRTSCHAFT ARBEIT UND FRAUEN, 2004).

ing on the area around the Kurfürstendamm that is unique in the level of geographic disaggregation in a historical context. Our results suggest that the emergence of Berlin's duo-centric structure was essentially promoted by market access generated by rail-based public infrastructure, indicating that economic activity within focal areas may be fostered by means of a well-directed development of public transport infrastructure. While section 2 provides a detailed overview of the perspectives of urban economics and planning studies on the related spatial dynamics, it is followed by a description of collected data sets and the empirical strategy. Based on the idea of *Directed Urban Concentration* developed in section 2 and our empirical findings presented in section 4, section 5 concludes our contribution to the discussion on how to achieve sustainable urban growth.

2 Planning the Post-Monocentric City

2.1 New Economic Geography and Urban Economics Background

Common explanations for the uneven distribution of economic activity across space refer to differences in location endowments (BLOOM & SACHS, 1998) or the quality of institutions (ACEMOGLU, JOHNSON, & ROSINSON, 2001), while the new economic geography literature emphasizes the role of market access in shaping patterns of economic activity (DAVIS & WEINSTEIN, 2002; KRUGMAN, 1991).[3]Accordingly, regions may benefit from good access to other regions' markets due to a reduced cost for firms supplying customers and the raised availability of goods for consumers (CRAFTS, 2005). Recent empirical evidence confirms theoretical implications showing that access to regions is of causal importance

[3] See for a synthesis of theoretical research FUJITA, KRUGMAN & VENABLES (1999) and BALDWIN (2001).

for the economic performance of regions (REDDING & STURM, 2008).[4] It has been shown that these principles also apply to an urban scale and that access to regions (AHLFELDT, 2008) as well as to intra-urban markets (AHLFELDT, 2007) shape spatial patterns of economic activity within cities.

Considering internal and external scale economies,[5] transport costs and the mutual attraction of business and customers, processes of cumulative causation may lead to a stable equilibrium where income and economic activity concentrate in regional (or urban) agglomerations. In contrast to the view that fundamentals such as institutions or endowments determine patterns of economic activity, new economic geography models predict that the steady-state distribution depends on a range of parameter values as well as on initial conditions and historical accident. This kind of path dependency is also referred to as "hysteresis" (ARTHUR, 1994; BALDWIN & KRUGMAN, 1989; DAVID, 1985). REDDING, STURM & WOLF (2007) provide compelling evidence for the existence of multiple equilibria in industrial location.

Early urban economics (ALONSO, 1964; MILLS, 1972; MUTH, 1969) assumed economic activity within cities to be completely concentrated in the urban core. However, over the course of the last decades urban economic research has made considerable advances in theoretically explaining the existence of complex polycentric structures (LUCAS & ROSSI-HANSBERG, 2002). ANAS & KIM (1996) develop a general equilibrium model of urban land use that predicts multiple equilibria in

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[4] Empirical tests also reveal a significant spatial correlation between regional wage levels and market access for the U.S. (HANSON, 2005), Europe (NIEBUHR, 2006), Germany (BRAKMAN, GARRETSEN, & SCHRAMM, 2004) and Italy (MION, 2004). In a cross-country analysis, REDDING & VENABLES (2004) provide evidence for the geography of market access being a significant determinant for worlds' income differentials. HEAD & MAYER (2004) and OVERMAN, REDDING & VENABLES (2003) provide surveys on the empirical literature.

[5] Internal scale economies occur in the production of local public goods (KOIDE, 1987; STIGLITZ, 1977) as well as in private production (STARRETT, 1974). External scale economies are also referred to as economies of localization when occurring between firms of the same industry, and economies of urbanization if across industries (ANAS, ARNOTT, & SMALL, 1998). Other forms of external scale economies, also called statistical economies of scale, occur from reduced larger labor markets mismatch, improved information exchange and incentives for human capital accumulations due to specialization within larger cities (HELSLEY & STRANGE, 1991).

production agglomeration depending on agglomeration and access. Stronger agglomeration leads to fewer and bigger urban cores while with the increasing cost of congestion, the number of centers increases. ANAS (1992) shows how a monocentric equilibrium may become unstable after a city's population exceeds a certain threshold. As a result a duo-centric equilibrium emerges following accident migration. These theoretical implications are in line with tendencies of urban decentralization occurring in developed countries while in many mega-cities, particularly in developing countries, traffic nightmares are still observed within the CBDs (BOARNET, 1994). The case of Los Angeles even demonstrates that proximity to the urban core may become an inferior indicator for attractiveness of location compared to several smaller sub-centres (HEIKKILA *et al.*, 1989).

Hence, from the existing urban economics and new economic geography literature we conclude that following increasing population and congestion a monocentric urban equilibrium may become unstable. Given attractive alternatives, sub-centers are expected to emerge at those locations that exhibit a comparable advantage in terms of market access. Initial advantage together with processes of cumulative causation may then lead to path dependent development and a new spatial equilibrium where the significance of new centers depends on the degree of their effective accessibility.

2.2 Directed Urban Decentralization

Besides the mere economic view on the physical structure of cities, another important perspective can be identified. Without having to go back to VON THÜNEN (1826), there is a tradition of urban sociologists, planners, and geographers in describing urban patterns that started long before Alonso concluded his work. In fact, it was Ernest BURGESS (1925) who first implemented an early classical model to explain monocentric structures. It provided a conceptual framework for the thoughts of many generations (DAVOUDI, 2003; LEGATES & STOUT, 1996). HARRIS & ULLMAN (1945) even introduced the idea of several centers of economic activity existing in one city, and the city's size defining their number. During the

1960s the conceptual idea of polycentric urban areas gained wide consideration (KLOOSTERMAN & MUSTERD, 2001) owing to further pioneer work (FRIEDMAN & MILLER, 1965; LYNCH, 1961; LYNCH & RODWIN, 1958; WURSTER, 1963). As for the main reasons of spatial reorganization within complex systems, the literature offered the same combination of influential forces as formalized by the urban economists decades later.

The idea of cycles existing in the evolution of urban spatial structure is discussed by CHESHIRE (1995). Accordingly, following a period of rapid urban growth and an increasing concentration of economic activity within urban cores up until the mid 20th century, the second half was mainly characterized by processes of urban decentralization. While Cheshire finds signs of re-urbanization within continental European metropolises, many mega-cities in developing countries are currently experiencing the first stage of rapid urbanization, where high congestion leads to reduced mobility, rising transport costs and an overall economic inefficiency (GORDON, KUMAR, & RICHARDSON, 1989; NEWMAN, 1996). Increasing commuting costs furthermore create social inequity and thus possible social exclusion (NEWMAN, 1996), which contradicts one of the core principles of sustainable development (HAUGHTON, 1997; TU & SHI, 2006).

The acknowledgment of changing economic principles going hand in hand with rapidly developing transport modes after World War II, and an overall shift within social life and therefore changing trip patterns, required new forms of defining and directing the ongoing processes of decentralization in growing as well as in shrinking regions of developing and developed countries (CHAMPION, 2001; DAVOUDI, 2003; KLOOSTERMAN & MUSTERD, 2001). In order to avert the numerous disadvantages linked to undirected spatial reorganization and the possibly negatively-associated resulting urban sprawl, well directed planning should foster the emergence of more efficient land use patterns (BURCHELL & MUKHERJI, 2003; CARRUTHERS & ULFARSSON, 2003; NELSON *et al.*, 1995; STURM & COHEN, 2004). Based on this principle the spatial planning concepts of *Multifunctional Land Use, New Urbanism, Smart Growth*, and the *Compact City* have gained considerable attention throughout the last decades (see for concept overviews COUPLAND,

1997; DE ROO & MILLER, 2000; JENKS & BURGESS, 2000; JENKS, BURTON, & WILLIAMS, 1996). Besides manifold sets of detailed planning agendas they all aim at the efficient and sustainable development of urban designs emphasizing an overall compact urban form and good accessibility by means of public transport infrastructure. Various social and economical synergy effects in areas characterized by higher densities and mixed use may lead to an overall improvement in economic performance, increased social equity and to a more modest consumption of resources (NEWMAN & KENWORTHY, 1989; POUYANNE, 2005; VREEKER, 2004; WILLIAMS, 1999; WILLIAMS, BURTON, & JENKS, 2000).

But the nature of proliferated and persisting urbanization processes raises more questions. Keeping in mind the very complex interdependencies between constantly desired economic growth and emerging, positively linked economies of scale on one hand, and the negatively associated effects on the urban and social structure on the other, one might ask whether the mere idea of slightly intensifying the density within residential and activity areas throughout a city goes far enough. Although generating indisputable additional values to urban lifestyle, reduced energy consumption and more social equity, it remains questionable whether a widely dispersed range of mixed-use areas would be capable of generating sufficiently high economical synergy effects to support persistent and desired growth paths. In order to benefit from these effects, dense clusters of economic activity – as initially provided by the historical CBDs – establish a major prerequisite. Thus, from an economic perspective one might suggest combining the striking benefits of widely dispersed mixed-use areas with additional highly agglomerated areas of economic activity (VREEKER, 2004). Taking into account findings that indicate that central locations of activity clusters in combination with well directed housing policies are capable of reducing overall commuting costs (NAESS & LYSSAND SANDBERG, 1996; NOWLAN & STEWART, 1991) and therefore, even under ongoing downtown employment concentration, transport energy consumption can be reduced (NOWLAN & STEWART, 1991), a new planning implication emerges.

2.3 Directed Urban Concentration

One of the common principles of the abovementioned planning concepts, which we subsume under the main idea of directed urban decentralization, is to optimize overall trip patterns by bringing places of work and residences closer together. In this context it is important to note that, despite the theoretical prominence, commuting time and cost in practice appear to play only a limited role in determining households' residential location choice. Empirical results suggest that cross-commuting accounts for the larger share of overall commuting compared to the commuting "up the land gradient" (GIULIANO & SMALL, 1993; HAMILTON & ROELL, 1982; SMALL & SHUNFENG, 1992). This finding contradicts theoretical implications as households could maximize utility by interchanging houses and hence reduce commuting time without having to face higher rents. Common explanations refer to idiosyncratic preferences for local mixes of amenities, sentimental attachments, constraints in location choice of two-worker households and frequent job changes leading to the consideration of a wider array of job opportunities rather than a particular job location (ANAS, 1992). Ethnical segregation, which is one of the key issues in urban social sciences (CUTLER & GLAESER, 1997), may also account for residents choosing locations that deviate from the economic optimum (WALDFOGEL, 2008).

However, if residents do not choose locations with respect to their place of work, then more dispersed employment no longer guarantees a reduction in the overall length of commuting. Particularly in light of the occultation of one-employee households and the increasing frequency of job changes, it is becoming less probable that average commute may be effectively reduced by means of households locating closer to dispersed job-opportunities. Planners may therefore wish to consider complementary strategies to the abovementioned concepts of directed decentralization. As noted in the sub-section above, the ongoing relevance of agglomeration forces as a determinant of business location implies a continuous demand for central locations that can only be satisfied within business areas characterized by a very high density of economic activity and outstanding access to consumer markets. To avoid continuous concentration in an overburdened CBD, the provision of an attractive alternative location for dense business agglomeration represents an intuitively plausible strategy. Still, having economic activity concentrated to a large extent in focal locations, employees' and customers' access to business activity can more easily be organized by means of public mass transport compared to a situation where economic activity is widely dispersed across a space. Hence, the considered creation of duo-centric spatial structure (or at least the generation of very strong sub-centers) may represent a pragmatic approach for the optimization of residents' trip patterns, at least when authorities also aim at improving the competitiveness of public relative to individual transport. Referring to the abovementioned model developed by ANAS (1992), the provision of an attractive, highly accessible alternative location to the existing CBD could represent an incident that facilitates the directed transformation into a stable duo-centric equilibrium. Hence, considered planning could encourage new (sub-) centers to emerge at designated locations before congestion in the existing cores becomes unbearably large.

However, we would like to emphasize that such a strategy may feasibly be employed in addition to – not instead of –mixed or multifunctional land use strategies. There are certainly numerous services regarding daily demand (e.g. for shopping and entertainment) that represent perfect substitutes and are not subject to very large scale economies, and hence may efficiently be provided locally in more peripheral areas of mixed use. Experiences in the city of Toronto also indicate that downtown population intensification in mixed areas surrounding the very urban core – which reads similar to the ideas of *Multifunctional Land Use* – reduces the need for commuting facilities even in times of growing downtown office space and ongoing downtown employment agglomeration (NOWLAN & STEWART, 1991). In contrast, as the experiences of most U.S. cities during the second half of the 20th century demonstrate, growing areas of widespread low-density developments not only increase overall commuting length, but also lead to a decline in the competitiveness of public transit (BAUM-SNOW & KAHN, 2005).

3 Data, Methodological Issues and Empirical Strategy

In order to validate our assumptions and affirm suggested planning strategies, the spatial transformation of Berlin from a dense monocentric structure to a state of commonly accepted duo-centricity offers a unique natural experiment. Collecting a one-of-a-kind historical data set provides the rare opportunity to historically track the evolution of market access generated by means of public railway transport over the key-period of network implementation.

Firms tend to outbid households in competition for central locations since the attractiveness of commercial areas critically depends on access to consumer and labor markets. In equilibrium markets, any increase in location attractiveness perceived by market participants due to improved accessibility will capitalize into land values of designated business areas, and hence become observable. Therefore, for the purposes of our empirical analysis, it was indispensable to meet both requirements, identifying designated business blocks within our observation area (3.3) and collecting the corresponding land values assigned to them.

Our empirical strategy basically consists of comparing the evolution of land valuation and access to markets within the study area in order to allow for conclusions on a casual relationship. The next sub-sections introduce our data and indicators of economic activity, which we employ in our empirical setup discussed in section 3.3.

3.1 Data

The analytical frame is defined by a georeferenced GIS map of the whole of Berlin based on the Urban and Environmental Information System of the Senate Department of Berlin (2006). It divides the area of approximately 892 km^2 into 15,937 statistical blocks, which represent the most disaggregated level for data provided by the Senate Department. With a median surface area of less than 20,000 m^2 they correspond to the size of a typical inner city block of houses. Hence, they offer a feasible level to model their intra-urban accessibility within the city's railway network. However, population data for this level of disaggregation covering the whole research period from 1875-1936 could not be retrieved. The most disaggregated data available refer to the wider areas of 94 historical villages and adjacent communities. They were collected from Leyden (1933) and the Statistical Yearbook of Berlin (STATISTISCHES AMT DER STADT BERLIN, 1878-1939) and were found to be consistent across sources.

Notwithstanding, assuming the population being equally distributed within the built up area of village *o*, we approximate block *i*'s population (P_i) with respect to its proportion at the total village's built up area D_o

$$P_i = P_o \frac{D_i}{\sum_o D_o}, \quad (1)$$

where D_i represents the total built up area within block *i* in m^2 and P_o is the total population of village *o*.

Processing historical cartographic maps made it possible to obtain the relevant information. For this purpose, they needed to be scanned and georeferenced. Further steps included digital editing, color extraction and the assignment to Berlin's official GIS map. The subsequent application of standard GIS software allowed for calculating and aggregating the areas of interest. In a next step, we gradually traced back the evolution of the city's complete public railway network over the course of our study period in order to form digital maps.[6] In line with the available census data, which offer population data for approximately every five years, the work was carried out for the observation period from 1875 to 1936. That information had to be gathered as a prerequisite for later modeling of centrality indicators (3.2).

Since we are dealing with historical data sets, the collection of the abovementioned information regarding land values and the location of designated business blocks within the observation area proved to be sophisticated. Bruno AUST (1986)

[6] Relevant information and network plans can be found at http://www.bahnstrecken.de/indexf.htm; http://www.bahnstrecken.de/bse.htm; http://berlineruntergrundbahn.de/; www.stadtschnellbahn-berlin.de

rendered outstanding services to all subsequent Berlin related research by collecting invaluable information regarding historical land uses. This way, by extracting the relevant blocks and digitally processing them, the areas of interest could be properly identified.

As for the collection of corresponding land values, two sources proved to be essential. Firstly, maps drawn by Gustav MÜLLER (1890-1910) indicating land values of Berlin's inner city on block level were digitally processed and the relevant data digitized. Secondly, street directories were used, which provided land values on street level (KALWEIT, 1928, 1936). The data appendix offers a more detailed description on the process of value generation and assignment to subject blocks.

3.2 Market Access Indicators

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

$$PP_i = \sum_j Pop_j \exp(-a \ d_{ij}) \quad (2)$$

is the population potentiality (PP_i) of block *i*, where Pop_j is the population of block *j*, *a* is a distance decay factor implicitly determining transport costs, and d_{ij} is the straight-line distance between the geographic centroids of blocks *i* and *j*. Because we deal with blocks of different sizes, a basic concept of empirical economic geography (CRAFTS, 2005; KEEBLE, OWENS, & THOMPSON, 1982) is employed to generate a block internal distance measure based on surface area, which can be used to determine the self-potential:

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

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

This indicator represents a fairly intuitive measure for urban centrality in a broad sense from a business perspective, since regions with high population potentiality maximize access to employees and customers.

However, accessibility within metropolitan areas is essentially determined by metro-rail and suburban railway networks. AHLFELDT (2007) develops a multi-level market access indicator allowing for spatial aggregation of population on the basis of public transportation networks. It considers both distance to stations and the centrality of stations within the network as well as the effective distribution of population on micro-level and hence, for the purposes of our research, draws a more comprehensive picture of rail-based centrality than standard approaches exclusively relying on distance to railway stations (BOWES & IHLANFELDT, 2001; GATZLAFF & SMITH, 1993; GIBBONS & MACHIN, 2005; GRASS, 1992; MCMILLEN & MCDONALD, 2004). All 15,937 statistical blocks of Berlin are related to each other by combined network distances allowing for distinct travel costs for train rides and walks. Assuming that residents use the nearest station, choose the shortest network connection within the combined metro and suburban railway network, and leave the railway system at the station located closest to their destination, the generation of population potentiality basically consists of three steps.

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

$$SP_m = \sum_j P_j \exp(-b\, d_{mj}), \tag{4}$$

where SP_m is the population potentiality, respectively market access, of station m, P_j is the resident population of block j, b is a distance decay factor, and d_{mj} is the straight-line distance between station m and block j.

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

$$NSP_s = \sum_m SP_m \exp(-a\ d_{sm}),\ \text{for } m \neq s \tag{5}$$

where NSP_s is the population potentiality of station *s*, which can be thought of as the potential for a resident who lives immediately adjacent to station *s* and wishes to commute by rail-based public transportation. Parameter *a,* again, determines spatial decay and d_{sm} is the shortest network distance between stations *s* and *m*. Stations' self-potentials are not considered since residents travelling within the catchment area of the same station will obviously not take the train.

Finally, network station potentiality has to be discounted by the walking distance from the station to a business location in order to account for customers' or employees' transport costs:

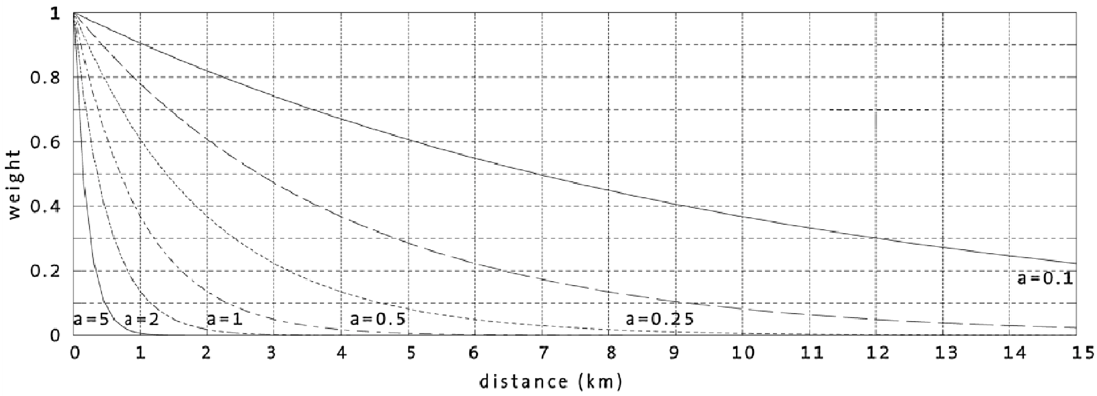
$$RPP_i = NSP_s\ \exp(-b\ d_{is}), \tag{6}$$

where RPP_i is the population potentiality generated by the urban railway network at business block *i* and d_{is} is the distance from block *i* to the nearest station *s*. Combining equations (4) – (6), employment potentiality can be written as:

$$RPP_i = \exp(-b\ d_{is}) \sum_m \left(\sum_j P_j \exp(-b\ d_{mj}) \right) \exp(-a\ d_{sm}),\ \text{for } m \neq s \tag{7}$$

AHLFELDT (2007) estimates a market potential equation similar to the one proposed by HARRIS (1954) and presents a discussion showing that the standard decay parameter value for *a* of 0.5 (WU, 2000) may be employed for broader spatial discount within an urban environment, while a parameter value *b* of 2 models walking speed. Figure 1 shows implicit decay functions for distinct decay parameter values. A parameter value of 2 implies a maximum range of approximately 2 km or 20-30 minutes of walking time. GIBBONS & MACHIN (2005) show that this range represents a feasible approximation of urban railway stations' impact areas.

Fig. 1 Spatial Decay Parameters and Implicit Decay Functions



Source: AHLFELDT (2007)

3.3 Empirical Strategy

Given that firms outbid each other for location, we assume land valuation within areas legally assigned to business use to be a feasible indicator for economic activity and the attractiveness of a business location within an urban environment. Relying on historical data on standard land values, we show that over the course of our observation period the location of the City-West of Berlin experienced an impressive increase in significance compared to the historical urban core as well as to the next strongest sub-centers. We track land gradient over time to identify whether and when the new center emerged as a self-sufficient core.

The relevance of market access for the emergence of the new center is investigated at two stages. First we employ accessibility indicators described in the section above to test whether preceding the concentration of economic activity the area exhibited an initial advantage in terms of accessibility compared to alternative locations that may explain the emergence of the new urban core. Second, we focus on the heart of the new urban core around Breitscheidplatz to analyze the role of accessibility at a micro-level. Therefore three areas are defined and compared over time. Kudamm Area 1 is limited to the very urban core around Breitscheidplatz, Kurfürstendamm and Tauentzienstrasse, while Kudamm Area 2 and Kudamm Area 3 cover considerably larger areas of Berlin's western downtown area. The data appendix provides a rationale for the definition of these areas and visualizes them. We track differences over time by application of simple difference estimation:

$$\log(Y_{bt}) = d_t \ a + Kudamm1_b \times d_t \ b + Kudamm2_b \times d_t \ c + \varepsilon_{bt} \tag{8}$$

where Y_{bt} either stands for standard land values (*SLV*), population potentiality (*PP*) or rail population potentiality (*RPP*) of business block *b* in period *t*, d_t is a full set of time dummies and *a*, *b* and *c* represent the sets of coefficients to be estimated. ε_{bt} is an error term satisfying the usual conditions. *Kudamm1* and *Kudamm2* are dummy variables denoting business blocks within Kudamm Area 1 and Kudamm Area 2 respectively. We use a pooled sample of data on SLV for the years 1890, 1896, 1900, 1905, 1910, 1929 and 1936, while *RPP* data is available for five-year intervals from 1875 to 1930 with the exception of 1915. 1936 data was constructed using the 1936 railway network and the linearly interpolated population of 1933 and 1939. For *PP*, additional data is available for 1871 when the whole area had not been connected to the railway network yet.

Since our sample is restricted to Kudamm Area 3, coefficients on interactive terms give average block differences between Kudamm Area 1 and Kudamm Area 2 and Kudamm Area 2 vs. Kudamm Area 3 respectively for all available years. As we use a log-linear specification, estimated coefficient *d* can be interpreted as percentage differences (*PD)* according to a well-established formula (HALVORSEN & PALMQUIST, 1980; KENNEDY, 1981).

$$PD = 100\exp((d - \frac{\text{var}(d)}{2}) - 1) \tag{9}$$

4 Results

Our empirical findings regarding the emergence of the Kudamm area as a self-sufficient center tell a clear story and support anecdotic evidence provided by many historians. A general population movement towards the west and south-west in combination with continuous investments in public infrastructure and real estate led to a gradual establishment of the city-west accompanied by a relative decline in the importance of the historical CBD, particularly during the 1920s

(KRAUSE, 1958; LEYDEN, 1933). This development started-off the ongoing tendency towards Berlin's duo-centricity.

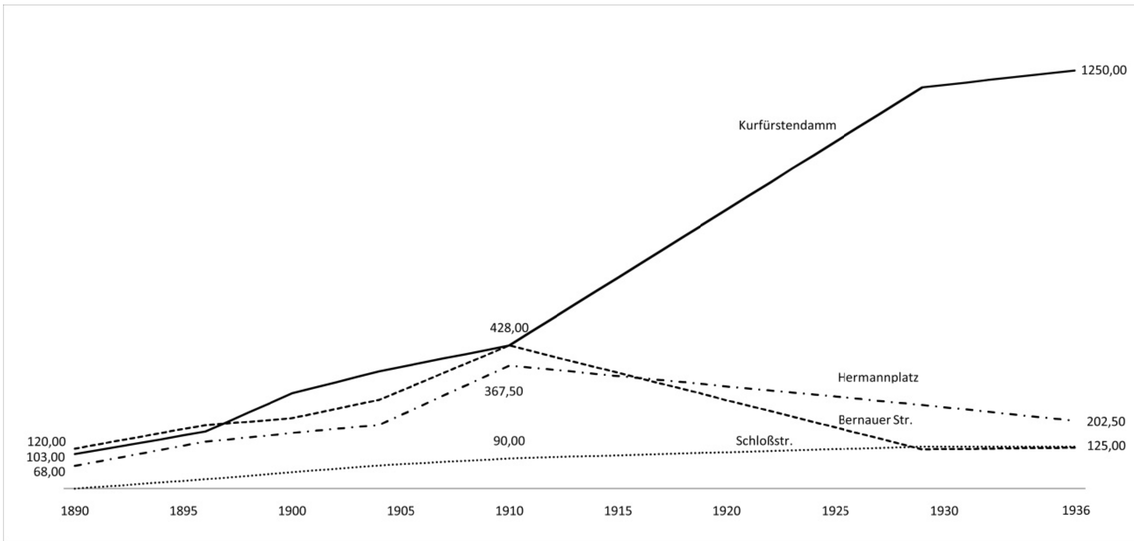
4.1 Market Access as Spatial Determinant for emerging Sub-Centers

The powerful dynamics of spatial reorganization triggered by a rapid population growth during the 19th century led to a general gain in the importance of slightly decentralized sub-centers in Berlin. Figure 2 shows the general land value development for representative business blocks within the most important sub-centers.[7]

After 1895 the Kudamm started overtaking the other sub-centers and extended its lead from 1910 on. Given its evident dominance regarding land value development, the objective to unravel the relevant determinants for the emergence of economic activity clusters was restricted to that area. In terms of relative centrality quantified by the abovementioned indicator (*RPP*) this area demonstrated a remarkable initial advantage, which emerged after 1880 and was strengthened during the first decade after the turn of the century owing to far-reaching extensions of the railway network (Figure 2).

[7] Sub-centers were identified by LIPMANN (1933). Each one is represented by the one business block that demonstrated the strongest development in terms of land values and railway potential up until 1936.

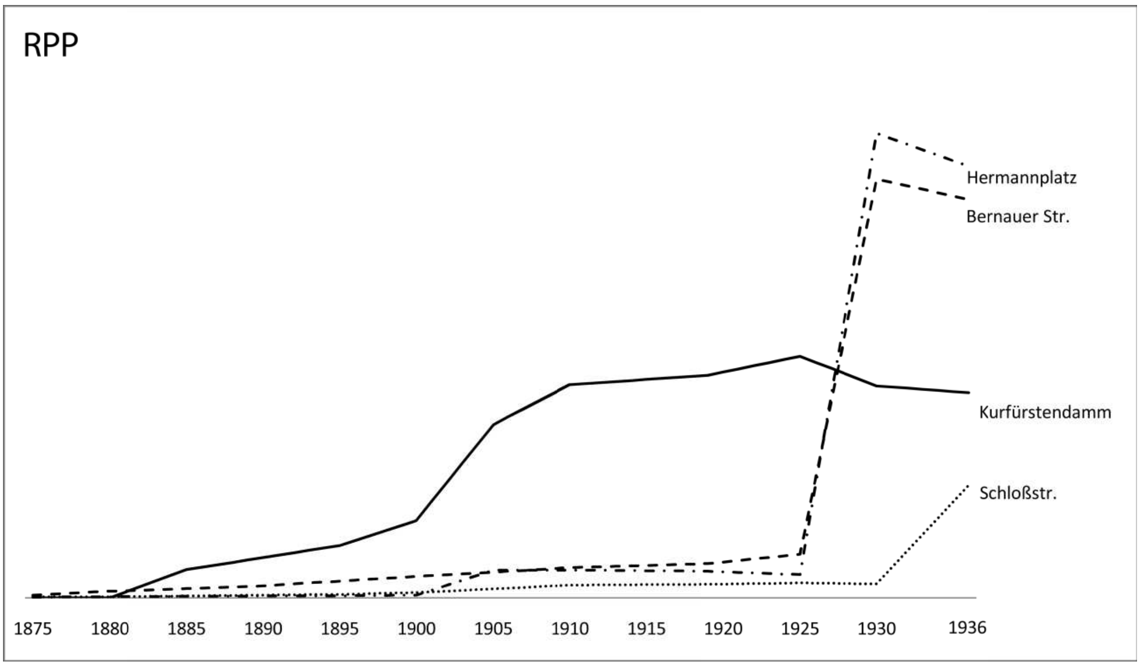
Fig. 1 Standard Land Values for Important Sub-centers



Notes: Authors` own calculations.

Apparently, emerging agglomeration forces together with cumulative causation, accompanied by supplementary amplifications of the network, established a path-dependent development so that the Kudamm area maintained its role as the most important center besides the historical CBD, despite a considerable relative decline in accessibility after 1925.

Fig. 2 Rail Potentiality for Important Sub-centers



Notes: Authors` own calculations.

The importance of the Kudamm region within the whole area of Berlin can be even better demonstrated by directly comparing it to the old CBD, which by the beginning of our observation period had already been the center of economic activity for hundreds of years. Figure 3 visualizes trends in *PP, RPP*, and *SLV* for the Kudamm area relative to the historical CBD.[8]

While the general shift in market access is owed to the increasing population of western and south western districts, the undertaken investments regarding public infrastructure further benefited the Kudamm area, exposing remarkable location advantages and therefore attracting business to a large extent. In 1910 it even represented the most advantaged area in terms of network-based market access. The perceived attractiveness apparently capitalized into land values while agglomeration forces may have led to spillover effects, which at least supported the impressive economic growth within Kudamm3 region until the end of the 1920s.

Fig. 3 Kurfürstendamm vs. Historical CBD

Notes: Indices represent ratios of Kudamm values to the respective values in the historical CBD. Authors` own calculations.

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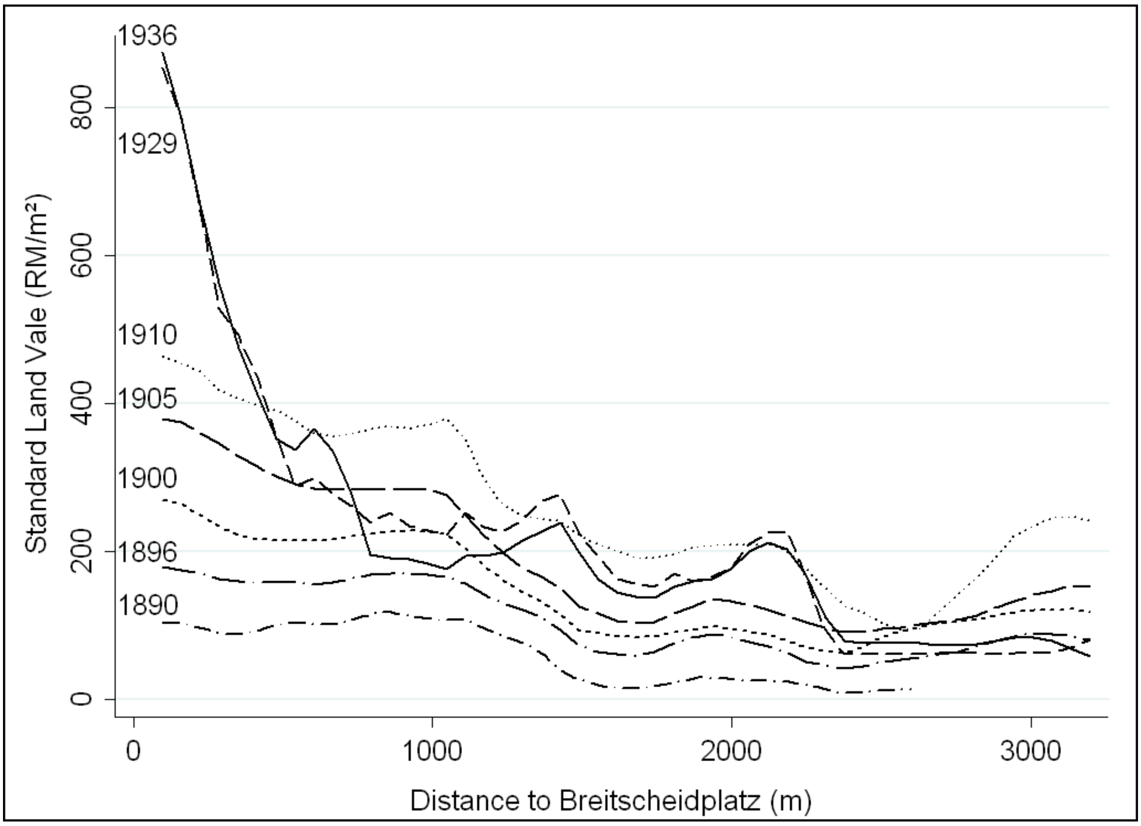
[8] In order to represent the CBDs performance the same strategy was applied as for the representation of sub-centers. The one business block with the best performance regarding its land value and railway potentiality until 1936 was chosen.

Considering land value trends until 1910, which were in line with those for the other major sub-centers, the large investments into connectivity of the Kudamm area are surprising since, intuitively, one would expect the focal node of a transport network within the existing core of economic activity. From the historical center, the other major sub-centers, Hermannplatz and Bernauer Strasse, could also have been connected more easily. However, despite their shorter distance from the historical center, these centers were not connected until the end of the 1920s, almost 30 years after the Kudamm, although metro lines would have run through very densely populated areas. Even the obvious underground line below the traditionally most important retail and commercial boulevard Friedrichstrasse was not developed until the mid 1920s. Anecdotic evidence also shows that the selection of the first metro rail paths was determined exogenously to urban economic development (ERBE, 1987). The extension of preexisting railway tracks took place through widely undeveloped areas, which led to the effect of a perceived increasing attractiveness created by improved accessibility. The declared intention of property developers was to promote further investments and building (BOHM, 1980). Taking together these indications and the evident time lag, it appears more likely that causality runs from accessibility to economic development rather than the other way round.

Over the study period we observe how a former widely undeveloped area unexpectedly became perfectly integrated in the existing public infrastructure network. The good accessibility provided initial location advantages that led to a path-dependent development, which was not reversed by a relative decline in centrality during the 1920s. This is completely in line with theoretical implications that highlight the role of initial advantage and cumulative causation for economic development (see 2.1). Kernel regressions depicted in Figure 4 show how, by 1936, a small sub-center had transformed into a self-sufficient main-center with precise land gradients around the very core. Thus, we provide strong evidence for the roots of Berlin's existing duo-centric structure dating back to the period of urban railway network construction, proving division not to be the causal determinant for its emergence.

Fig. 4 Kernel Smoothed Gradients for Kudamm Area



Notes: Authors` own calculations. Kernel is Epanechnikov.

4.2 Initial Advantage in Market Access, a Micro-Study

From comparison to other major sub-centers and the traditional CBD we know that during the early years of the 20th century the Kudamm area experienced a strong increase in significance, first in terms of market access and connectivity, then also in terms of economic activity reflected in land values. We conduct a detailed analysis on the Kudamm neighborhood in order to reveal whether the mechanisms discussed in the sections above also apply to a micro-level scale. In particular we are interested in whether the new economic core incidentally emerged after economic activity in the neighborhood exceeded a critical mass or if the new center developed around a core that benefited from an initial advantage from the very beginning. We therefore conduct simple difference estimations (8) in order to retrieve indices of relative *PP*, *RPP* and *SLV* for the Kudamm areas 1 and 2 defined in the appendix. Table 1 shows the estimation results, which are visualized in Figure 5.

Note, that our sample is restricted to all business blocks within Kudamm Area 3 and all blocks within Area 1 also belong to Area 2. Estimates therefore yield differences between areas 3 and 2 and areas 2 and 1 respectively.

While in 1875 *PP* already showed a remarkable advantage for area 1, it still did not capitalize into corresponding *SLV*.[9] The continuously decreasing *PP* of area 1 relative to area 3 until 1936 is owed to an rapid population growth within the broader area, which before was unpopulated in most parts. In 1890 land values of Kudamm Area 1 had exceeded Area 2 and Area 3 by 55.7%, which underlines a relatively high attractiveness from the beginning of the Kudamm development. Preceding, the core region had gained an advantage in *RPP* of 112.1% compared to Area 3, following the inauguration of the east-west suburban railway line in 1882 (Stadtbahn).

9 Up until the beginning of the 1880s, most parts of the Kudamm area were still not developed and the land was mainly of agricultural use, which implied marginal land values (BOHM, 1980; MÜLLER, 1881-1910)

Tab. 1 Empirical Results

	(1) Log(SLV)	(2) Log(PP)	(3) Log(RPP)
Kudamm1 x 1871		0.2985*** (3.97)	
Kudamm1 x 1875		0.2834*** (5.52)	-1.2536*** (-5.29)
Kudamm1 x 1880		0.2834*** (3.89)	-1.0913*** (-4.2)
Kudamm1 x 1885		0.2723*** (3.84)	0.5651*** (3.96)
Kudamm1 x 1890	0.4474*** (4.65)	0.2061*** (3.42)	0.5558*** (3.93)
Kudamm1 x 1895/1896	0.3448*** (6.18)	0.1626*** (4.32)	0.4969*** (3.68)
Kudamm1 x 1900	0.5107*** (7.5)	0.1217*** (4.29)	0.1005 (0.85)
Kudamm1 x 1905	0.5274*** (7.37)	0.0888*** (4.49)	0.2338** (2.29)
Kudamm1 x 1910	0.3438*** (5.91)	0.0527*** (4.79)	0.2191** (2.04)
Kudamm1 x 1919		0.0112* (2.93)	0.1644 (1.44)
Kudamm1 x 1925		0.0072 (1.83)	0.1668 (1.46)
Kudamm1 x 1929/1930	0.8022*** (5.82)	0.0035 (1.24)	0.1750 (1.55)
Kudamm1 x 1936	1.080*** (8.11)	-0.0005 (-0.16)	0.1725 (1.52)
Kudamm2 x 1871		0.0402 (0.36)	
Kudamm2 x 1875		0.0365 (0.48)	-0.0379 (-0.22)
Kudamm2 x 1880		0.0368 (0.34)	-0.3335 (-1.18)
Kudamm2 x 1885		0.0417 (0.39)	0.3495*** (3.12)
Kudamm2 x 1890	0.1324 (0.81)	0.0505 (0.55)	0.3390*** (3.06)
Kudamm2 x 1895	0.0822 (0.99)	0.0872* (1.43)	0.2820*** (2.71)
Kudamm2 x 1900	-0.0403 (-0.47)	0.0914** (1.86)	0.5170*** (5.7)
Kudamm2 x 1905	0.0880 (1.01)	0.0963*** (2.53)	0.2561*** (2.85)

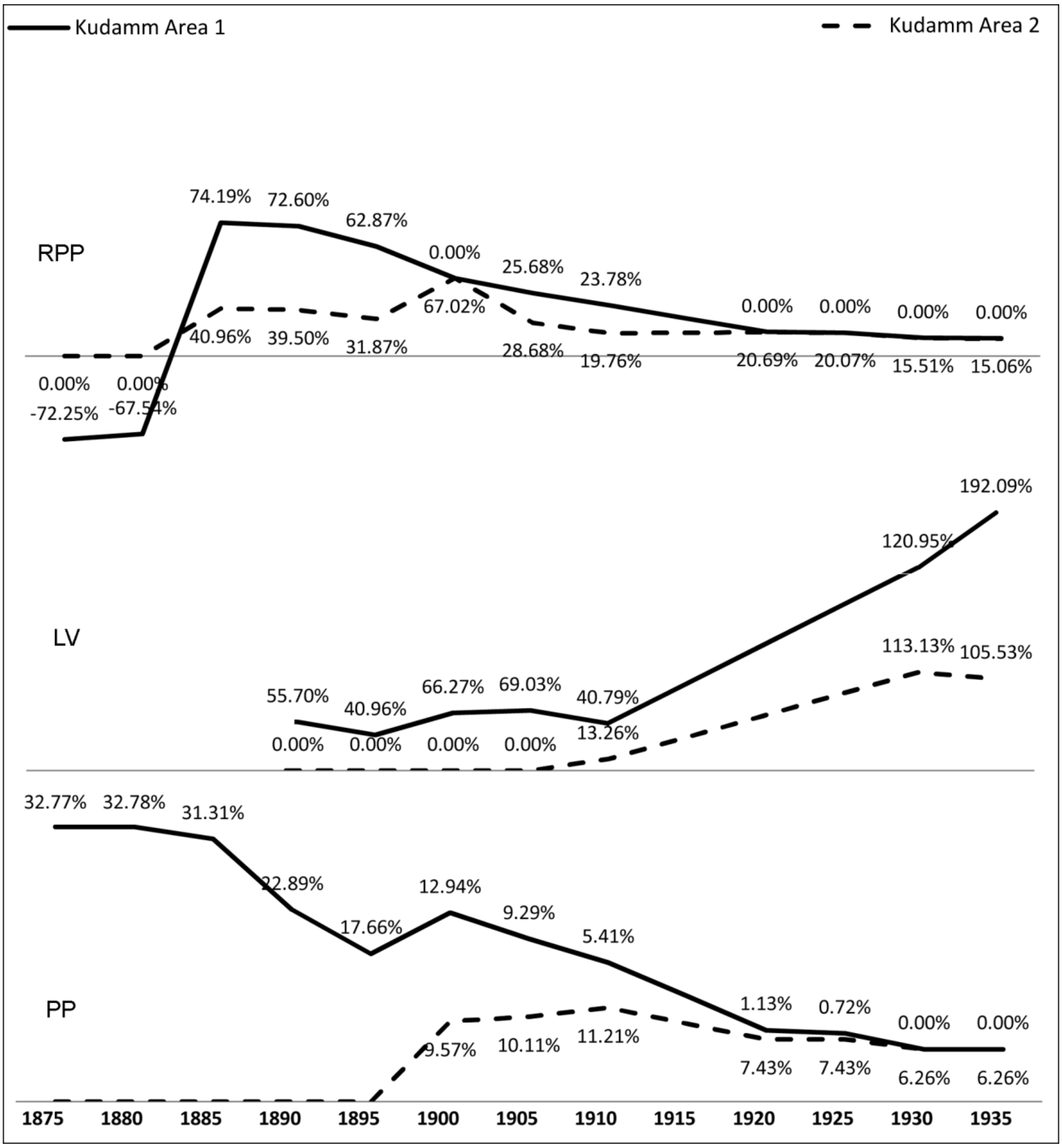
Tab. 1 Empirical Results (Continued)

Kudamm2 x 1910	0.1269* (1.8)	0.1062*** (3.99)	0.1842** (2.09)
Kudamm2 x 1919		0.0716*** (5.68)	0.1917** (2.24)
Kudamm2 x 1925		0.0716*** (6.16)	0.1866** (2.16)
Kudamm2 x 1929/1930	0.7239*** (8.58)	0.0606*** (5.88)	0.1478* (1.73)
Kudamm2 x 1936	3.916*** (27.62)	0.0606*** (6.4)	0.1438* (1.7)
Observations	1109	2254	1932
Sample	Kudamm Area 3	Kudamm Area 3	Kudamm Area 3
R squared	0.5212	0.7766	0.9465

Notes: Endogenous variables in Models (1), (2) and (3) are log of standard land values (*SLV*), log of population potentiality (*PP*) and log of rail population potentiality (*RPP*). *Kudamm1* and *Kudamm2* are dummy variables denoting business blocks within Kudamm Area 1 and Kudamm Area 2 respectively. *1871 – 1936* similarly represent year dummies. Sample is restricted to business blocks within Kudamm Area 3 in all models. All models include a full set of year dummies. T-statistics (in parenthesis) are heteroscedasticity robust. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level.

These results suggest that public infrastructure not only accounts for a big proportion of the whole area's gains, but also considerably contributes to the core region's emergence and growth. It is evident that the remarkable increase in relative land values around the very core from 1910 on follows a period when the area demonstrated the highest *RPP* values not only within its neighborhood, but even compared to the other sub-centers and the CBD (4.1). The simultaneous increase within Area 2 may be attributable to spill-over effects owed to an overall positive and expansive development of that area.

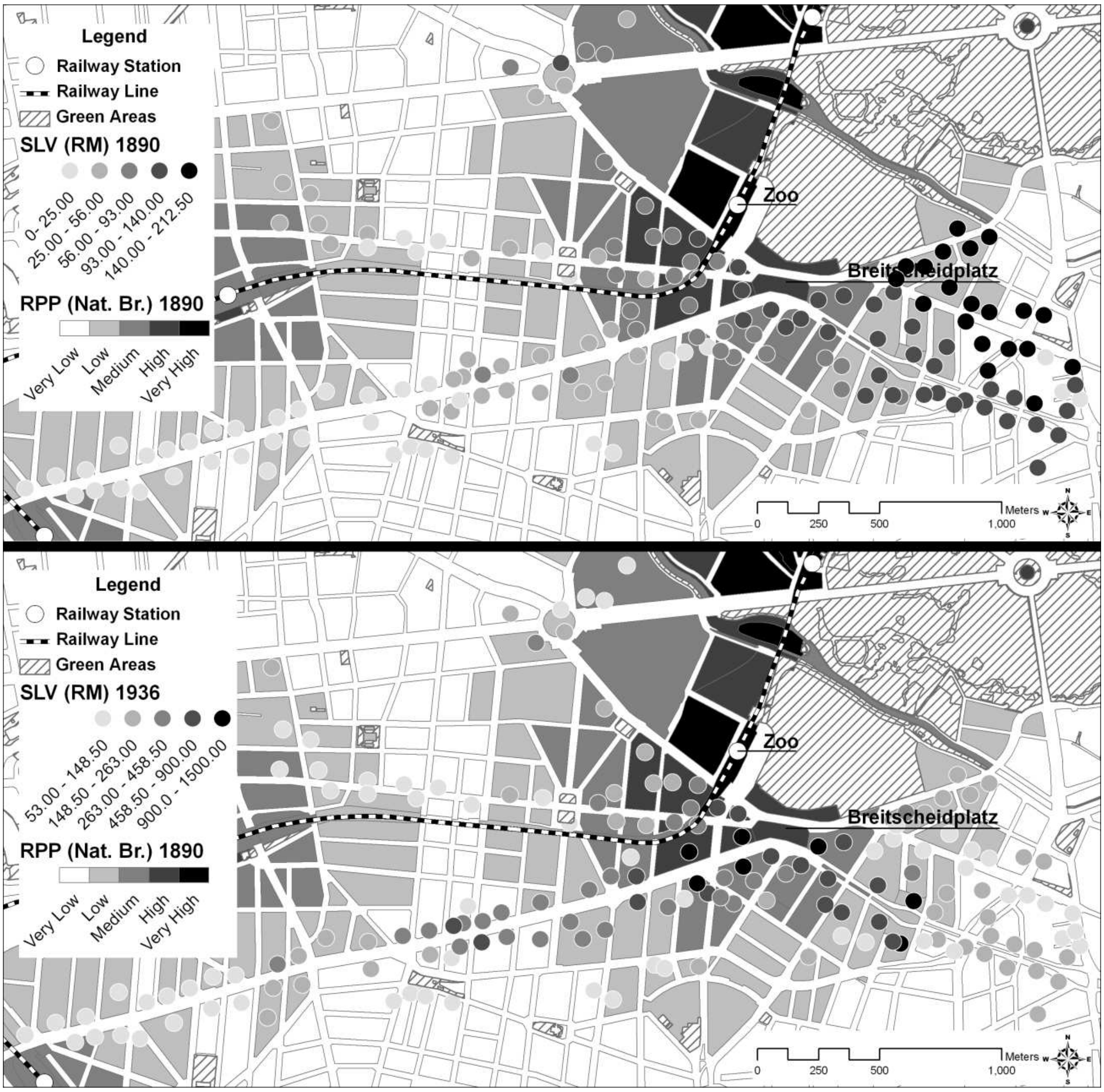
Fig. 5 Micro-Level Market Access and Land Value Development



Notes: Authors` own calculations. Relative development of the indicators *RPP*, *LV*, and *PP* for Kudamm Area 3 against Kudamm Area 2 and Kudamm Area 2 against Kudamm Area 1, respectively.

Figures 6 and 7 stress the role of *RPP* in forming an area of high accessibility and, after some time lag, correspondingly adjusting attractiveness capitalized into land values. Figure 6 compares *SLV* and *RPP* within Kudamm Area 3 for the first (1890) and the last (1936) year for which *SLV* were available. By 1890 a certain pattern of rail accessibility had been formed within the area. However, block values had still not adapted to that. Higher plot prices still were realized along the radials towards the traditional CBD to the east of the Kudamm area (upper picture). Interestingly, in 1936 the highest values had regrouped around the initially better accessible blocks and hence adapted to the previously created pattern.[10] The magnitude of adaption becomes even more evident when looking at Figure 7, which visualizes *SLV* of the whole Kudamm Area 3 in 3D. The height corresponds to the blocks' average *SLV* represented in map units (meter).

Fig. 6 Pattern of Land Valuation 1890 and 1936



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

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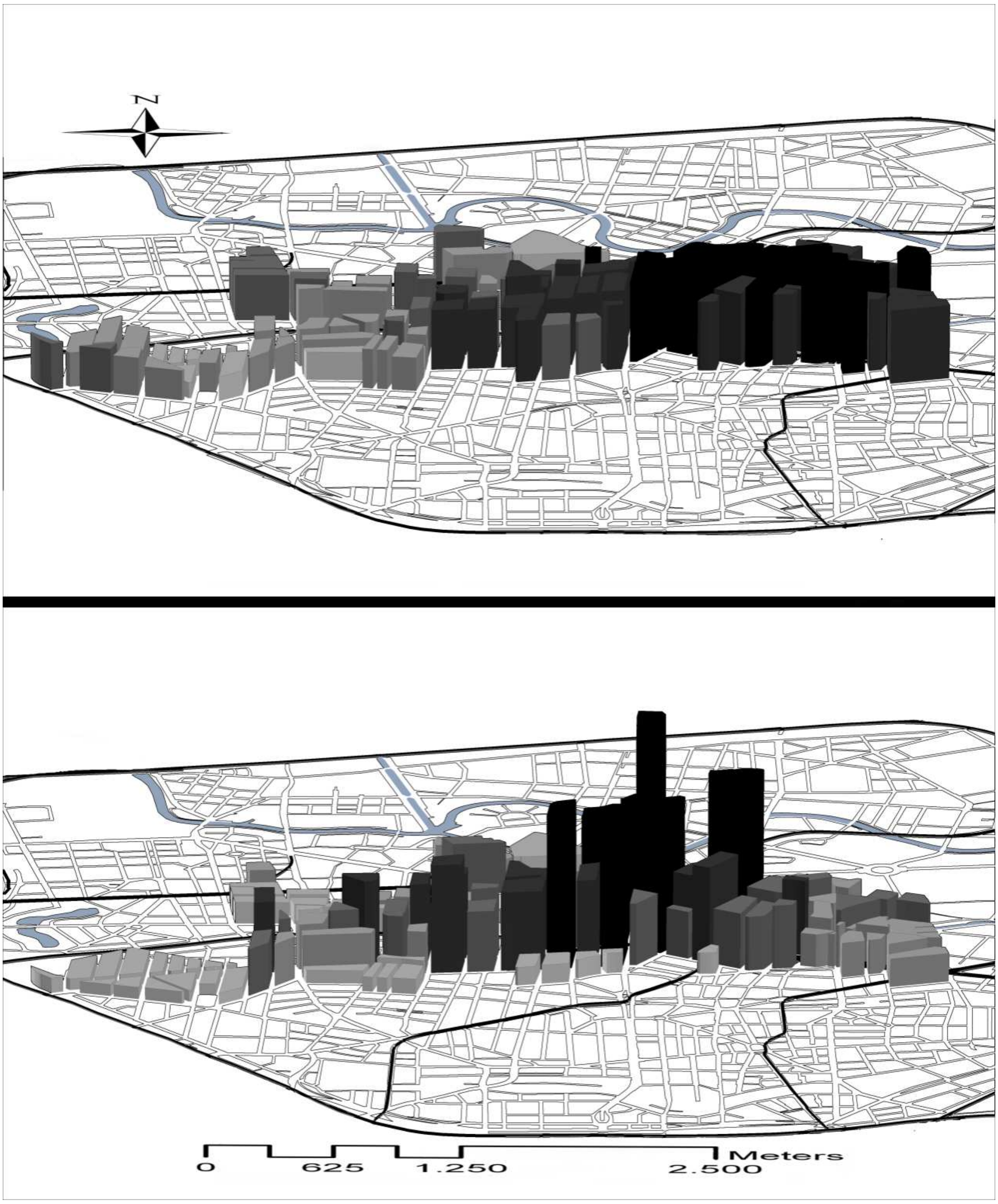
[10] Of course, Breitscheidplatz also exhibited a certain prestige from a town planning perspective. However, Wittenbergplatz, much closer to the high priced areas in 1890, had similar preconditions.

The formerly small sub-center originated at an exposed position within the boundaries shaped by the initial market access advantage. Apparently, owing to this advantage, a core of economic activity emerged around the Breitscheidplatz, which became the center of forces of agglomeration and consolidated its position as a new urban core in the course of typical processes of cumulative causation.

Fig. 7 Block Averaged *SLV* 1910 and 1929



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

5 From Theory to Praxis (Conclusion)

Our study explicitly aims at developing an interdisciplinary perspective on the sustainable development of metropolitan areas. While economists and urban planners evidently pursue the same goals they often miss the opportunity to effectively combine their knowledge. While on one hand we develop our empirical strategy vis-à-vis economic theory, we also try to place our contribution into the context of the existing planning literature in order to enrich the interdisciplinary dialogue and to inform planning and development practitioners.

Combining empirical and theoretical findings of both research areas with results from the case study on Berlin, we conclude that the constant effort to create livable and sustainable urban environments within rapidly growing cities does not necessarily lead to conflicts regarding the exploitation of economics of agglomeration through the creation of dense economic clusters. We propose a concept of *Directed Urban Concentration* as a complementary to existing concepts of mixed use and multifunctional land use, which implies a well-directed combination of decentralized mixed-use areas, densely inhabited downtown areas and highly agglomerated clusters of economic activity.

Since a large proportion of consumption and service facilities represent perfect substitutes and thus are not subject to excessive economies of scale, locating them within or adjacent to residential areas may promisingly reduce lengths of non work-related trips. But within a framework of regular job changes and increasing numbers of two-earner households this strategy might be less successful in reducing the overall length of work-related trip patterns since households are less likely to choose places of residence with respect to decentralized job locations. Therefore, we suggest the efficient concentration of employment in economic cores that are highly accessible by means of public transport as a pragmatic approach towards sustainable urban growth.

Particularly in combination with surrounding densely populated mixed-use areas, we expect the best evolution of agglomeration forces and a switch of the modal split towards decreasing use of automobiles. Our case study links these conceptual ideas to empirical findings in order to verify whether theoretical implications apply to real world settings. Indeed, results strongly indicate that urban economic activity is causally related to accessibility. Therefore, applying these findings to an interdisciplinary urban planning context, we propose the following agenda for a directed urban concentration and a discharge of overburdened CBDs:

First, a suitable area should be identified, exposing special characteristics regarding its design and prestige, like a representative plaza. It must be neither located within existing high-price areas nor too remote, providing several development opportunities. Ideally, the site would also be chosen with respect to the main direction of an ongoing process of urban expansion. Second, it should rapidly become excellently connected to existing railway networks creating accessibility and expectations about the positive prospects of location. An initial accessibility advantage should be provided at the location that is intended to represent the new core area within the economic cluster, e.g. the abovementioned plaza. Cumulative causation and externalities may be expected to spread from that initially developed new core. Third, the development should be promoted by commonly applied development kits such as subsidies and directed land use regulations, aiming at the intended focus the area is to represent. A representative anchor structure characterized by an iconic architecture may also be employed to improve the prestige of the location and to attract tourists and spending.[11]

Leaving much room for further research, our initial contribution aims at opening an interdisciplinary discussion on *Directed Urban Concentration*, which implies a wide range of planning applications combined with a fostered development of public mass transportation.

By suggesting the considered creation of highly accessible multiple urban job agglomerations this concept may further enrich the vivid discussions regarding the

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[11] Recently, planners have considered cultural institutions and sports stadia as anchor structures for urban (re)development, e.g. the Tate Modern extension at the London South Bank, the Elbe Philharmonic Hall within the Hafencity in Hamburg or the Kings Park Stadium at the end of the Golden Mile in Durban (AHLFELDT & MAENNIG, 2008).

sustainable development of metropolises within an environmental framework that tends to faster and faster urbanization processes and literally exploding urban areas.

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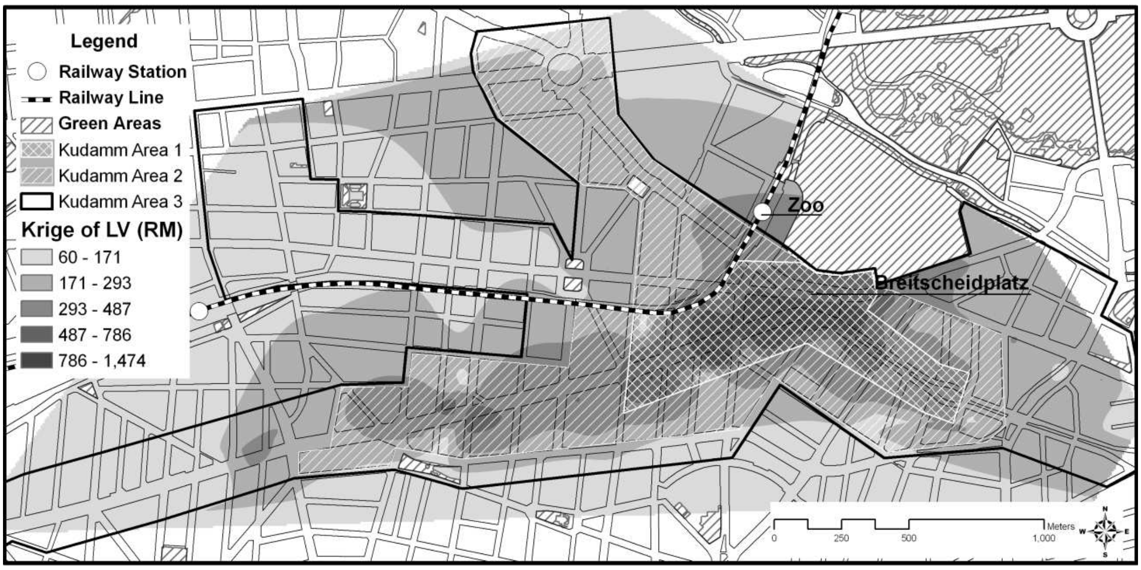
Data Appendix

The data collection and preparation involved various processes. The first step consisted of properly defining the areas of business use for our year of reference in 1936. A detailed map (AUST, 1986), showing the relevant parts of Berlin and indicating the corresponding land use for each built up block, was consulted. The information was extracted by digitally processing the map and assigning the relevant information to Berlin's official block structure of 2006. Standard GIS software was able to provide feasible methods in order to gain reliable results. Consulting historical sources about the economic structure of the city (HOFMEISTER, 1990; LEYDEN, 1933; LIPMANN, 1933; LOUIS, 1936) allowed for feasibly defining three areas, which represent the core regions of economic activity within the research area (figure A1). Due to its spatial and historical significance, the Kaiser-Wilhelm-Gedächtniskirche represents the center of the very core region and, extended about 700 m the east to Wittenbergplatz (location of the KaDeWe) and 700 m to the west, forms Area 1. The second region is also comprised of the highly vivid Hardenbergstrasse towards the Technical University in the north, Olivaer Platz in the west and Nollendorfplatz in the east. The third area is represented by a wider range of what is still considered as belonging to the center and also includes the shopping area along Wilmersdorfer Strasse (Fig. A1).

The corresponding land values had to be collected from two different sources. MÜLLER (1881-1910) provided detailed maps indicating values on block and house level for a wide area of the city's contemporary boundaries. The collected values are restricted to formerly identified business blocks, therefore other land uses and values were excluded, except those that switched to commercial use during the course of our observation. In order to determine a representative land value for each area used for business related purposes, the arithmetic average of all values being located within that area was assigned.

KALWEIT (1928, 1936) chooses a different form to present the data. Based on a complete street index of Berlin, he assigned the minimum and maximum values to each street and therefore provides slightly less detailed data compared to Müller. Since business blocks are assumed to represent a higher value than residential blocks (3.) it can be argued that the indicated maximum values most likely correspond to the respective business blocks. A built up block can also be represented as part of one, or the crossing point of, several streets. Consequently, taking the arithmetic average of the maximum values of all streets involved generated the value of a subject area.

Fig. A1 Definition of Kudamm Areas and Kriged *SLV* 1929



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

This graphic shows, by means of kriging interpolation, commercial land valuation for 1929 as well as the outlines of the three defined Kudamm core areas of economic activity. We chose this year since it represents the overall peak for our research area in terms of economic development. Interpolated land values support the feasibility of core regions definition.