GEOGRAPHY OF A SPORTS METROPOLIS

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Abstract - *This study analyzes the sports infrastructure of Hamburg, Germany, from the residents' perspective. Empirical evidence is provided using a micro-level dataset of 1,319 sports facilities, which is merged with highly disaggregated data on population, socio-demographic characteristics and land values. Based on implicit travel costs, locations' endowment of sports infrastructure is captured by potentiality variables, while accounting for natural and unnatural barriers. Given potential demand, central areas are found to be relatively underprovided with a sports infrastructure compared to peripheral areas where opportunity cost in the form of price of land is lower. The determinants of spatial distribution vary systematically across types of sports facilities. Publicly provided open sports fields and sports halls tend to be concentrated in areas of relatively low income which is in line with their social infrastructure character, emphasized by local authorities. In contrast, there is a clear tendency for market allocated tennis facilities to follow purchasing power. Areas with higher proportions of foreigners are subject to relatively lower provision of a sports infrastructure, which contradicts the stated ambitions of planning authorities*.

Keywords **-** PUBLIC INFRASTRUCTURE, SPORTS FACILITIES, SPORTS GEOGRAPHY

JEL classification: H4, R53

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1. INTRODUCTION

Top-level professional sports teams and mega-sports events represent landmarks for their hometowns and are much appreciated by politicians aiming at establishing identity and improving the image of their hometowns. Large amounts of public money are spent on subsidizing representative sports venues to improve the competitiveness of local teams or to attract mega-sports events and major league franchises. Moreover, in recent years spectacular stadium architecture is employed to maximize attention and to create new visiting cards for their hometowns.[1] Therefore, the impact of large sports stadiums, professional sports teams and mega-sports events has attracted much interest in scholarly debate.

Empirical ex-post studies hardly find evidence for the positive impact of sports teams and events in traditional economic terms of income, employment and taxes, even on a city or metropolitan scale (Baade, 1988; Baade and Dye, 1990; Baade and Sanderson, 1997; Coates and Humphreys, 1999, 2003; Matheson, 2008; Siegfried and Zimbalist, 2006). More recently, empirical studies using more disaggregated data have found positive effects on location desirability for large sports facilities within a range of up to 3 miles (4.8 km) (Ahlfeldt and Maennig, 2008, 2009a; Coates and Humphreys, 2006; Tu, 2005). While large facilities have been the main focus of public debates, attracting the attention of various interest groups, local authorities and neighborhood activists, urban sports geography obviously consists of more than only representative professional sports venues. However, with the exception of Bale (2003), mass sports infrastructure has still found little regard in the empirical scholarly discussion. To our knowledge, no empirical evidence is available on the determinants of the spatial distribution of recreational sports facilities. This is somewhat surprising in light of the widely-acknowledged positive impact of sports on health and physical condition as well as the important role sports plays in integrating socially disadvantaged groups. This paper aims to fill this gap by analyzing a metropolis' sports geography with the full diversity of all officially registered professional, recreational, publicly and privately provided[2] sports facilities.

Public provision of sports infrastructure is exemplary for the provision of social infrastructure within an urban environment. Following a standard market failure argumentation, public provision of sports facilities may be justified by positive external effects, the merit good character and special demands of certain population groups. Moreover, referring to Alonso's (1964) bid-rent theory, providers of sports outlets are likely to be defeated in the competition for central locations due to limited revenues, which, from a social planner perspective, possibly causes underprovision in downtown areas. Our study area covers the whole of Hamburg, Germany, presently Europe's largest non-capital city. In its role as the country's second biggest city and dominating harbor metropolis, it shares some similarities with the French city of Marseille, to which Hamburg is

[1] Ahlfeldt and Maennig (2009c) offer a survey on recent trends in stadium architecture.
[2] Privately provided sport facilities are represented by tennis courts.

connected by a sister-city arrangement for more than half a century. Notably, however, Hamburg's relative nationwide importance compared to the leading capital city is larger than in case of the French counterpart, given that the city features roughly 50% of the population and even 82% of the area compared to Berlin. Moreover, Hamburg represents an ideal candidate for the evaluation of sports infrastructural policy in Germany since local authorities keep up the claim of Hamburg being a "sports metropolis" and should therefore be expected to take particular care of the appropriate allocation of (public) sports infrastructure. This study assesses whether the distribution of sports facilities effectively corresponds to the claims postulated by authorities and whether the outcome of public provision compared to market allocation indeed justifies public provision.

Our research strategy consists of two basic steps. First, we analyze the spatial distribution of sports facilities in Hamburg within a theoretical framework of abstract space. Sports facilities are hierarchically classified by size to test for implications of the Sports Place Theory. Effective catchment areas are defined based on pair-wise distances and compared to theoretical predictions (Bale, 2003). In the second step, we relax the assumptions of plain ground and evenly spread population to account for the obvious reality of natural and unnatural barriers and heterogeneity in population distribution. Employing a standard New Economic Geography concept we calculate the population potentiality representing distance-weighted population relying on effective road distances. Spatial weights are assigned according to previously assessed spatial demand curves. Similarly, sports potentialities are created on the basis of distance-weighted sports facility size. These potentiality variables are employed to identify the determinants of an absolute and relative location endowment with a sports infrastructure. We introduce the concept of potentiality differentials to assess whether market allocated sports infrastructure is concentrated in areas of relatively higher purchasing power and whether local authorities indeed focus on providing infrastructure in socially disadvantaged areas. Land price is also considered in our analysis to capture opportunity cost of sports facility provision in space and to reveal whether it is a less-striking determinant in public compared to profit-orientated provision.

The next section presents our data. In Section 3 we test whether sports infrastructure follows the theoretical predictions assuming an idealized environment. The assumptions of featureless plain and homogeneity in socio-demographic characteristics of population are relaxed in section 4 in order to identify the determinants of locations' absolute and relative endowment with sports infrastructure. The final section concludes.

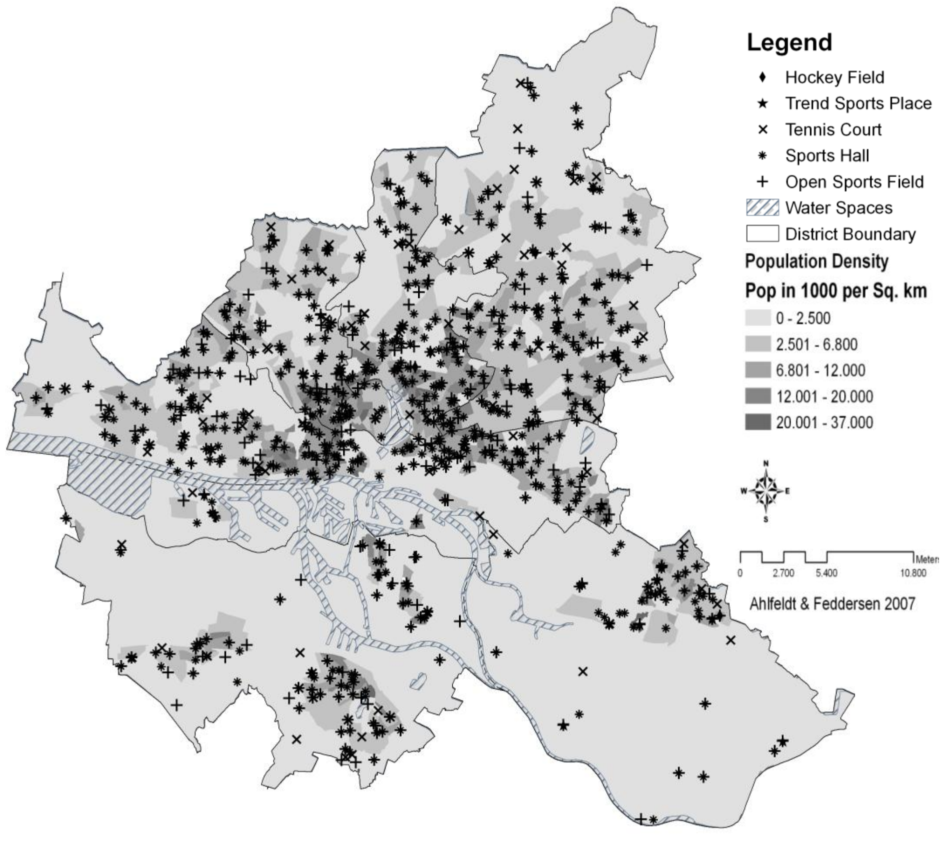
2. DATA

The study area covers the whole of Hamburg, which, on December 31, 2000, had 1,704,929 inhabitants and an area of approximately 755.3km^2. We collect data on 1,319 sports facilities obtained from local authorities (Sports Office of the city of Hamburg), which we georeferenced based on addresses to allow for spatial analysis.

Table 1 : Descriptive statistics: Number and Size of the Sports Facilities (in m²)

	Halls	Fields	Tennis	Field Hockey
N	685	495	122	17
Mean	428.6	8,034.5	5,231.1	15,742.4
Median	362.0	5,570.0	4,507.0	14,200.0
Std. Dev.	305.1	9,331.9	3,794.7	9,156.5
Min	54.0	600.0	144.0	2,100.0
Max	2,880.0	85,119.0	20,000.0	39,220.0

Figure 1 : Spatial Distribution of Sports Places



Note: Own illustration. GIS content provided by the statistical office of Hamburg and Schleswig-Holstein.

We merge data on sports places with data on population, including socio-demographic characteristics on age, income, employment and origin, disaggregated to 940 officially defined statistical areas. To analyze this disaggregated dataset, GIS tools and a projected GIS map of the official statistical area structure (*statistische Gebiete*) are employed enabling generation of impact variables that are discussed in more detail in section 4. Land valuation is captured by standard land values per square meter (*Bodenrichtwerte*) representing aggregated market values based on property transactions within the reporting period. We consider the most recent available data which dates to the end of 1999 (Freie Hansestadt Hamburg, 1999). Data on population and socio-demographic characteristics refer to the end of 2000, with the exception of income, which was only available for 1995.

3. ON PLAIN GROUND

3.1. Sports Place Theory

Bale's (2003) Sports Place Theory builds on Central Place Theory (Christaller, 1933; Lösch, 1940), which is one of geography's most prominent concepts. Derived from the same assumptions of the hierarchical order of central places, rational behavior and abstract space, the Sports Place Theory predicts the location of sports places within an idealized world. While Bale (2003) labels it a "normative model", it arguably better corresponds to a classification scheme then a theory in traditional economic understanding since it does not explain how the predicted spatial equilibrium would emerge out of any decentralized process (Krugman, 1996).

The assumption of abstract space involves a plain, unbounded surface inhabited by an evenly-spread population. On this featureless ground, sports places lie centrally within their catchment areas and provide sports outlets for their hinterlands. Sports places can be classified according to the number of sports provided. While small sports places have small population thresholds and catchment areas, sports places of higher order need larger population thresholds for viability. High-order places thus have larger spheres of influence, are fewer in number and have larger distances between them. The perfect distribution of sports facilities minimizes travel for consumers who wish to have access to the sport they want while ensuring a minimum level of sports places' utilization. Such an ideal pattern is achieved by the hierarchical arrangement of central places of different order (Christaller, 1933). Travel costs are minimized by a lattice formed by a set of nested hexagons where spheres of influences, in contrast to circular spheres, do not overlap (Lösch, 1940). Figure 2 represents the ideal organization of a sports system, the structure of which can be perfectly described by pairwise distances between sports places of the same hierarchies due to perfect symmetry.

3.2. Sports Hierarchies

The demand for sports outlets diminishes with distance due to increasing travel costs. A sports facility's sphere of influence obviously ends where demand is reduced to zero. According to the Sports Place Theory, such a point, where travel cost would become prohibitive, is a potential location for a neighboring sports facility. Conversely, it is possible to infer the effective sphere of influence from pairwise distances for sports facilities of distinct hierarchical order.[3] Considering that higher-order sports places carry out all functions provided by sports places of lower order, we derive spheres of influence derived from pairwise distances to facilities of the same as well as higher classes.

Figure 2. Hierarchical Order of Sports Places in Abstract Space

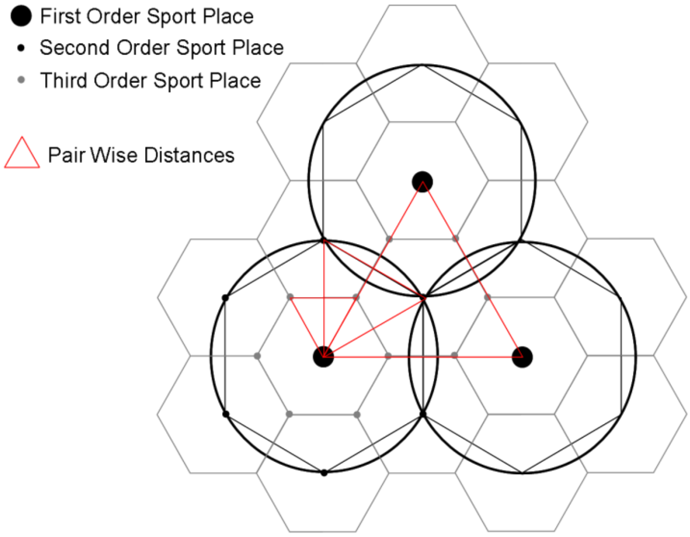


Table 2. Mean Distance to Three Nearest Neighbors (in m)

	Halls	Fields	Tennis	All
All	731	752	2,076	566
Medium & Large	2,994	2,097	2,994	
Large	5,608	5,087	4,965	
Small	767	822	2,076	
Medium	3,442	2,311	3,442	
Incl. Large Field		1,109		
Incl. Grass Field		1,129		
Incl. Athletics		1,173		
Incl. Hockey		4,652		
Incl. Trendy		4,309		
Incl. Hall			2,448	

[3] Assuming pairwise symmetry as in Figure 2, the distribution of central (sports) places is perfectly described by distance to one of six neighbors of the same or higher class. In order to account for the uneven distribution of facilities visible in Figure 1, an averaged distance to six neighboring places would be suggested by the idea of a hexagonal lattice. However, we chose to restrict the number of considered neighbors to three to avoid bias in remote areas.

Bale (2003, p. 86) suggests a sphere of influence of 800m for sports places of the lowest order and approximately 2,000m for medium-size facilities, which is perfectly in line with our findings for open fields. However, we note that both Bale's prediction and our observation contradict the theoretical implication of the hexagonal lattice depicted in Figure 2, which suggests distance between large facilities to be three times that of small ones.

4. RELAXING PLAIN GROUND

The assumption of plain ground and evenly distributed population is unrealistic for most cities and metropolitan areas. For instance, population density is typically higher within downtown areas compared to the urban periphery while within the very urban core land is used almost exclusively for commercial purposes. In the case of Hamburg, there are two additional striking particularities that contradict the assumption of abstract space. First, the rivers Alster and Elbe represent two major natural barriers. Secondly, there is a considerable north-south heterogeneity in the distribution of population. While Hamburg's north accounts for the vast majority of residents, the south is largely occupied by industrial areas. This part of the city also hosts the harbour, which on the list of largest European harbors features one place behind leading Rotterdam and one place ahead of Marseille. Moreover, considerable income disparities across space violate the assumptions of abstract space. The economic wealth of a neighborhood possibly represents a location determinant, in particular for infrastructure provided with the intention to make a profit. Demand for social functions carried out by sports infrastructure depends on a neighborhoods' socio-economic characteristics, which also vary across space and need to be addressed within an appropriate empirical framework.

4.1. Generating Potentialities

In economic geography there is a long tradition dating back to Harris (1954) in representing the market potential by the distance-weighted sum of population. We adopt the idea of spatial aggregation of population and approximate the demand for sports infrastructure by a population potentiality measure. For instance, let P_i be statistical area's i population, then

$$PP_i = \sum_j P_j \exp(-a\ d_{ij}) \qquad (1)$$

is area's i population potentiality (PP_i), where P_j is the population of area j, and a is a distance decay factor determining the spatial weight of surrounding areas. As we relax the assumption of plain ground we define d_{ij} as the effective road distance between areas' i and j geographic centroids. Statistical areas defined by the Hamburg Senate Department differ considerably in size. Thus we employ a basic concept of empirical economic geography (Crafts, 2005; Keeble *et al.*, 1982) to generate an area internal distance measure based on the surface area, which can be used to determine the self-potential.

$$d_{ii} = \frac{1}{3}\sqrt{\frac{Area_i}{\Pi}} \tag{2}$$

where d_{ii} is block's i internal distance equaling one-third of the radius of a circle of block's i surface area ($Area_i$).

The same concept is employed to capture the sports infrastructure. In previous research, locations' endowments have been represented by spatially aggregated surface areas of water bodies, green spaces and retailing centers, which allows for relaxing the assumption of perfect substitutability of location amenities (Ahlfeldt, 2010; Ahlfeldt and Maennig, 2009b). Similarly, we aggregate the surface area of sports facilities given in square meters to obtain an indicator for the spatial supply of a sports infrastructure, taking into account both the size and proximity of all sports facilities within the neighborhood. We define sports potentiality (SP_i) in statistical area i as:

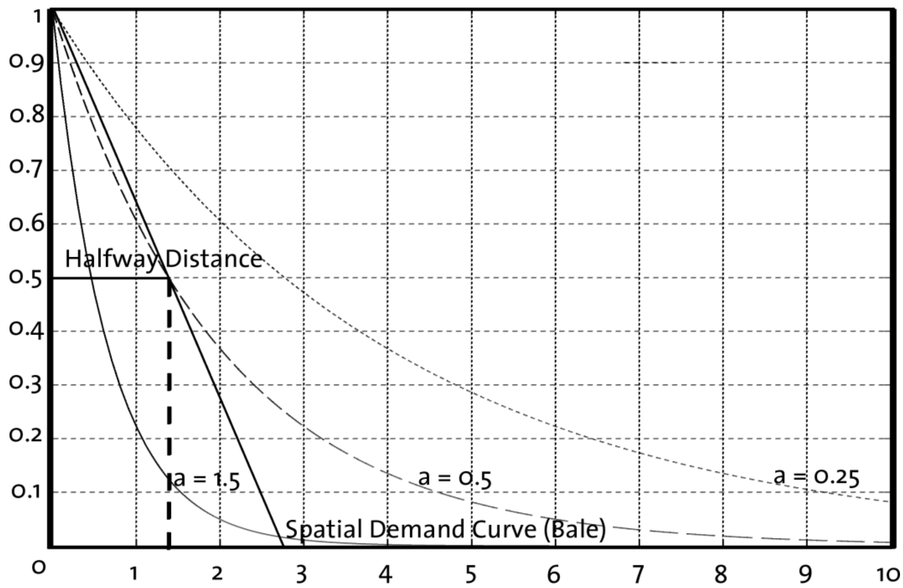
$$SP_i = \sum_j S_j \exp(-a\ d_{ij}) \tag{3}$$

where S_j is the aggregated size of sports facilities in square meters within statistical area j and a and d_{ij} are defined as in equation (1). When aggregating surface areas across distinct types of sports facilities we normalize the surface area by dividing by median values.

The distance-decay parameter in equations (1) and (3) determines the weight with which the surrounding population or sports facilities enter potentialities. In order to account for travel costs, more distant areas are discounted stronger than areas in close proximity. Figure 3 shows the spatial weight functions for distinct parameter values. Larger parameter values imply that surrounding areas are spatially discounted stronger.

The spatial weight functions may be interpreted as spatial demand curves revealing the spheres of influence of sports facility classes defined in section (3.2). Bale (2003) suggests a linear demand curve as represented in Figure 3, which declines with distance to a sports facility located at 0. At the intersection with the x-axis, where travel costs are prohibitive for people living in 0, he predicts the location of another facility. In contrast, we assume an exponential cost function (equations (1) and (3)) since we believe that even at relatively large distances there is some demand remaining due to individual affiliations. We choose decay parameters such that the half-way distances of exponential cost functions equal one-half of the average distance to three nearest neighbors determined in section (3.2) for distinct classes of sports places. At this point, where the exponential function intersects with Bale's (2003) linear demand curve, the implicit spatial demand has decreased by 50%. In this way, we find that the decay parameter of 0.5 represents a feasible approximation for medium-class facilities. Similarly, for small and large facilities, surrounding areas are spatially discounted employing parameter values of 1.5 and 0.25 respectively.

Figure 3. Spatial Weight Functions

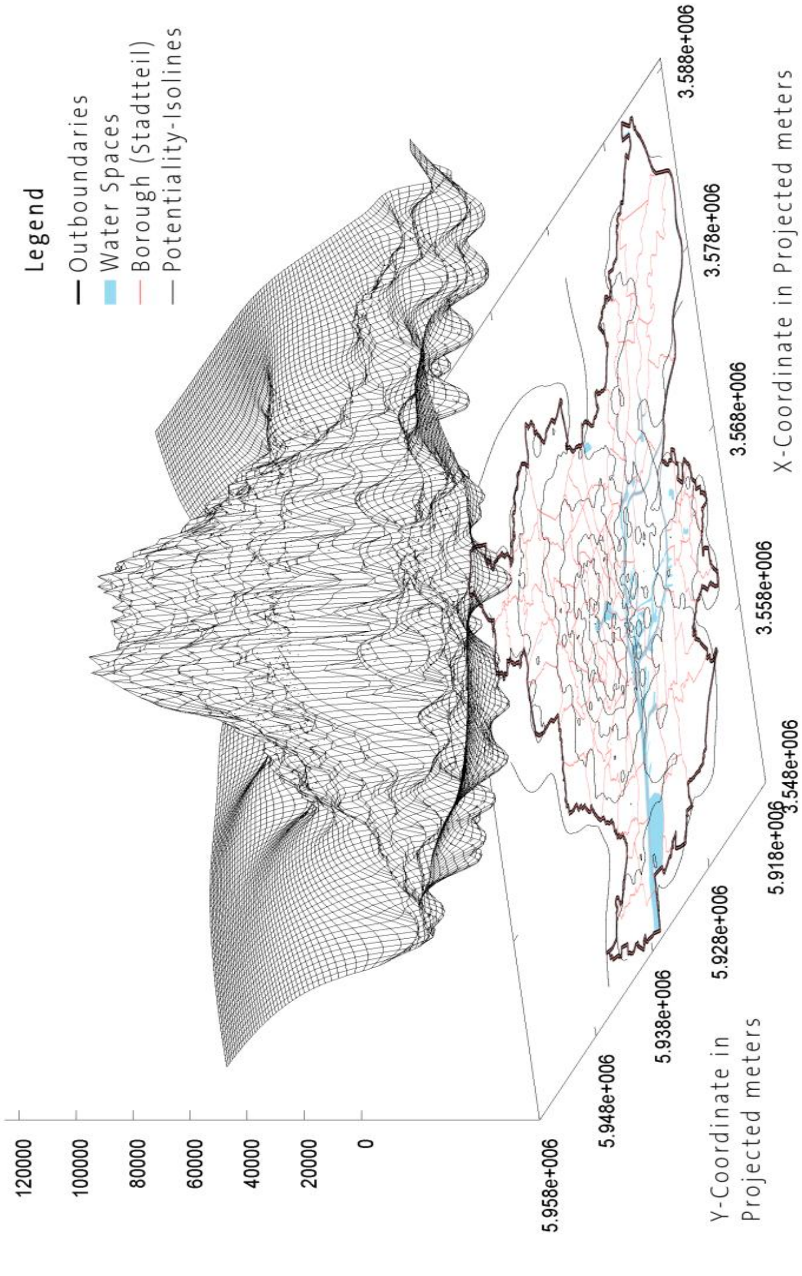


The population potentiality representing the potential group of users should be expected to be a striking determinant for spatial distribution at an intra-urban level since the proximity to population is a major criterion in the planning of publicly funded sports facilities (Ashworth, 1984). In Figure 4 and 5 we plot population and sports potentiality generated on the basis of all officially registered sports facilities in three-dimensional spaces.

Potentialities show a striking similarity, both peaking in downtown areas and steeply descending southwards towards the river Elbe which represents a strong natural barrier separating the densely populated areas to the north from the industrialized south. Although sports potentiality looks slightly more expanded towards the rich westward areas along the riverbank, and despite a small heap in the south east without a counterpart in the population potentiality, these figures clearly suggest that sports infrastructure follows the distribution of population.

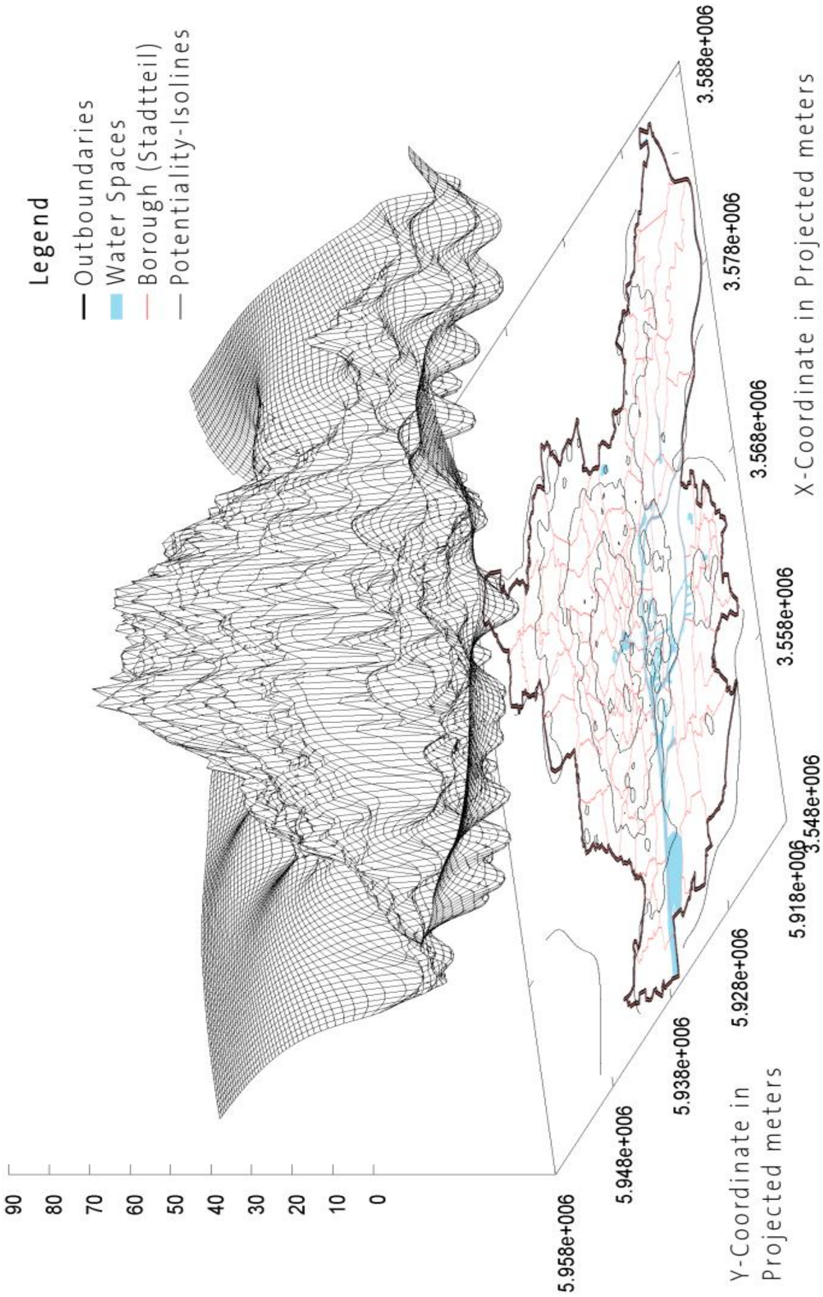
However, particularly for the market allocated sports infrastructure, purchasing power within sports facilities' spheres of influences may be an additional location factor of relevance. We define the purchasing power of statistical area *i* as the product of population and average income. In order to account for residents being mobile across statistical areas, we capture relative economic wealth by the potentiality difference between the current purchasing power at a given location and a counterfactual potentiality using the average income at city level. The purchasing power potentiality difference (PD_i) at location *i* represents the neighborhoods' spatially aggregated purchasing power exceeding what would be predicted if income was evenly distributed across space.

Figure 4. Population Potentiality



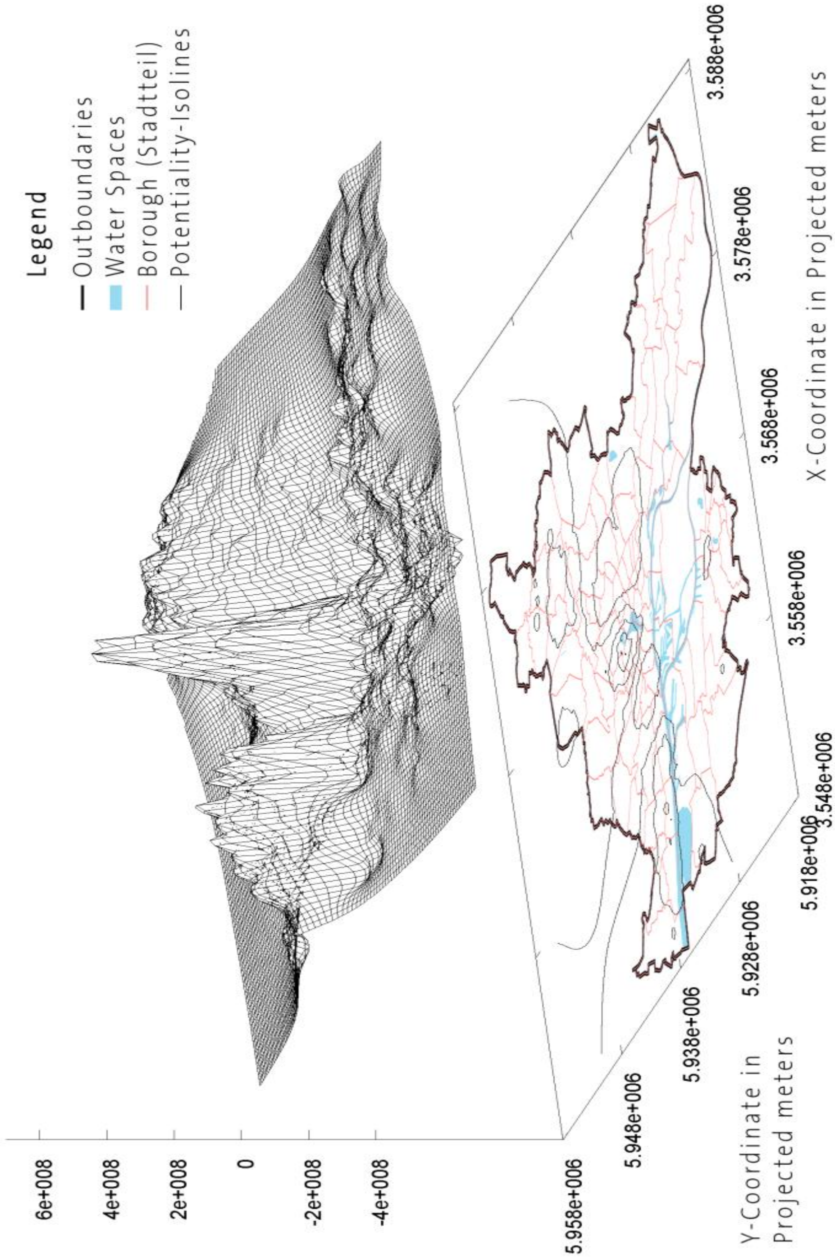
Notes: Figure represents population potentiality as defined in equation (1) employing a decay parameter value of 0.5.

Figure 5. Sports Potentiality (All Facilities)



Notes: Figure represents sports potentiality as defined in equation (3) employing a decay parameter value of 0.5.

Figure 6. Purchasing Power Potentiality Difference



Notes: Figure represents purchasing power potentiality difference as defined in equation (4) employing a decay parameter value of 0.5.

$$PD_i = \sum y_j P_j \exp(-a\ d_{ij}) - \sum \bar{y}_j P_j \exp(-a\ d_{ij}) = \sum \left(y_j - \bar{y}\right) P_j \exp(-ad_{ij}) \quad (4)$$

where y_j is the average per capita income at area j and $\bar{y}$ average income at city level.

According to the current "*Leitfaden*" (code of practice) of the Senate Department, there is special need for supply with social infrastructure in socially disadvantaged areas. Special need is also located in areas with a high concentration of foreigners due to the importance of sports for the process of integration. Similarly, we apply the concept of potentiality difference to the rate of unemployment, which represents a proxy for an area's social evils. The respective potentiality difference for unemployment, hence, indicates whether a neighborhood may be regarded as socially disadvantaged compared to the Hamburg average. Neighborhoods characterized by an above or below proportion of non-German population are represented in the same way.

$$FD_i = \sum F_j \exp(-a\ d_{ij}) - \sum f_j P_j \exp(-a\ d_{ij}) = \sum \left(f_j - \bar{f}\right) P_j \exp(-ad_{ij}) \quad (5)$$

where FD_i is the potentiality difference for foreign population at area i, F_j is the total number of foreigners within area j, f_j is the proportion of foreign population within area j and $\bar{f}$ is the same referring to the Hamburg average.

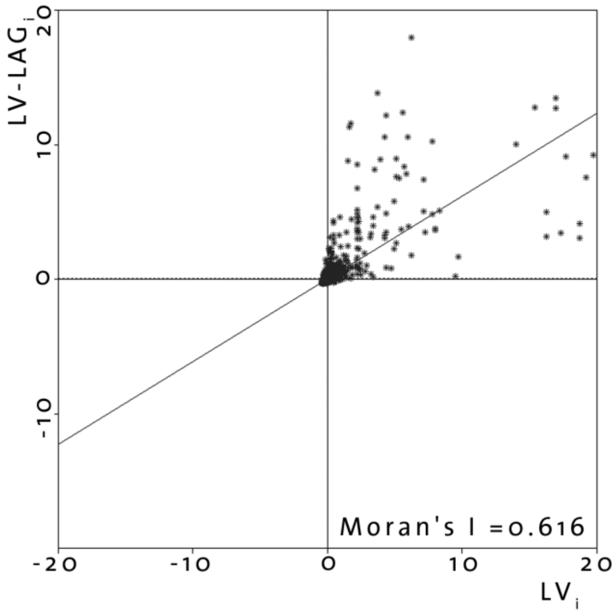
Figure (6) visualizes the purchasing power potentiality difference for Hamburg. Income agglomerations are clearly identifiable along the Elbe riverbank in the western part of the city and at downtown areas in proximity to the inner-city Alster reservoir. Apparently higher-income households are willing to bid out lower-income households at these locations, which highlights the value of these natural amenities. Figure (6) also shows a flatter, although massive heap in the north-east, indicating a large agglomeration of middle-high-income households.

4.2. Empirical Strategy

Two empirical models are estimated in order to identify the determinants of the spatial distribution of sports facilities and to assess whether systematic disparities in the relative provision with sports infrastructure are spatially correlated with neighborhood characteristics.

In model 1 we attempt to identify the major determinants of the distribution of sports facilities. Our model specification explains the sports potentiality as defined in equation (3) by population potentiality, potentiality differences for foreign population and purchasing power and land valuation. The price of land represents planning authorities' opportunity costs of providing public sports facilities. Arguing that sports infrastructure is provided publicly to guarantee demand-orientated allocation, property prices should not systematically influence the distribution of public sports facilities. In contrast, for non-public operators of sports facilities competing for locations on real estate markets, land price is expected to be of particular relevance since the provision and operation of sports facilities is land intensive and revenues generated by non-professional sports are limited. Since there is typically a high spatial correlation between land value at a given location and neighboring locations, we do not average land value in order to obtain representative values for the neighborhood. Figure 7 represents the Moran's I scatter plot for our land price data. There is a clearly positive relationship between current land values and spatially weighted averages revealing the typical spillover effects in real estate markets.[4]

Figure 7. Morans's I Plot



Model 1 specification thus takes following form :

$$SP_i = \alpha + \beta_1 PP_i + \beta_2 PD_i + \beta_3 FD_i + \beta_4 LV_i + \varepsilon \qquad (6)$$

where SP_i, PP_i, PD_i and FD_i are defined as in equations (1) - (5), LV_i is mean standard land value for area *i*, α and β_1 to β_4 represent coefficients to be estimated and ε is an error term.[5]

While model 1 identifies determinants for the effective distribution of sports facilities, model 2 focuses on areas' relative endowments with sports infrastructure. We create an index of sports infrastructure (*ISI*) on the basis of

[4] Spatially weighted lags are calculated using inverse distance weights and considering three nearest neighbors. This specification was proposed by Can and Megbolugbe (1997) and proved to be efficient (Ahlfeldt and Maennig, 2008).

[5] Due to problems of multicollinearity, the potentiality difference for unemployment is not included into our baseline model specification.

the ratio of sports potentiality to population potentiality, which we regress on a set of attributes capturing areas' socio-demographic and location characteristics.

$$ISI_i = \alpha + \beta_1 \frac{y_i}{\overline{y}} + \beta_2 u_i + \beta_3 uyouth_i + \beta_4 f_i + crime_i + POP_i a + LV_i + \varpi \qquad (7)$$

ISI_i is the ratio of sports to population potentiality for area i and y_j, $\overline{y}$, f_i and LV_i are defined as in equation (1) - (5). u_i is the rate of unemployment within area i, $uyouth_i$ is the same for 15 to 25-year-olds, $crime_i$ is the number of crimes committed per capita within area i and POP_i is a vector of residents' proportions of age groups.

Besides serving as a robustness check for model 1 results, this specification allows for considering the age structure of the residential population and additional attributes due to less problems of multicollinearity. Furthermore, results allow for defining priorities in the planning agenda by providing recommendations on how to achieve policy objectives like e.g. the integration of foreigners by means of a sports infrastructural policy.

4.3. Empirical Results

4.3.1. Absolute Endowment with Sports Infrastructure

The empirical results corresponding to model 1 are represented in Table 3 to Table 5. First, we estimate equation (6) based upon the entire sample of all 1,319 sports facilities. Second, we divide the sample into several subsamples to get a differentiated glance on different types and classes of sports facilities. Therefore, sports facilities are differentiated by their size into small, medium and big facilities (Table 4). To create another view, we separate sports facilities according to their use. Thus, they are classified as sports fields (e.g. soccer, field hockey, athletic sports), halls (e.g. team handball, basketball, volleyball, gymnastics) and tennis courts. As the concept of potentialities derived from equations (1) to (5) is relatively abstract, we desist from interpreting the magnitude of estimated coefficients. We are mainly interested in the signs and significance levels of the coefficients since these allow for a qualitative interpretation.

Table 3. Empirical Results I (All Facilities, Model 1)

	Coef.	t-stat
C	5.1890 ***	17.874
PP	$6.97e^{-4}$ ***	133.994
FD	$-7.11e^{-4}$ ***	-8.873
PD	$-2.46e^{-9}$ ***	-2.878
LV	$1.17e^{-4}$ ***	1.952
R²	0.962	
adj. R²	0.962	
F-stat	5,498***	

*Notes: *** p<0.01, ** p<0.05, * p<0.10.*

Table 3 shows a good overall fit of the model. The R² and the adjusted R² exceed a value of 0.96 and the F-statistic is significant at the 1%-level. All coefficients are significant at the 1%-level except the coefficient of the land value (*LV*).

First, it is notable that the coefficient of the population potentiality is positive and highly significant, meaning that sports facilities are not evenly allocated across space. After relaxing the idea of a plain ground it is fair to state that the supply of sports facilities follows the demand deduced from the population potential. The significantly negative sign of the foreigner potentiality difference indicates that neighborhoods with a relatively higher proportion of non-German population are characterized by a lower supply of sports facilities. The same conclusion holds for the purchasing power potentiality difference. Areas with a higher relative purchasing power have lesser sports infrastructure potentiality, maybe indicating different preferences for a local mix of public goods and eventually the existence of lobbying. The significantly positive sign of the coefficient on *LV* implies that sports facilities are relatively concentrated in areas with higher land values. This might be interpreted as a sign of local governments ignoring the opportunity cost of sports facilities supply and hence a considerable divergence from the expected market solution.

A look at the subsamples confirms the findings with respect to the population potential. The according coefficients are all positive and highly significant. Also, an interesting pattern can be found for the purchasing power potentiality difference. Distinguishing between the size of facilities and forms of sports, a positive relation with purchasing power is only found for tennis, which is generally known as an upper-class sport. Accordingly, tennis courts are located in particularly wealthy areas.

Table 4. Empirical Results II (Subsamples, Model 1)

	Large Facilities		Medium Facilities		Small Facilities	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
C	0.8050 ***	3.606	2.2960 ***	12.990	0.8370 ***	9.117
PP	$2.59e^{-4}$ ***	64.927	$1.09e^{-4}$ ***	34.337	$4.52e^{-5}$ ***	27.480
FD	$-9.43e^{-4}$ ***	-15.303	$1.03e^{-4}$ **	2.105	$5.90e^{-5}$ **	2.326
PD	$-1.22e^{-9}$ *	-1.853	$-2.74e^{-9}$ ***	-5.279	$-7.71e^{-10}$ ***	-2.855
LV	$2.53e^{-4}$ ***	5.506	$-1.67e^{-5}$ *	-0.458	$-9.82e^{-5}$ ***	-5.195
R²	0.842		0.672		0.557	
adj. R²	0.841		0.671		0.554	
F-stat	1,160.376***		445.633***		272.959***	

*Notes: *** p<0.01, ** p<0.05, * p<0.10.*

The results for the impact of land value on the sports facility supply are heterogeneous. Hence, economic constraints do not seem to represent the major driving force for the public allocation of sports infrastructure. While this result confirms our expectation, some more interesting patterns are evident: Large sports fields are characterized by an extensive land use. Thus, the opportunity cost of provision is highest in absolute terms for these kinds of sports facilities, which provides a feasible explanation for large sports fields being located in areas with lower land value.

Table 5 : Empirical Results III (Subsamples, Model 1)

	Fields		Halls		Tennis	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
C	21,562.260 ***	18.220	452.696 ***	5.953	3,875.667 ***	14.042
PP	1.699 ***	80.192	0.157 ***	115.616	0.243 ***	49.144
FD	-6.009 ***	-18.390	0.169 ***	8.065	-1.055 ***	-13.841
PD	-2.57e-5 ***	-7.380	-1.55e-7	-0.691	8.70e-6 ***	10.722
LV	-0.474 *	-1.948	0.074 ***	4.730	0.027	0.482
R^2	0.890		0.956		0.745	
adj. R^2	0.889		0.956		0.744	
F-stat	1758.584		4760.051		635.949	

*Notes: *** p<0.01, ** p<0.05, * p<0.10.*

Evidently, the highest coefficient of determination is found for large facilities, possibly indicating that this kind of sports facility is allocated by the local government after particularly careful evaluation. This is not surprising, since large facilities also fulfill the function of small and medium facilities and require the largest commitment of public funds.

4.3.2. Relative Endowment with Sports Infrastructure

From model 1 results, population potentiality seems to be one of the major determinants that are explicitly or implicitly taken into account by urban planners for the allocation of sports facilities. This can be attested by taking a glance at Figure 3 and 4. Both potentialities look very similar suggesting a high correlation between population and sports potentiality. This assumption – as shown above – is supported by the fact that the variable population potentiality (PP) is positive and highly significant in all regressions of model 1. However, as described in section (4.2), model 1 only identifies the determinants for the effective distribution of sports facilities. No conclusions about the relative spatial endowment with sports infrastructure can be drawn from model 1 results.

Figure 8 plots the ratio of sports to population potentiality (ISI) to illustrate the relative provision with sports infrastructure for the 940 statistical areas in Hamburg.

The map provides an intuitive illustration of areas with a disproportionately good and disproportionately poor availability of sports facilities in terms of standard deviations from the mean value. Shaded arrays mark areas with an *ISI* below average and plain arrays mark statistical areas with an *ISI* above average, while the degree of shading indicates the level of variation from a standard deviation of zero in both directions. When compared to Figure 5, the advantages of this presentation become evident. A naive view of Figure 5 suggests that the centre of the city is well-equipped with a sports infrastructure. In contrast, Figure 8 reveals that the high-populated areas in the city center – in spite of high provision in absolute terms – are poorly endowed with a sports infrastructure taking into account the large potential demand. A similar pattern is found for some of the (highly populated) subcenters like "Harburg" in the south and "Bergedorf" in the south-east. In contrast, the wealthy area of "Blankenese", on the western riverbank of the Elbe, as well as the also wealthy but lower-populated areas in the north of Hamburg can be regarded as disproportionately highly endowed areas. Moreover, some low-populated areas display an above average endowment, which might be attributable to the federal structure of the city of Hamburg, where delegates of the parliament of the city have to be (re-)elected by the voters of the district in which they are nominated.[6] Lobbying processes may explain a disproportionately high infrastructural endowment in peripheral areas since, in federal structures, small administrative units typically receive a relatively large proportion of delegates in the parliament and, hence, bargaining power (Knight, 2008). In addition, relative overprovision in peripheral areas is potentially amplified by the indivisibility of sports facilities.

Some quick recommendations might be derived from Figure 8. In spite of a high sports potentiality in the city center the urban planner should – regarding the high-population potentiality in these areas – enforce her effort in building sports facilities there. However, besides the mere provision of sports infrastructure with respect to potential demand, one may also ask whether the (urban) social planner is doing a good job with respect to other stated social policy objectives. In other words: Besides the absolute determinants of the spatial distribution of sports infrastructure, what determines the relative endowment of statistical areas with sports facilities within the city of Hamburg?

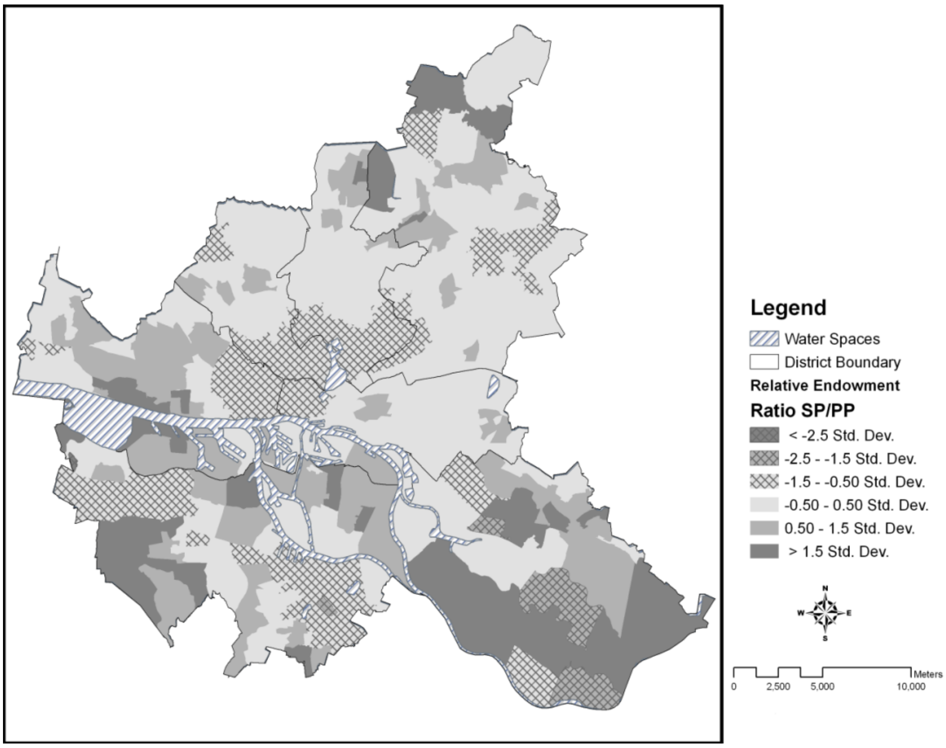
In order to address this question, we estimate the effect of socio-demographic factors and opportunity costs on the ratio of total sports to population potentiality according to model 2 (Table 6). We repeat the estimates, considering only private tennis clubs, in order to identify possible differences between public and private sports facilities (Table 7).

The economic wealth of a statistical area, again, does not have a positive impact on the provision of sports infrastructure as the coefficient of relative income is not statistically significant, neither in variant (a) nor in variant (b). This supports the results of model 1, where the purchasing power potentiality difference is either negative significant or insignificant (see Table 3 to 5). Also the overall unemployment as well as unemployment among adolescents exhibits no significant effect. The different age groups – besides the group of 21 to 45-year-olds – also have insignificant coefficients indicating no evidence for systematic under- or overprovision of a sports facilities. Areas with a higher crime

[6] The city of Hamburg represents one of the 16 federal states of the Federal Republic of Germany and is divided into 7 districts and 105 districts on the administrative level.

rate show an above average relative endowment of sports facilities. The crime indicator probably captures effects related to social disadvantages, thereby also explaining why unemployment indicators are not statistically significant at conventional levels.

Figure 8. Ratio of Sports and Population Potentiality



Note: Own illustration. GIS content provided by the statistical office of Hamburg and Schleswig-Holstein.

Table 6 shows significantly negative coefficients for the proportion of foreign population, the proportion of middle-aged people (age group 21-45) as well as the land value. An evident common feature of these three variables is that they have higher values in the city center and lower values within peripheral areas. Therefore, the relatively low provision of sports infrastructure could be erroneously attributed, e.g. to discrimination of foreign and middle-aged people instead of extensive land use of sports facilities, which complicates provision in densely developed and populated areas. We are possible only observing an effect of urban densification in statistical areas with high proportion of foreigners, middle-aged people and with high land values.

In order to disentangle the effects of urban centrality from those of land value and the proportion of the respective population groups, we include in variant (b) of model 1 the effective road distance (in km) from a statistical areas' centroid to the central business district (indicated by the location of the town hall).[7] The implicit assumption which is in line with standard urban economic models (Alonso, 1964; Mills, 1969; Muth, 1969) as well as the monocentric reality in Hamburg is that the density of development decreases with distance to the urban core. Indeed, we find an inverse gradient of relative sports facility provision, which renders the three discussed variables insignificant and supports the hypothesis of an urban densification effect.

Table 6. Empirical Results IV (All Facilities, Model 2)

	(a)		(b)	
	Coef.	t-stat	Coef.	t-stat
Constant	$1.50e^{-3}$ ***	4.139	$1.17e^{-3}$ ***	3.341
Relative Income	$1.51e^{-8}$	0.153	$5.28e^{-8}$	0.555
Rate of Unemployment (overall)	$-2.58e^{-6}$	-0.977	$-1.24e^{-7}$	-0.048
Rate of Unemployment (youth)	$-1.75e^{-7}$	-0.068	$-1.59e^{-6}$	-0.639
Proportion of Foreign Population	$-1.56e^{-6}$ ***	-3.424	$-1.44e^{-7}$	-0.310
Committed Crime per Capita	$3.26e^{-5}$ **	2.791	$3.35e^{-5}$ ***	2.989
Proportion of Age Group (6y-10y)	$-9.69e^{-6}$	-1.227	$-1.28e^{-5}$	-1.685
Proportion of Age Group (10y-15y)	$2.55e^{-6}$	0.407	$1.79e^{-6}$	0.297
Proportion of Age Group (15y-21y)	$3.89e^{-6}$	0.913	$4.04e^{-7}$	0.098
Proportion of Age Group (21y-45y)	$-1.02e^{-5}$ ***	-2.706	$-6.78e^{-6}$ *	-1.853
Proportion of Age Group (45y-65y)	$-5.74e^{-6}$	-1.572	$-3.27e^{-6}$	-0.931
Proportion of Age Group (65y+)	$-4.79e^{-6}$	-1.297	$-3.10e^{-6}$	-0.871
Land value	$-5.52e^{-9}$ **	-2.259	$-3.22e^{-9}$	-1.365
Road Distance to CBD			$-9.52e^{-6}$ ***	8.533
R^2	0.242		0.302	
adj. R^2	0.231		0.291	
F-stat	22.562***		28.189***	
N	862		862	

*Notes: *** p<0.01, ** p<0.05, * p<0.10.*

In light of these findings, caution is recommendable before reproaching the urban planner for discrimination of, for example, foreigners. But nevertheless, high-priced areas or areas with a high proportion of e.g. foreign or middle-aged people are effectively underprovided with sports infrastructure. Given the stated policy objectives the urban densification effect provides only an explanation, but not an exculpation for this deficiency. If sport is a tool for urban planners or politicians to encourage the social integration of foreigners, then – based on the results of model 2 – we recommend boosting endeavors to improve the endowment of sports infrastructure in these particular areas.

[7] Due to the abstract nature of this variable, simple straight-line distances to the city center appear plausible. However, in this case the geographic particularities of the study area described in the data section make it inevitable to use a more precise indicator of urban centrality.

Comparison of Table 6 to Table 7 results yields similarities as well as differences. First, the rate of unemployment among adolescents and most age groups are, again, insignificant. Second, in contrast to the results for the sample of all facilities, the proportion of older people (65 plus) is significantly negative even though only at the 10%-level. Also, differing from Table 6, the number of crimes committed per capita shows no significant impact for the subsample "tennis courts".

Table 7. Empirical Results V (Subsample: Tennis, Model 2)

	(a)		(b)	
	Coef.	t-stat	Coef.	t-stat
Constant	1.1650 ***	2.739	0.8490 **	2.037
Relative Income	$3.77e^{-4}$ ***	3.251	$4.13e^{-4}$ ***	3.653
Rate of Unemployment (overall)	-0.0060 **	-2.010	-0.0040	-1.277
Rate of Unemployment (youth)	-0.0020	-0.751	-0.0040	-1.226
Proportion of Foreign Population	-0.0020 ***	-3.780	-0.0010	-1.199
Committed Crime per Capita	0.0030	0.183	$3.40e^{-3}$	0.255
Proportion of Age Group (6y-10y)	-0.0030	-0.320	-0.0060	-0.656
Proportion of Age Group (10y-15y)	-0.0100	-1.427	-0.0110	-1.567
Proportion of Age Group (15y-21y)	$-1.15e^{-5}$	-0.002	-0.0030	-0.684
Proportion of Age Group (21y-45y)	-0.0120 ***	-2.621	-0.0080 *	-1.912
Proportion of Age Group (45y-65y)	-0.0060	-1.442	-0.0040	-0.913
Proportion of Age Group (65+y)	-0.0070 *	-1.663	-0.0060	-1.320
Land value	$-7.07e^{-6}$ **	-2.465	$-4.87e^{-6}$ *	-1.733
Road Distance to CBD			-0.0090 ***	6.858
R²	0.245		0.284	
adj. R²	0.234		0.273	
F-stat	22.921		25.922	
N	862		862	

*Note : *** p<0.01, ** p<0.05, * p<0.10.*

The most striking distinction of the results derived for all facilities is the positive and significant coefficient of *Relative Income*. While the findings for all facilities suggest that income plays no role for the relative endowment of a sports infrastructure, statistical areas characterized by higher relative income show higher relative endowments with tennis facilities than areas with relative poor inhabitants. This result is in line with intuition as tennis is still typically representative of a mainly upper-class sport. Thus, it is not surprising that most of the (privately provided) tennis infrastructure is agglomerated in relatively rich areas of Hamburg.

As in model 1, some variables capturing socio-demographic characteristics (foreign and middle-aged people, high rate of overall unemployment, and high land values) of population groups that cluster within densely developed downtown areas are negative significant in variant (a). Again, the hypothesis of explicit discrimination of individual groups of the population might be rejected in favor of an urban densification effect. The inclusion of road distance to CBD as a control leads to the respective variables becoming almost insignificant.[8] However, these findings – analogous to the previous results – suggest a significant bias in the allocation of tennis courts, which violates the objective of socially equal provision. Obviously, in favor of the planner, the same mitigating circumstances apply as in the previous case. Moreover, the vast majority of tennis facilities are provided privately, providing some exculpation for the planner.

5. CONCLUSION

This paper contributes to the empirical literature on the location of public infrastructure, especially sports facilities. It also adds to the sports economics/geography literature as it serves an academic analysis of mass and recreational sports infrastructure where, so far, only studies analyzing the economic effects of stadiums and arenas used for professional sports have been available. In a first step, assuming plain ground and evenly distributed population, we analyze the spheres of influence of recreational sports facilities based on the theoretical considerations of Bale (2003). Presuming a hierarchical order of sports places in abstract space (small, medium, and larger-sized facilities) we provide the first empirical evidence for Bale’s (2003) theoretical predictions. Our results suggest a sphere of influence of 752m corresponding to small sports fields and 2,092m for medium-size fields respectively. These estimates closely match Bale’s (2003) predictions for low (800m) and medium (2000m) order facilities.

In the next step we relax the assumption of plain ground and evenly spread population by applying a standard (New) Economic Geography concept, the distance-weighted potentiality. Based on effective road distances, which account for major natural barriers within the city boundaries of Hamburg (rivers Elbe and Alster), and using distance decay parameters derived from the effective distribution of sports facilities, we identified the determinants of sports facility allocation. The major findings are that: (1) the urban planner follows population potentiality while locating the sports infrastructure; (2) areas with a disproportionately high foreigner potentiality have lower access to recreational sports facilities, and (3) neighborhoods’ purchasing power exhibits negligible or negative impact on the overall endowment with a sports infrastructure, i.e. publicly provided sports facilities qualify as social infrastructure.

Third, we analyzed the relative endowment of a sports infrastructure within the framework of 940 official statistical areas. Using an index of sports infrastructure (*ISI*) –the ratio of the sports potentiality and the population poten-

[8] In the case of the variable *Proportion of Age Group (21-45y)* the coefficient is significant at the 1%-level in variant (a) and becomes significant only at the 10%-level after inclusion of the distance to the CBD in variant (b).

tiality – the previous findings from the analysis of absolute supply with sports infrastructure were generally confirmed. In addition, the econometric analysis of the *ISI* revealed some socio-demographic determinants of the relative endowment of statistical areas. One of the main findings of model 2 estimations is that – in line with the results of model 1 – purchasing power is not significant for the sample of all sports facilities while it is significant and positive for the tennis sample. Given that tennis facilities are largely privately provided, we conclude that there is a significant difference in the spatial allocation between privately and publicly provided (sports) infrastructure. It can be conjectured that market-oriented providers of sports facilities follow purchasing power and, hence, the customers while providers of public sports facilities follow the population and, hence, the voters.

Another major finding of this paper is the apparent discrimination of some social groups like non-Germans in terms of access to recreational sports facilities. However, this reproach should be weakened since the relatively adverse endowment with infrastructure is at least partially attributable to an urban densification effect, which complicates provision within downtown areas. But nevertheless, if the stated objective of social integration of the foreign population by means of mass sports activities is taken for serious, then boosting endeavors to improve the endowment with a sports infrastructure in the respective downtown areas is strongly recommendable.

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LA LOCALISATION DES INSTALLATIONS SPORTIVES DANS LA MÉTROPOLE DE HAMBOURG

Résumé - *Cet article étudie la localisation des infrastructures sportives dans la ville de Hambourg, en s'appuyant sur une base de données de 1319 installations. Il montre, dans un premier temps, que les quartiers centraux sont, de façon générale, relativement dépourvus d'infrastructures sportives, du fait des coûts fonciers prohibitifs. Dans un deuxième temps, l'article tente d'expliquer la localisation des installations sportives selon leur nature. Les installations nécessitant une forte emprise foncière (par exemple les stades de football) se trouvent en périphérie, non seulement par calcul économique, mais également parce qu'elles correspondent à des activités sportives plutôt exercées par des ménages à revenu faible ou moyen. A l'inverse, les installations sportives réclamant peu d'espace, comme le tennis, se rapprochent du centre-ville, car elles correspondent également aux préférences des ménages à revenu plus élevé.*