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Abstract

Classical theories of competition in two-dimensional space mainly deal with the questions of where firms locate in the plane and what shape their market areas will consequently adopt. Out of that develops the construct of catchment areas. As part of long-term infrastructure equipment, an airport can not change location. Once it is chosen and operational, an airport has to compete for passengers and market share on basis of its prevailing catchment areas. Passenger choice determines the shape of an airport's market and these markets, other than in the presented theories, commonly overlap. On the basis of passengers' selection criterions, the valuation of an airport's attraction takes place. The developed procedure is applied to the state of Baden-Württemberg. It paints a picture of airport competition in the German Southwest. In order to get a sharper image, the formed catchment areas are subdivided into zones of different competition intensity.

JEL-Classifications: L93, R41
Keywords: Airport, catchment area, spatial competition

I. Introduction

The Federal Republic of Germany has one of the densest airport networks in Europe. Seen before the background of an emerging competition within the European airport industry, this means new challenges for the future of airports in Germany. First steps have been done, as the privatization of a few airports shows. But this will not be the only changes to come. Low Cost Carriers are emerging in Germany, and this will be a chance for smaller airports with spare capacity. On the other hand, these airports are in danger of becoming dependent on some air carriers. Another way of creating new business is to focus on freight services. The airport of Leipzig is developing as a hub for DHL, a subsidy of the Deutsche Post. This strategy is possible especially for airports that have no operational constraints during night time. Here, smaller airports could even compete with large hub-airports as Frankfurt, which are facing operational and capacity constraints. Competition with hubs is only feasible for regional airports, when it comes to competition for certain businesses. Regarding the number of services and destinations offered, competition among hubs and regional airports differs. Hub airports are concerned with a wider catchment area. They are competing on a European level. On the regional level, competitive pressure is rising, because many former military air fields are waiting to be converted into civil airports. In some cases regional governments are trying to promote these new airports, without having a closer look at costs, existing competitive forces and a modest future for their new airport.

This paper discusses the meaning of competition among airports on a regional base. It creates a picture of the current situation of competition for the Southwest part of Germany, in particular the state of Baden-Württemberg.

Starting point for the considerations is the nature of competition in two-dimensional space. From this theoretical base, a model of decision-making is constructed. The factors which influence passengers the most, when deciding for an airport, flow into a ranking system to describe airport significance.

II. The theory of spatial competition

1. Competition in one-dimensional space

Firms choosing a location on a predefined interval with evenly distributed customers try to reach as many of them as possible. In a duopolistic environment, they end up in a socalled "back-to-back-solution" in the middle of the interval. This is a *Nash-equilibrium*[1] of the underlying location game. The solution is also known as the *principle of minimum differentiation* and is used to explain spatial as well as non-spatial topics (e.g. matters of product differentiation), however it is not a social optimum, because the sum of transportation costs for customers is not minimised. The conditions for a social optimum require an equal distribution of *n* firms over the whole interval. That implies a catchment area of *1/n* for each company.[2]

In contrast to the interval, the circle is an unlimited space. The socially optimal evenly distributed firms are also a Nash-equilibrium, but just one out of many. Another form of equilibrium contains a pair-wise arrangement of firms, back-to-back, as seen above.[3]

Collusion is profitable, if the participants comprise more than half and less then all of the companies in the market[4].

2. Competition in two-dimensional space

The following section concisely portrays important classical theories about location and competition in two-dimensional space. In what follows, it is assumed that customers are distributed equally in the plane.

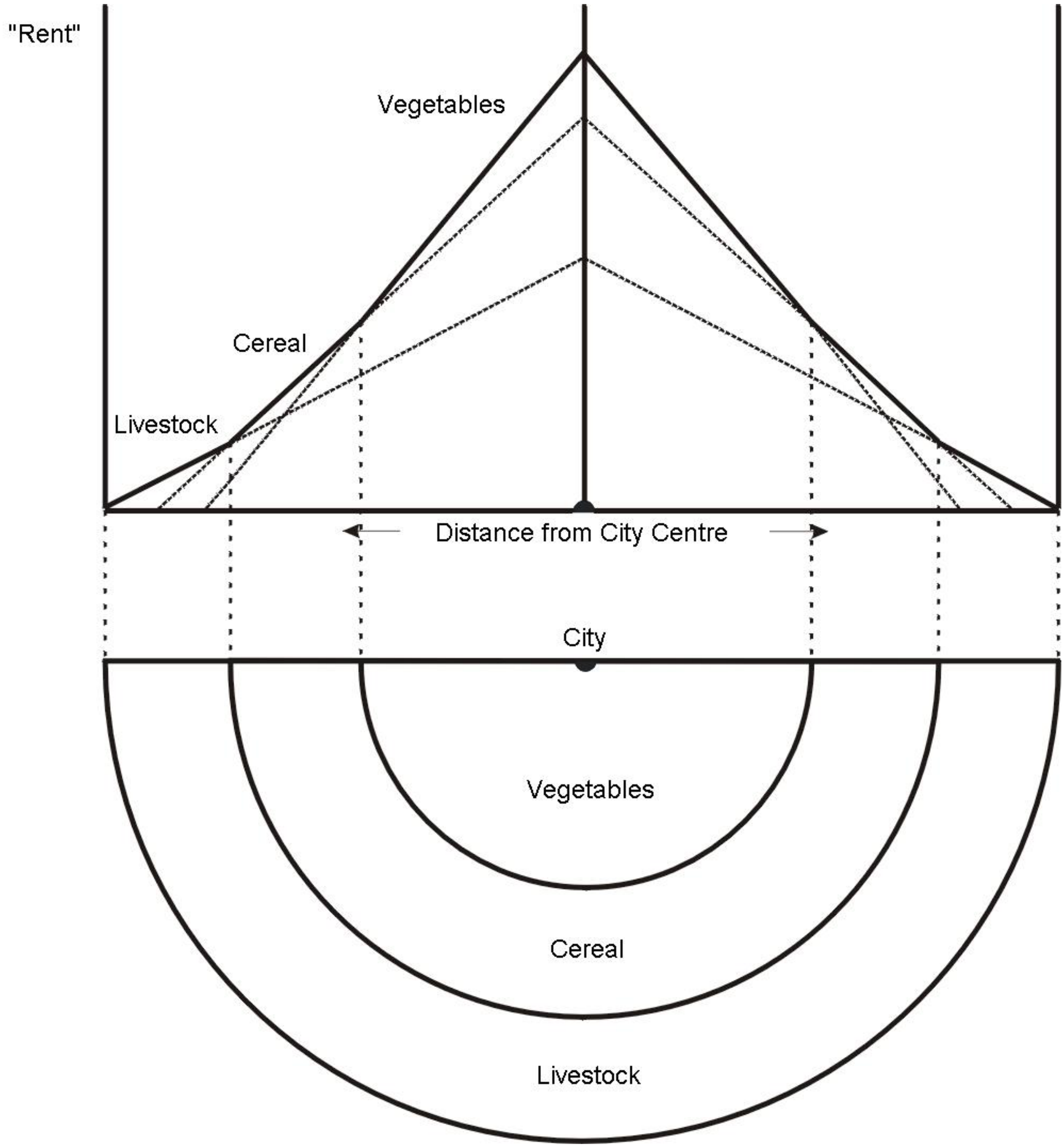
Cost-based theories suppose that firms have to serve a given demand with fixed prices. A profit-maximizing strategy is focused on finding the optimal location from where the market can be delivered with minimum costs.

Von Thünen developed his theory on an agricultural framework[5]. Here the conditions for producing several goods are the same around the plane. The goods have to be transported to the market place in a centrally located city. Choosing the optimal location is based on different cost schemes. Facing costs for production and transportation, goods with the minimum overall costs close to town will be produced in the inner circle surrounding the city. The producers of these goods have the highest willingness to pay for land. In the end, a system of concentric circles around the city develops, each one concentrating on the production of specific goods. Figure 1 illustrates von Thünen's circles.

The theory is also used to explain the structure and development of urban areas[6].

[1] See Hotelling (1929), p. 45ff; Okabe/Aoyagi (1991), p. 364.
[2] See Eaton/Lipsey (1975), p. 29ff.
[3] See Eaton/Lipsey (1975), p. 31f.
[4] See Huck/Knoblauch/Müller (2003), p. 501f.
[5] See von Thünen (1826), p. 2ff, 128ff, 175ff.
[6] See Fujita/Krugman/Venables (1999), p. 15ff.

Figure 1: The system of circles after *von Thünen*



Source: D.Strobach, following Fujita/Krugman/Venables (1999), p. 16

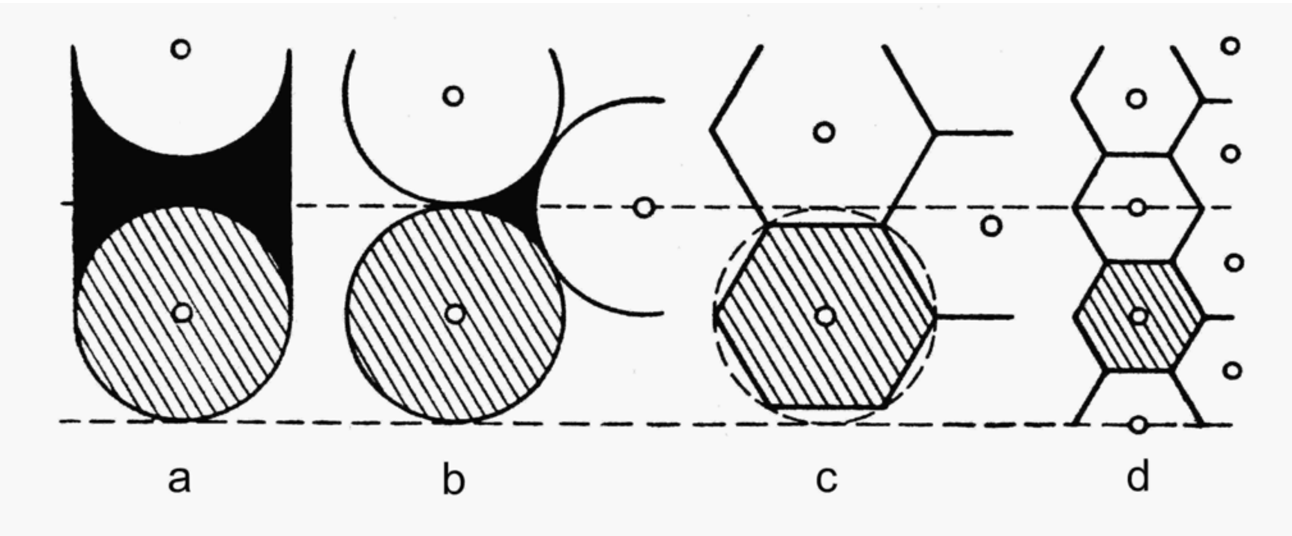
Weber focused on the location choice of industrial companies when sources of raw material and the market place geographically break up[7]. If prices for raw material and labour are fixed, transportation cost are the relvant factor. They vary, depending on quantity and distance. Around all the different centres of resources and market, it is

[7] See Weber (1922), p. 41ff.

possible to draw lines of equal cost. By means of these isocost lines, the most cost-efficient location can be found. Usually the place of production is located between different sources of raw materials and the market place. If transportation costs are extreme for one material or the manufactured good, the production site ends up at the specific source or straight at the market place.

The shape of market areas was introduced by *Lösch*[8]. He expanded the frame by focusing on oligopolistic markets in combination with ideas from monopolistic competition. Consumer demand is described by a demand curve with negative slope Preferences and income are identical for all consumers. The conditions for production at any place and transportation in any direction are homogeneous. The manufactured good sells within a circular catchment area (Figure 2a) whose size is limited by increasing transport costs and, therefore, increasing prices. Existing companies make profit at this stage, so new firms are attracted. Catchment areas decrease and move closer together (Figure 2b). Formally, the demand curve shifts to the left until Chamberlin's tangential solution is reached. During this process, the shape of catchment areas changes. Overlapping markets are not possible, and a network of circular catchment areas does not cover the whole plane. But a hexagonal net fulfils this condition, so a company´s catchment area takes on the form of a hexagon and all potential costumers are served (Figure 2c). Market entries occur and catchment areas shrink until equilibrium is reached and profits are eliminated (Figure 2d).

Figure 2: The development of a hexagonal network



Source: Lösch (1962), p. 75.

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[8] See Lösch (1962), p. 71ff.

A result of Lösch's theory is that firms spread through the plane and try to cover the whole demand. On the other hand, cost advantages of agglomeration lead to a certain degree of concentration within an industry, an effect observed in reality. To find an explanation for this phenomenon, the assumption of equal costs at any place has to be given up. Firms tend to choose places with low costs as their production site. Market participants who are not able to realise economies of scale, can settle at more distant places where they can develop a smaller market, apart from the large companies. The large ones can not compete with their cheaper offers, because of the higher transportation costs to distant places. Consequently distance and transportation costs are a kind of protection against larger competitors. Conversely, if all manufacturers are large in size and able to realise economies of scale, there will be a tendency to produce in cost-efficient and demand-intensive locations and to compete directly against each other. Incomplete information about whether there are favourable locations leads to concentration in one place. Equal cost conditions and differentiation of company size cause a tendency of firms spreading around the plane.[9]

As discussed above, the theory of *Lösch* shows that hexagonal network is an equilibrium. Now the question arises whether this type of catchment area is the only stable solution. Other geometrical shapes, like rectangles, squares and triangles, could also form a network which covers the whole plane. A square and hexagonal lattice makes up a global equilibrium. That means the whole market or network is stable. Beside the Löschian explanation for hexagons, *Knoblauch*[10] gives a geometrical proof that a square will establish a strict Nash-equilibrium. Rectangles and oblong hexagons could only set up a local equilibrium, which means the network is stable only within a sufficient vicinity of the firm under consideration. Triangular networks have an incentive built in for the firms to deviate. They are unstable and can not make an equilibrium[11].

The results above are valid for a market without entry. If market entry is possible, firms enter the market as long as profits are achievable and the market reaches a certain density. Then the process stops. It could take several rounds to bring the market back into stable conditions. Two rounds are needed for a square lattice to form another stable square lattice. The number of market participants then have been multiplied by four. A network of regular hexagons needs three rounds to become a new equilibrium, but not identical in shape. Then there will be as many as twelve times the number of firms before. These processes can only run until there are no profits. Thus, it is not sure,

[9] See Greenhut/Norman/Hung (1987), p. 267ff.
[10] See Knoblauch (2002), p. 46ff.
[11] See Okabe/Aoyagi (1991), p. 351f, 360ff.

whether the process runs long enough to end up in a new stable state. If the new entrants can change their location, the process needs only one round to reach an equilibrium in a network of regular hexagons.[12]

As a global equilibrium, square- and especially hexagonal networks form a solution in two-dimensional space, which is closer to social equilibrium than in one dimension, as transport costs are minimized.[13]

All results so far consider an unlimited plane. If the plane is limited and it takes on a shape with *x* corners, the Löschian system is disturbed. Possibly firms in limited markets have an permanent incentive to wander around, which leads to an oscillating behaviour. The closer the market comes to a disk ($x \to \infty$), the higher is the likelihood for a balanced solution. One or two firms settle in the middle of the disk. Other companies form a settlement of concentric rings, without regular shape for the catchment areas. It is very unlikely that all firms form one circle, as this arrangement is unstable. An interesting case is the rectangular market ($x=4$). Within a square, there does not exist an equilibrium configuration. The more unequal the ratio of sides, the more likely is a reproduction of a balanced configuration along the symmetry axis of the market, comparable to those in one-dimensional space.[14]

The next step is to include price, transportation cost and demand into the considerations of location choice. These factors are of special interest, if the urban agglomeration and the geographical centre of a market fall apart. In the case of concave transportation costs, i.e. if there are economies of long haul, a firm settles at the urban centre of the market. Because of decreasing marginal transportation costs, the supply of customers in the periphery can be handled under acceptable conditions. In the reverse case, if costs are convex, firms tend to settle at the geographic centre, since the supply of the outskirts of the market is more expensive. Convex demand leads to a concentration of competitiors, while concave demand causes a tendency to spread in space. The effect of choosing a production site in the urban centre strengthens, if costs are concave and demand convex. If the conditions are the other way round, there is a stronger tendency to settle near the geographic centre of the market. If both components are concave or convex, the outcome is not predictable.[15]

The final price contains a factor α that determines to which degree transportation costs are passed on to consumers. In a duopolistic market, firms compete for the customers

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[12] See Eaton/Lipsey (1976), p. 80ff.
[13] See Okabe/Aoyagi (1991), p. 365f.
[14] See Aoyagi/Okabe (1993), p. 266, 270, 275ff; Eaton/Lipsey (1975), p. 40ff.
[15] See Greenhut/Norman/Hung (1987), p. 275ff.

located between them. While being able to decide freely about α, they try to differentiate prices and increase their profit. But on the other hand, they have an incentive to decrease prices in the competitive zone. Therefore, competition law enforces collusive behaviour as well as price dumping.[16]

III. Reality and theory – the development of catchment areas

1. Catchment areas and competition

All the models mentioned above employ quite restrictive conditions, which seem very much an ideal case in comparison to the geography and topography of the real world. Proceeding on the assumption that the surface is a plane, where travelling in all directions is possible under unique cost and time conditions, this leads to a distinction between the market areas of different firms. The theoretical result is a network of strictly divided monopolistic areas. But topography causes the emergence of a traffic axis, which means that different travel directions are connected with varying cost and time components. A strict divison of market areas and the existence of regularly shaped networks is not likely under these premises.

Catchment areas, as a synonym for market areas, play a vital role in the airport business. The term describes a geographical space, within which the probability of selection is so high that the majority of potential passengers living in the region decide for this particular airport. In other words, an airport gets the bulk of its traffic volume out of this area. Catchment areas are not static structures. They can vary, caused by changes in determinant factors. What these factors are is the subject of the next section. Also, catchment areas are overlapping.[17] The definition via the probability of choosing a particular airport shows that other alternatives are imposed with positive probabilities as well. A point in space could rarely be assigned to one airport solely.

Competition among airports is based on catchment areas. Irregularity in shape is typical, and overlapping is vital in this process. Location plays an important role in competition, but airports are immobile. Once a location has been chosen, this strategic decision can not be changed. If a firm can not be shifted, it has to rely on the flexibility of its customers. Thus passengers' recognition and decision for an airport determine its catchment area, market share, revenue and profit.

[16] See Greenhut/Norman/Hung (1987), p. 280ff.
[17] See Zeike (2003), p. 71f.

2. Relevant factors

Certain factors make up an airports' recognition and cause the existence of a positive choice probability. These factors determine to which extent passengers choose a specific airport and, therefore, strongly influence the dimension and shape of catchment areas, as well as competition among airports.

For the discovery and description of factors that are important for passenger's choice, Multinomial Logit (MNL) or Nested MNL (NMNL) can be used[18]. Because a broad database is necessary for such investigations, many examinations rely on a survey covering the San Francisco Bay Area in 1995[19]. Within the scope of most of these investigations, the quality of airport access, offered frequency of flights and price are emphasized as the most important factors[20]. When analyzing an airport, these and additional factors are the base of competition. Passengers are influenced by these parameters, choose a particular airport on this basis and thus determine market share.

The most common factors are[21]:

- Airport Access Quality: This factor can be described by values of time, distance and cost. While it is relatively easy to transform distance into monetary dimensions, this is much more controversial when it comes to the valuation of time. Usually the ways reaching an airport are divided into private and public transport. Access time is an important, maybe the central factor, in airport competition. It can be shown that access time reaches higher elasticities concerning choice probability and market share than flight frequency[22]. The importance of access time may vary according to flight length. On short-haul routes, access time becomes a higher weight in relation to total travel time than it does on long-haul or intercontinental routes. Thus it is a more important criterion on short- or medium-haul routes, for instance national or European traffic, as on intercontinental routes[23]. One explanation for these high values of access time could be risk minimization. Long access times and distances increase the risk of delays and missing a flight.

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[18] An overview on the different models can be found in Bondzio (1996), p. 11ff.

[19] Study on the San Francisco Bay Area: Basar/Bhat (2004), p. 895ff; Hess/Polak (2004), p. 4ff; Pels/Nijkamp/Rietveld (1998), p. 6ff – Study on extension of Sheffield Airport: Thompson/Caves (1993), p. 138ff – Study on airport access in Southern Germany: Bondzio (1996), p. 42ff.

[20] See Harvey (1987), p. 443ff; Cohas/Belobaba/Simpson (1995), p. 41ff; and the sources mentioned in the previous footnote.

[21] Essential to this topic are the sources contained in the last two footnotes.

[22] See Basar/Bhat (2004), p. 899f.

[23] See Harvey (1987), p. 448.

- Frequency: Airports offer their passengers a variety of flights and destinations. Beside the number of destinations, reachable via direct connections, the frequency of flights is the decisive parameter. Flights are originally supplied by airlines. It is their competition parameter to reach or maintain market share on specific routes or airports. Airlines have an incentive to compete by offering a dense network of services, which is of advantage to the airport. These try to attract airlines in order to proffer an attractive supply. From an airports' point of view, an optimal timetable contains a sufficient number of flights. At minimum a pair of flights should be offered per day. Flight frequency has a decreasing marginal utility. Nine flights per day can be seen as a kind of saturation point. As access time and frequency are the most important factors, the tendency is that if two airports offer a similar number of flights, travellers choose on the basis of other factors, most likely the nearest airport.[24]
- Air Fare: Beside the two parameters above, air fare seems to be very important, although not all studies verify this assumption[25]. Air fare causes severe problems in data collection. That is the reason why many authors do not include it in their studies. Airlines offer different service categories and use for price differentiation. Ticket prices may vary with time, capacity and category. Thus accuracy in data collection is hard to reach.
- Experience: This is a subjective element in airport choice. Positive experiences with a specific airport increase the probability that the passenger will choose this airport again in the future. But the question how to measure experience is difficult.
- Tax: Total air fare contains charges and taxes, which may differ between airports.
- Type of Aircraft: Despite their economic efficiency on short-haul routes, many passengers prefer jet-propelled to propeller driven planes[26].
- Aircraft Size: Larger aircraft are linked with higher comfort.
- Delays and Punctuality: These points describe inconvenience and the risk of missing a flight.

A common distinction separates business and leisure travel. In general, business travellers are more time-sensitive, and leisure travellers more cost-sensitive. Business

[24] See Cohas/Belobaba/Simpson (1995), p. 34, 39; Harvey (1987), p. 446ff; Hess/Polak (2005), p. 63f; Thompson/Caves (1993), p. 143, Zeike (2003), p. 78f.
[25] Pro: Thompson/Caves (1993), p. 139, 145; Contra: Pels/Nijkamp/Rietveld (2003), p. 79.
[26] For Innes/Doucet (1990), p. 514f this factor is of high relevance.

travellers are more likely to accept higher fares in exchange for higher frequencies[27]. Local residents have a broader base of knowledge and experience. They sensitively react on changes in access quality and air fare. Visitors mainly focus on access time[28].

IV. Development of a model to describe competition among airports

1. Outlining the goals and course of action

Passengers choose their preferred airport based on the attributes described above. They thus influence shape and size of an airport's catchment area and its market share. Passenger's preferences establish the foundation of competition among airports. These preferences, more exactly the attributes and factors they are based on, are used in the following sections to model competition among airports. This is done in a general form, which makes the model easier to handle, because of adjusted requirements for the data material that is needed. The design also allows a repetition at any time, if the basic facts change, and an analysis of other regions.

This study covers Baden-Württemberg. To develop a spatial reference, the state of Baden-Württemberg is subdivided into cells, based on existing administrative districts. Within these, the administrative centre of a district usually reflects the centre of economy and population and, therefore, serves as a reference point for the determination of access quality. In special cases, the reference point or divison of districts can vary, if suitable[29]. A problem concerning the transfer of information related to one specific point into space automatically arises. The finer the subdivision, the more accurate the information is. But improved accuracy implies higher expenditures.

A ranking method is used to rate all values of a specific factor. The score reaches from 9 for the best to 1 for the worst performer. These score values are weighted and accumulated. At the end, this method leads to one value per cell and airport. This can be interpreted as a measure of an airport's attraction concerning a particular cell. Conclusions about competition among airports and their catchment areas can be derived from comparing the results.

The factors used in the present study are grouped into a cell-specific and an airport-specific part. The cell-specific part measures the connection between an airport (as a point in space) and a geographically differentiated area. This is done on the basis of

[27] See Hess/Polak (2005), p. 65f; Pels/Nijkamp/Rietveld (2003), p. 79.
[28] See Harvey (1987), p. 440; Hess/Polak (2005), p. 66.
[29] For a closer look on the division, see Table 4 and Figures 3 and 4.

attributes concerning access quality. Airport-specific factors assess the airport itself. On one side is traffic supply, with flight frequency as the most important attribute. Connected to this point are factors which describe the conducting of traffic. On the other side are attributes concerning the convenience of an airport. They measure how stress-free and entertaining an airport's design is for travellers. At the end, the evaluation of airports as a point in space is combined with the assessment of airport access. These results have a multidimensional shape, reflecting competition in space.

Passenger's preferences and an airports' attractiveness for travellers are useful indicators of competition, but are not a perfect measure. Ideally, the results should be compared with data reflecting traffic streams on a regional base, i.e. passenger's origin at selected airports as well as the alternative travellers of a specific region are currently choosing. Although at least the latter information is difficult to obtain, a detailed verification on the basis of such data is an important topic of further research. The present study has to be considered as a first approximation to the spatial dimension of airport competition, not as an exact measure, while keeping in mind the overall goals mentioned above.

2. Selection of attributes

The following chapter is an overview on selected factors.

Airport access can be measured in quantities of time, distance and cost. In the case of private transport, distance can be transferred into cost using a linear function. However, this is difficult, because prices for gasoline and the use of a particular type of car has to be determined. Therefore, only distance and time are calculated. Cost is not considered. It is assumed that a passenger leaves a train station at a reference point at nine o'clock in the morning and prefers a quick routing. Regarding public transport, ticket prices (regular tariffs) and travel times are calculated. The passenger leaves the mentioned train station around eight o'clock with the fastest connection possible. If an airport has no mainline station, the connecting services are added and a transfer time of 10 minutes is included.[30]

Flight frequency is the most important factor within the bounds of airport-specific attributes. With overlapping catchment areas, direct connections (point to point) are of main interest. To equalize the conditions for all airports under view, the present study

[30] Private transport elements are calculated using an actual commercially available digital road map. The internet website of Deutsche Bahn AG (www.diebahn.de) and municipal transport services are used to calculate the access via public transport. Thursday august 25th is the fixed date.

concentrates on destinations in Germany and Europe (Table 1). The most frequently served destinations from the centrally located airport of Stuttgart[31] constitute the starting point. The inclusion of the main administrative and economical centres, as well as popular destinations of low cost carriers, guarantee a balanced choice. Principal destinations of package holidays are excluded. Only Northern German cities are included in order to minimize intermodal competition.

Table 1: Worldwide arrivals at selected European airports, 2004

Destination/ Airport		**Code**	**Passengers**
Germany			
Berlin	Schönefeld	SXF	3.382.166
	Tegel	TXL	11.048.000
	Tempelhof	THF	441.580
Düsseldorf		DUS	15.256.500
Hamburg		HAM	9.893.700
Hannover		HAJ	5.249.169
Europe			
Amsterdam		AMS	42.541.200
Barcelona		BCN	24.549.600
Brüssel		BRU	15.583.700
Budapest		BUD	6.444.700
Graz		GRZ	898.504
Istanbul	Atatürk International	IST	n/a
	Sabiha Gokcen	SAW	n/a
Kopenhagen		CPH	18.965.700
London	City	LCY	n/a
	Gatwick	LGW	31.461.500
	Heathrow	LHR	67.344.000
	Luton	LTN	7.500.000
	Stansted	STN	20.908.100
Mailand	Bergamo	BGY	3.334.161
	Linate	LIN	8.947.900
	Malpensa	MXP	18.554.000
Palma de Mallorca		PMI	20.410.900
Paris	Orly	ORY	24.032.200
	Charles de Gaulle	CDG	50.860.600
Prag		PRG	9.696.413
Wien		VIE	14.785.500

Source: ACI (2005), Internet websites of the subject airports.

31 See Flughafen Stuttgart GmbH (2005), p. 28.

As a criterion for flight frequency, the number of flights per week are measured for the summer period 2005[32]. Two flights per day are the minimum and 9 flights per day are a saturation point. With a number of just 6 connections per day at the weekend, this leads to a saturation level of 57 flights per week. Less than 14 flights per week have the lowest value, while 57 flights or more have the highest. This range is divided evenly.
Additional factors concern the handling of traffic. Minimum Connecting Time (MCT) and the number of gates and check-in-counters describe the ability to process passengers without delays and to ensure a stable process control. MCT defines the time range in which an airport guarantees the transfer of passengers and luggage from one flight to another. The lower the danger of a negative experience for passengers, the more likely it is that they will make the same choice again.

Table 2: Share of individual factors

Factors	Share of Final Results (%)		
Access Quality			**50**
Private Transport		27,5	
Distance	*13,75*		
Time	*13,75*		
Public Transport		22,5	
Expense	*11,25*		
Time	*11,25*		
Airport Quality			**50**
Traffic Supply and Handling			**42,5**
Frequency		36,125	
Minimum Connecting Time		2,125	
Gates		2,125	
Check-In		2,125	
Convenience			**7,5**
Parking Space		2,55	
Expense per Week	*0,765*		
Expense per Day	*0,765*		
Total Supply of Parking Space	*1,02*		
Terminal Area		2,475	
Area for Shopping and Services		2,475	

Source: D. Strobach

32 Timetables published (via internet) by the airports in question make up the source for the survey. A flight was taken into consideration if it was offered for more than half of the period.

Table 3: Presentation of airports included in the study

Airport	Code	Passengers	Freight (to)	Aircraft Movements	Ownership structure
Basel	BSL	2.545.687	88.312	57.915	50% République francaise 50% Schweizerische Eidgenossenschaft
Frankfurt	FRA	51.098.300	1.750.996	477.475	31,9% Land Hessen 20,4% Stadt Frankfurt 18,3% Bundesrepublik Deutschland 29,4% Free Float
Friedrichshafen	FDH	500.892	-	7.884	25% Stadt Friedrichshafen 24,75% Bodenseekreis 16,14% ZF Friedrichshafen AG 13,23% Luftschiffbau-Zeppelin GmbH 20,88% other shareholders
Innsbruck	INN	728.138	3.957	39.377	49% Innsbrucker Kommunalbetriebe 25,5% Land Tirol 25,5% Stadt Innsbruck
München	MUC	26.814.500	309.828	359.568	51% Freistaat Bayern 26% Bundesrepublik Deutschland 23% Stadt München
Nürnberg	NUE	3.648.580	71.000	71.818	50% Freistaat Bayern 50% Stadt Nürnberg
Strasbourg	SXB	1.942.296	-	-	Under the management of CCI Strasbourg & Bas-Rhin
Stuttgart	STR	8.821.533	18.227	125.220	50% Land Baden-Württemberg 50% Stadt Stuttgart
Zürich	ZRH	17.214.500	363.537	231.086	46,76% Kanton Zürich 5,4% Stadt Zürich 47,84% Free Float

Note: Data reflects the year 2004.
Source: Internet websites and company reports of the concerning airports, ACI.

A second part of the valuation of an airport's quality focuses on convenience for passengers. This relates to the positive experience passengers should get. Most passengers still reach an airport by car[33]. Price for and number of parking lots may be a good indicator to judge whether convenient conditions exist or not. Concerning costs, the cheapest price per day and week were measured. The number of parking lots was compared to the number of passengers in order to make airports comparable. The same was done with the size of the terminal and the shopping area, as well as with the number of gates and check-in-counters. Narrow terminals can be a reflection of insufficient capacity. They may cause delays, stress and a negative experience. Terminal amenities such as shopping, catering and similar services ensure a comfortable and entertaining stay. In addition, they give an airport the possibility to gain independence from aeronautical businesses. Profits from the non-aeronautical field may enable the airport to offer better conditions on the aeronautical side and to strengthen its competitive position.

The factors presented and discussed above are weighted according to their importance. Their influence reflects the results of the former studies mentioned in the last chapter. All specific weights were varied and seen as relatively robust. Variations do not change the hierarchy. Table 2 summarizes the structure and weights of attributes influencing the study.

All airports offering a certain measure of size and traffic are taken into consideration as competitors for passengers living in Baden-Württemberg. A condition is that they have to serve at least 4 of the selected destinations. Table 3 gives an overview of the included airports.

V. Results

Table 4 presents the results. Based on these values, a ranking for all cells can be established. To analyze the competitive situation, a division into different zones is introduced. Referring to the highest value of a particular cell, two additional limiting values are set at 90% and 80% of the maximum value. The choice of these limits creates a sensible relation between potential improvements and competitive positions. Extensive investments should make an upper zone reachable, whereas incremental improvements should have no drastic effect on the new position. The limits are selected

[33] See for instance data concerning Munich Airport in 2004 under www.munich-airport.de/DE/Areas/Company/Daten/Verkehrsstrukturdaten/index.html: Car (47%), S-Bahn (31%), Taxi (10%), Bus (6%), Rental Car (6%). The relationship between public and private transport is also reflected in the construction of weights for measuring access quality (Table 2).

according to this aim. It should be noticed that under different circumstances, determination of limiting values could change.

Table 4: Final results

Reference Point	Airport								
	BSL	FRA	FDH	INN	MUC	NUE	SXB	STR	ZRH
Aalen	3,0486	5,5193	5,0759	1,9218	6,4807	5,1408	3,3286	6,8431	4,7576
Baden-Baden	5,0736	6,8818	3,5759	1,7843	4,4557	3,0033	5,6911	6,2306	5,3076
Balingen	4,5736	5,4943	5,2134	1,7843	5,5182	2,3658	4,1286	6,8431	6,4201
Biberach an der Riß	3,4986	4,6943	5,8759	2,8593	6,6182	3,6158	2,8286	6,4556	5,8951
Böblingen	3,1861	6,1568	4,6009	1,7843	5,0932	3,7033	4,6286	6,9556	6,0326
Calw	3,9361	6,6568	4,2384	1,7843	4,4557	3,1408	5,1911	6,9556	5,7826
Emmendingen	6,4611	5,8568	3,7634	1,7843	4,4557	2,7533	5,1911	5,3181	6,4201
Esslingen	3,0736	6,2943	4,7134	1,7843	5,9307	3,5908	4,8536	6,9556	5,0326
Freiburg i. Breisgau	6,5736	5,7193	4,1509	1,7843	4,4557	2,7533	5,3036	5,2056	6,4201
Freudenstadt	5,1236	5,6068	4,1259	1,7843	4,5932	2,9783	5,3286	6,8181	6,1201
Friedrichshafen	5,2986	4,2193	5,8759	3,5843	5,5682	2,4783	2,4661	5,7056	7,0326
Göppingen	3,1861	5,6318	5,1009	1,7843	6,5682	3,7783	4,5786	6,9556	4,6451
Heidelberg	4,5986	7,7693	3,6884	1,7843	4,5682	3,7783	4,8036	6,4556	4,5576
Heidenheim an der Brenz	2,6861	5,5443	5,1884	2,2843	6,5932	5,1408	3,1911	6,8431	4,8701
Heilbronn	4,0736	7,2693	3,8259	1,7843	4,5682	4,6408	4,4161	6,9556	4,9451
Karlsruhe	5,0736	6,9943	3,6009	1,7843	4,5682	3,4158	5,1911	6,8431	4,6701
Künzelsau	3,1861	6,4318	3,9384	1,7843	5,7307	5,3658	3,9661	6,8431	4,8701
Lörrach	6,5736	5,3818	4,4634	2,6718	4,2057	2,2283	4,4661	4,9806	7,0326
Ludwigsburg	3,3236	6,5443	4,3009	1,7843	5,0682	4,3658	4,7411	6,9556	5,0576
Mannheim	4,8236	7,7693	3,5759	2,0593	4,7932	3,5783	4,8036	6,4556	4,6701
Mosbach	4,4611	7,3818	3,4634	2,0093	4,5682	4,4783	4,4661	6,8431	4,4451
Offenburg	5,8486	6,2693	3,9384	1,7843	4,4557	2,7533	5,8036	5,7306	5,4201
Pforzheim	4,8486	6,8818	3,6009	1,7843	4,8182	3,5908	5,1911	6,9556	4,5826
Ravensburg	4,4111	4,3318	5,8759	3,3343	6,1182	2,7283	2,5786	5,9806	6,8951
Reutlingen	3,0736	6,1568	4,9884	1,7843	5,6807	3,4283	4,2661	6,9556	5,7826
Rottweil	4,5736	5,3818	5,2384	1,7843	4,5932	2,9783	4,2161	6,9556	6,5326
Schwäbisch-Hall	3,0736	6,4318	4,0759	1,7843	5,5932	5,3658	3,9661	6,9556	4,8701
Sigmaringen	4,8236	4,7193	5,8759	2,0343	5,8182	2,7283	3,5786	6,1181	6,7576
Singen (Hohentwiel)	5,2986	4,7693	5,7384	2,4718	4,8182	2,3408	3,8036	5,7306	7,3076
Stuttgart	3,0736	6,5443	4,4384	1,7843	5,0682	4,2283	4,7411	6,9556	5,5576
Tauberbischofsheim	3,3236	7,4068	3,6884	1,7843	5,7307	4,9783	3,9661	6,7306	4,6701
Tübingen	3,7986	6,0443	4,8509	1,7843	5,3182	3,0658	4,1536	6,9556	6,2826
Tuttlingen	4,8236	5,0193	5,6259	2,1968	4,6807	2,6158	3,9411	6,4556	6,7826
Ulm	3,0236	4,8568	5,4884	2,6968	6,8432	3,9158	3,1036	6,8431	5,7076
Villingen-Schwenningen	4,8236	5,1568	5,4884	2,0593	4,4557	2,7283	4,4161	6,5931	6,6451
Waiblingen	3,0736	6,5443	4,0509	1,7843	5,2307	4,4783	4,7411	6,9556	5,2826
Waldshut-Tiengen	6,1861	4,7693	4,8759	2,9468	4,6807	2,0908	4,0536	5,0931	7,4201

Source: D. Strobach

With these limits, competition can be described from a district's point of view. Area A (90%-100%) contains all competitors in proximity of the leading company; area B (80%-90%) all those with a looser contact to the top. The occupation of these areas, especially the first one, shows how competitive a district is and how many airports are considered as alternatives by passengers. For example, Karlsruhe has a maximum value of 6,994, reached by Frankfurt airport. But with Stuttgart airport in area A and no other challenger in area B, competition in this district tends to be duopolistic. Table 5 is an overview of the results related to this topic.

Table 5: Division into zones and competition

Reference Point	Max. Value	Leader	90%-Mark	Competitors Area A	80%-Mark	Competitors Area B
Aalen	6,8431	STR	6,1588	MUC	5,4745	FRA
Baden-Baden	6,88175	FRA	6,1936	STR	5,5054	SXB
Balingen	6,8431	STR	6,1588	ZRH	5,4745	MUC FRA
Biberach an der Riß	6,6182	MUC	5,9564	STR	5,2946	ZRH FDH
Böblingen	6,9556	STR	6,26	-	5,5645	FRA ZRH
Calw	6,9556	STR	6,26	FRA	5,5645	ZRH
Emmendingen	6,4611	BSL	5,815	ZRH FRA	5,1689	STR SXB
Esslingen	6,9556	STR	6,26	FRA	5,5645	MUC
Freiburg im Breisgau	6,5736	BSL	5,9162	ZRH	5,2589	FRA SXB
Freudenstadt	6,8181	STR	6,1363	-	5,4545	ZRH FRA
Friedrichshafen	7,0326	ZRH	6,3293	-	5,6261	FDH STR
Göppingen	6,9556	STR	6,26	MUC	5,5645	FRA
Heidelberg	7,76925	FRA	6,9923	-	6,2154	STR
Heidenheim an der Brenz	6,8431	STR	6,1588	MUC	5,4745	FRA
Heilbronn	7,26925	FRA	6,5423	STR	5,8154	-
Karlsruhe	6,99425	FRA	6,2948	STR	5,5954	-
Künzelsau	6,8431	STR	6,1588	FRA	5,4745	MUC
Lörrach	7,0326	ZRH	6,3293	BSL	5,6261	-
Ludwigsburg	6,9556	STR	6,26	FRA	5,5645	-
Mannheim	7,76925	FRA	6,9923	-	6,2154	STR
Mosbach	7,38175	FRA	6,6436	STR	5,9054	-
Offenburg	6,26925	FRA	5,6423	BSL SXB STR	5,0154	ZRH
Pforzheim	6,9556	STR	6,26	FRA	5,5645	-
Ravensburg	6,8951	ZRH	6,2056	-	5,5161	MUC STR FDH
Reutlingen	6,9556	STR	6,26	-	5,5645	FRA ZRH MUC
Rottweil	6,9556	STR	6,26	ZRH	5,5645	-
Schwäbisch-Hall	6,9556	STR	6,26	FRA	5,5645	MUC
Sigmaringen	6,7576	ZRH	6,0818	STR	5,4061	FDH MUC
Singen (Hohentwiel)	7,3076	ZRH	6,5768	-	5,8461	-
Stuttgart	6,9556	STR	6,26	FRA	5,5645	-
Tauberbischofsheim	7,40675	FRA	6,6661	STR	5,9254	-
Tübingen	6,9556	STR	6,26	ZRH	5,5645	FRA
Tuttlingen	6,7826	ZRH	6,1043	STR	5,4261	FDH
Ulm	6,8432	MUC	6,1589	STR	5,4746	ZRH FDH
Villingen-Schwenningen	6,6451	ZRH	5,9806	STR	5,3161	FDH
Waiblingen	6,9556	STR	6,26	FRA	5,5645	-
Waldshut-Tiengen	7,4201	ZRH	6,6781	-	5,9361	BSL

Source: D. Strobach

Another 5 zones now can be developed to describe competition from an airport's point of view. Zone 1 and 2 mark the areas where a particular airport has the leading role. In doing so, zone 1 describes the situation where no close competitors in zone A exist, whereas zone 2 represents the competitive case of leadership. Within districts of zone 3, the airport under view does not occupy the leading position anymore. It is situated in area A, closely competing with the leader. The distance between it and the leader grows, when ranked into zone 4. The attraction value now ranges within area B. The weakest competitive position is represented by zone 5, where an airport is no longer a strong competitor to the leaders.

In the district of Tuttlingen, for example, Stuttgart airport has a position in area B (6,4556), with Zürich airport occupying the leading position (6,7826) and the airport at Friedrichshafen (5,6259) as competitor in area B. In the eyes of Stuttgart airport, the district of Tuttlingen belongs to zone 3.

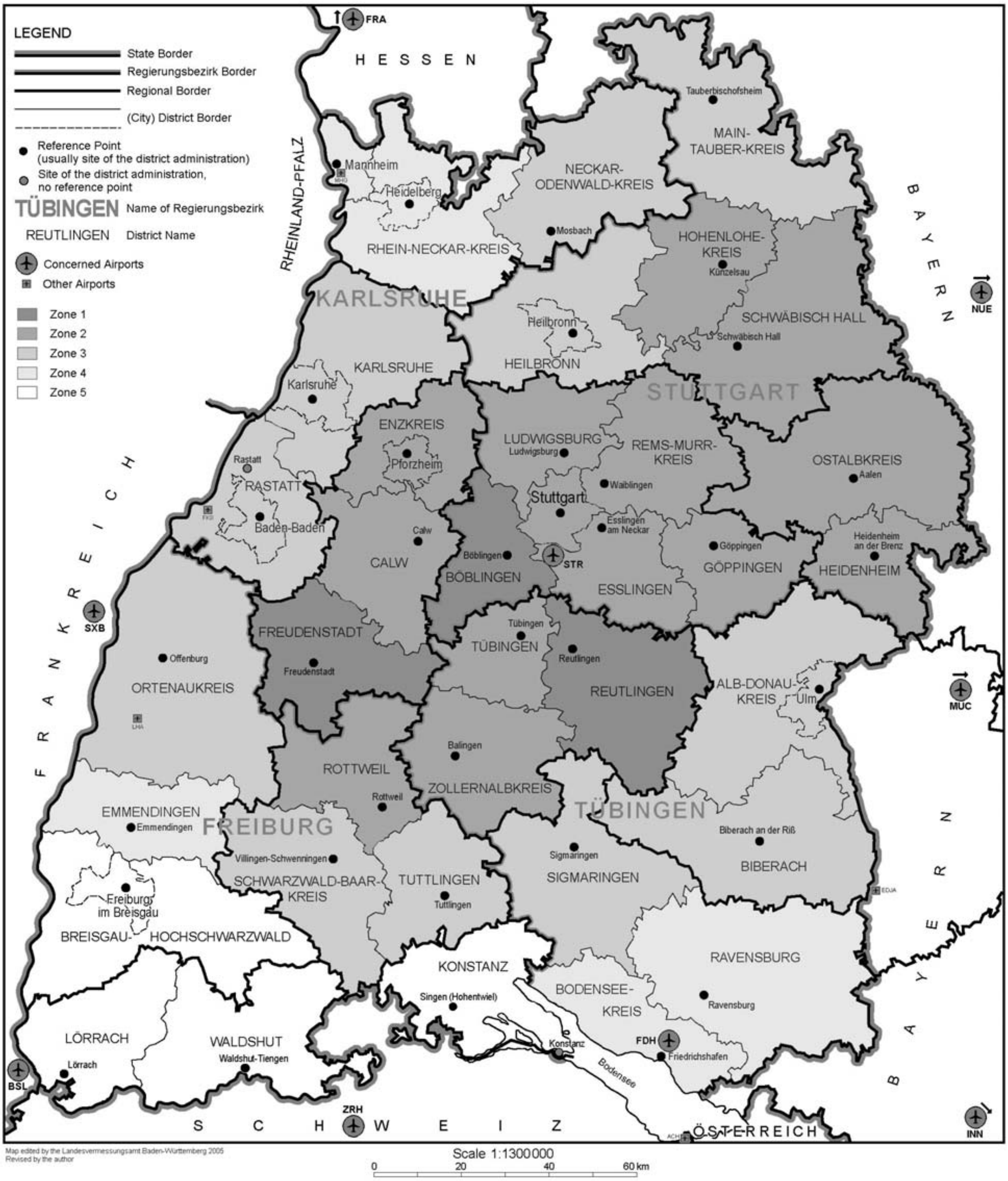
How these differentiations form a more precise picture of an airport's catchment area, is shown with Figure 3 at the example of Stuttgart airport. Figure 4 illustrates the leading positions for all districts in Baden-Württemberg.

A conspicuous fact is the influence of the Frankfurt airport reaching the South along the Rhine Valley. On one hand, the Black Forest creates a kind of natural barrier to the East with higher travel resistance. But on the other, the transport infrastructure along the Rhine Valley is excellently developed. Travelling to Frankfurt is getting more attractive, because despite longer distances, travel times are short. Contrary valuations of access time and cost for the Frankfurt airport in the Rhine Valley districts confirm this assumption.

An existing traffic axis of road or railway infrastructure thus plays a vital role in the moulding of catchment areas. Along these axes, even in more distant regions, the connectivity can be adequate enough so that the higher supply of flights and destinations compensate for disadvantages in access quality. Another example are the two districts in the East of Baden-Württemberg which belong to the catchment area of Munich airport. Both have better access to Stuttgart airport than to Munich. But they are also both very well linked to the highway- and/or railway-network serving the Bavarian capital. This restricts the disadvantage of poorer access quality in a favourable way, so that it can be compensated by advantages on the airport-specific side.

Therefore, it is no wonder that the most competitive districts are in the Rhine Valley (Emmendingen and Ortenaukreis) and in the East of Baden-Württemberg (Alb-Donau-Kreis and Ulm). These findings support the assumption that competition is most intense in centrally located districts between two airports. Reasons for the two cases are mentioned above.

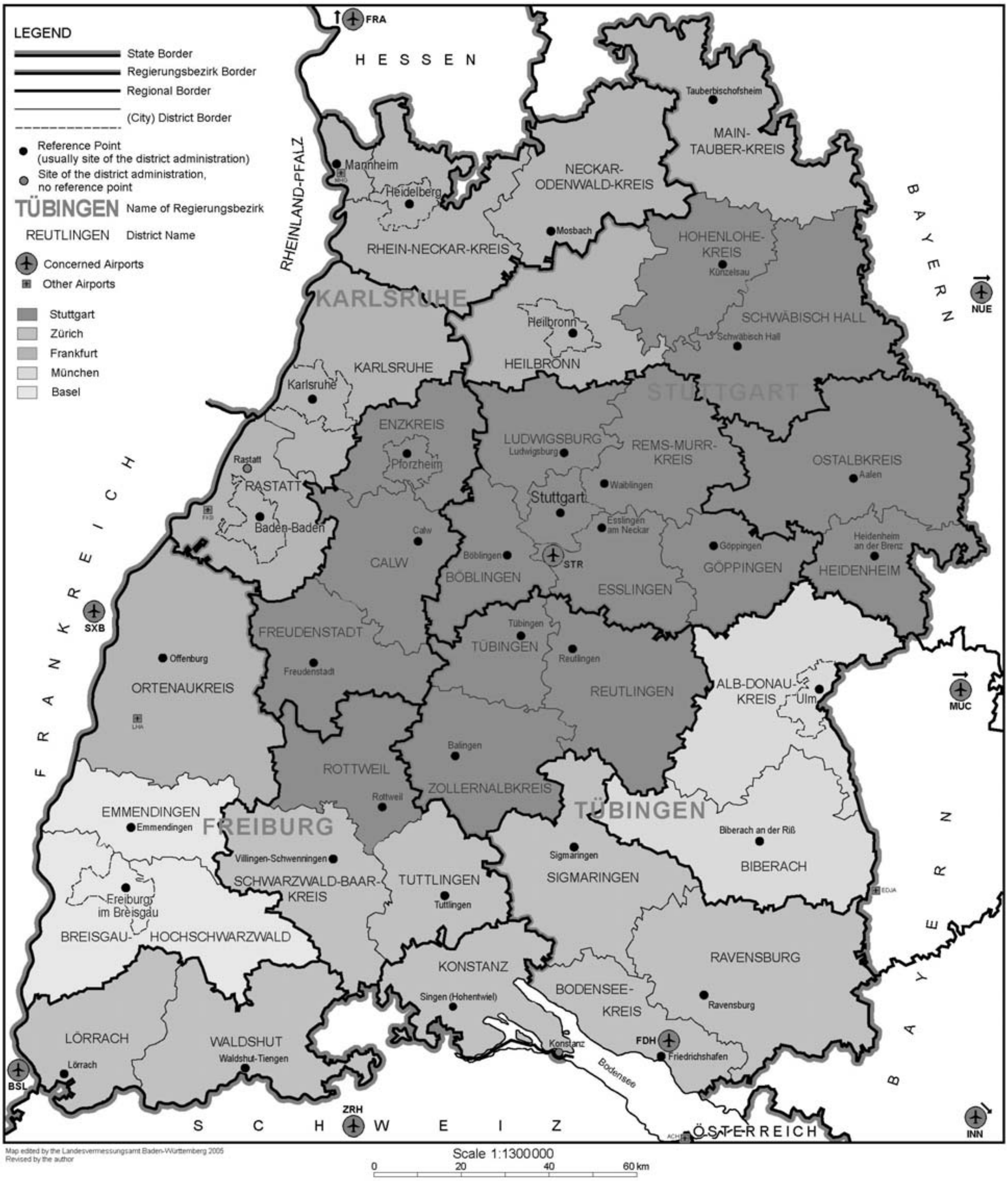
Figure 3: Catchment area and competitive zones of Stuttgart airport



Source: D.Strobach

Especially the Rhine Valley is an interesting case, because of the high density of competitors. The airports of Basel, Straßbourg and Stuttgart are in close proximity. Furthermore, the more distant hub airports of Frankfurt and Zürich are of great importance. It should be noted that three airports failed to be included into this survey because of their minor size (Baden-Airpark Karlsruhe and Mannheim) or outstanding operating licence (Black-Forrest-Airport Lahr). As potential competitors, they could be of significance in the future.

Figure 4: Competitive leadership of airports in Baden-Württemberg



Source: D.Strobach

The lowest intensity of competition appears at the Swiss border (Singen). It is a typical example for the assumption that a district in close proximity to an airport, especially a hub airport, will be "ruled" by this company in a sense of undisturbed market power (in this case Zürich airport).

Both assumptions concerning the spatial distribution of competitive forces and market power have to be interpreted as tendencies. According to these tendencies, it must be assumed that Stuttgart airport exerts a similar kind of distinct leading role in the centre of Baden-Württemberg. But the airport has only three districts (Böblingen, Freudenstadt, Reutlingen) assigned to zone 1. Within all other districts of its vicinity, the airport must deal with competitive pressures. Stuttgart airport is in the unlucky situation to face competition of large hub airports from three directions. Those three main competitors and the natural barrier in the West set the tone for developing a catchment area, in the end. For the hub airports, it is easier to compensate disadvantages and, therefore, enlarge their catchment area.

VII. Outlook

Concerning the widening of its catchment area, the potential for development of Stuttgart airport as the central airport of this study is limited. Together with EuroAirport Basel, it fills an intermediate position between hub and regional airports, especially when focusing on airport-specific factors. There is a risk of being stuck in the middle. But even with a difficult starting point, new opportunities are arising. The development of another classical hub does not seem a profitable strategy. But the attraction of charter and low cost airlines, as has happened in the recent past, could create growth. However, the dangers of too close ties to these types of airlines should be kept in mind. The new congress and exhibition centre (Landesmesse) built in the direct neighbourhood to the airport offers the opportunity to generate new traffic. As part of the project "Stuttgart 21", a new long-distance train station is planned in front of the terminal. The example of Frankfurt airport shows that such an investment opens up the opportunity to better exploit more distant catchment areas and strengthen its own competitive position.

Further studies could widen the geographical area examined or focus on several case studies. Lately a court judgement paved the way for conversion of the former military airfield at Memmingen into a regional airport. A case study approach could be used to

determine how the competitive environment could change and whether it makes sense to add a new regional airport in one of the densest airport networks in Europe.
Another interesting field could be the further development of existing theoretical models, for example including highways or natural barriers, so to say areas of different travel resistance.

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Frankfurt:	http://www.fraport.de; http://www.airportcity-frankfurt.de
Friedrichshafen:	http://www.fly-away.de/
Innsbruck:	http://www.innsbruck-airport.com/
München:	http://www.munich-airport.de
Nürnberg:	http://www.airport-nuernberg.de
Strasbourg:	http://www.strasbourg.aeroport.fr

Stuttgart: http://www.flughafen-stuttgart.de

Zürich: http://www.unique.ch; http://www.flughafen-zuerich.ch

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