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Hub airports, the knowledge economy, and how close is close?

A European perspective

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1 Introduction

Air transportation is gradually creating a completely new spatial pattern, as did other kinds of transportation modes in the past. Within this development process, airports are taking center stage. Formerly planned as stand-alone facilities in the cities' periphery, airports – particularly those with a hub function – have gone through a morphogenesis into more or less urban-like entities. As Güller and Güller (2003) have stated, today 'airports are not just airports any more'. Far more interactive within the spatial context than in the past, airports have evolved from purely infrastructure facilities into multimodal and multi-layered, spatial poles of growth and centers of competences distinguished by their unique accessibility and connectivity profiles.

In recent years, airports have not only made a contribution to a process sometimes referred to as 'urban restructuring' (Soureli and Youn 2009), but also in reshaping real estate markets (Schubert and Conventz 2011). Today, hub airports are perceived as powerful economic engines capable of having considerable economic and

social impact on cities and regions (ACI 2004) by acting as nodes of transnational value-creation chains and hubs of knowledge exchange.

As a consequence, airports are no longer primarily seen as pure infrastructure facilities, but rather as advantageous business sites. The European section of the Airports Council International, taking cues from different studies, considers global accessibility as 'absolutely essential' to businesses making location decisions (ACI 2004: 6). According to the ACI survey,

> 31% of companies relocating to the area around Munich Airport cited the airport as the primary factor in their location decision. A survey of businesses in the Hamburg area found that 80% of manufacturing companies reported air service connections as important to getting customers to look at their products. […] The ÎIe de France Region generates 30% of the French national GDP. Accessibility to Paris CDG Airport is powerful factor in companies' location decision, particularly for the large global companies headquartered in the Paris area, and to firms engaging in new High-tech and innovation industries. […] The attractiveness of airports and their hinterland is particularly strong for high tech industries as evidenced by Copenhagen und Nice Airports (ACI 2004: 6).

Regarding German airports, the European Centre for Aviation Development (ECAD) notes that they, and their key services as international network infrastructure, are a prerequisite for long-term competitiveness of regional and national economies (for a discussion of the role of small airports, see Redondi et al., 2013). Moreover, airports are essential not only for added value but also for the development of business markets in and outside Europe (ECAD 2007).

Against this backdrop, this paper scrutinizes spatial patterns and process of specialization in and around two major European airports: Amsterdam's Schiphol Airport and Frankfurt's Rhine-Main Airport.

The present paper thereby analyses the linkages between airports, air transport and the knowledge economy. In particular, we issue on the following questions: What are the contributions of the knowledge economy that explain the economic effects of airports on the spatial structure of cities and regions? What kind of locational patterns have already emerged around airports that have to be linked with the presence of firms from the knowledge economy realm? What is their spatial relationship to more traditional locations, for example within the Central Business District? Why does an array of knowledge-based companies relocate their business activities to spaces of highest accessibility such as international airports?

In order to get a deeper understanding of the subject matter, it is helpful to briefly look at the complex interplay between technological changes in modes of transportation and their impacts on rewriting the urban and metropolitan geography. After this, we reflect on the diverse morphogenesis of airports into complex and multifunctional real estate sites. Situated in this inquisitive background, part three is our argumentation that changed locational behaviour of the knowledge-economy and the way new knowledge is created plays an important role in understanding this newly emerged spatial entity. Part four concretizes these findings by discussing two selected European case studies. The paper is concluded with a discussion of some avenues for further research emerging from the analysis.

2 The past as prologue

Since the emergence of urban systems, advances in transportation technology have had a distinctive impact on urban forms, built environments and spatial patterns. The more radical the change, the more has been altered in the spatial structure. For a long time, traffic junctions and transportation facilities have functioned as nodes for trade of goods and knowledge, as well as platforms for communication and social interaction. Whether in ancient times or our contemporary world, transportation infrastructure is an initiator for supporting and shaping spatial development, and acting as a catalyst for further economic prosperity. Prior to the revolutionary 19th, 20th and 21st century improvements in transportation, animal-drawn carriages and merchant ships were the only forms of vehicular or maritime transportation that allowed for long-haul movement of commodities and people. Because of this, from a historical standpoint cities tended to be located alongside navigable rivers, canals or shorelines. However with the invention of the railway, streetcars and commuter trains, urban development started to radiate outward alongside of the railway tracks far into the hinterland of the cities. Similar to role played by harbours in the past, train stations soon became centers of urban development and new nodes of trade and communication. The upcoming mass motorization at the beginning 20th century brought a new break in the relationship between transport technology and urban development patterns. New dispersed spatial patterns appeared and highway intersections became highly popularized locations for commercial developments.

Thus, it can be deduced that new forms of transportation create new places and spatial structures. Since World War II, mobility has increased and many activities that were formerly centralized in the Central Business District (CBD), moved from the city

centers to the outskirts. With reference to airports, Edward J. Taaffe already stated in the mid 1950s that 'Canals, railroads, and highways, channeling the flows of traffic, have created new urban alignments, hinterlands and nodal points. Now air transportation promises to become a vital factor' (Taaffe 1956: 219). How appropriate Taaffe's assumption about interaction between airports and territorial development from the 1950's would turn out to be in contemporary settings is almost astonishing. This new role of airports as anchors of a new peripheral urban-like entity will be discussed in the next section.

3 Airports reconsidered: Evolving urban patterns at and around airports

From a lexical understanding, an airport is a large-scale, infrastructural facility or a point of interchange within the aviation industry where aircrafts, such as airplanes and helicopters, can take off and touchdown. Normally, airports are characterized by five core elements: runways and taxiing areas, the air traffic control building, aircraft maintenance buildings, passenger terminals and car parks, and the freight warehouses (Edwards 2005: 6). However, this very narrow, engineering-related definition falls short because it does not consider the current developments and dynamics that describe airports as a new multi-layered and self-contained spatial entities which they have become: a city or mall-like, multi-functional site and general-purpose public space where interchange takes place for and between a broad group of participants with diverse and flexible connections to local, regional, national and international market areas.

Forced by new general conditions within the international aviation industry, airport operators have started to open new business segments in order to realize

additional non-aviation revenues to supplement the traditional core business (e.g. ramp-handling, landing-fees etc.). In this context, airports have started to concentrate their engagement not only on supplying the core aeronautical infrastructure and services, but also on the development of the so-called non-aviation sector where commercial facilities and services play a key factor in terms of future growth (Deimler et al. 2004, Ringbeck et al. 2006). Such non-aviation activities can be comprised of retail developments and the implementation of new retail concepts like shopping arcades and malls, Michelin Star Award-winning restaurants, and other real estate developments such as offices, hotels, conference, exhibition and convention centers, hospitals and beauty facilities, leisure, recreation, museums, fitness facilities, and crematories. This developmental process is very often described by the term 'airport city'. Supposedly, this term was coined for the first time in 1960 when TIME magazine ran a five-page feature called 'Airport Cities, Gateway to the Jet Age' (Time Magazine 1960). Today, the term of airport city principally refers to 'the more or less dense cluster of operational, airport-related activities, plus other commercial and business corners, on and around the airport platform' (Güller and Güller 2003: 70). Already in 2004, the Boston Consulting Group (BCG) foresaw that the non-aviation sector would become a key factor in terms of future growth and profit of airports (BCG 2004: 10). Today, as clearly demonstrated in the cases of Oslo, Copenhagen, Munich or Zurich airports, non-aviation revenues already contribute around 50 per cent to the airport operators' profit (AT Kearney Consulting 2007, 2010). In this context, retail activities and office real estate developments in particular have become important for the airports' financial sustainability (Conventz 2008).

4 Knowledge, Airports and the Mega-City Region

4.1 The rise of the knowledge economy

The concept 'knowledge economy' as defined by Thierstein et al. (2006) refers to an interdependent system of advanced producer service (APS), High-Tech industries and knowledge-creating institutions such as universities and research establishments. Figure 1 depicts these three pillars of the knowledge economy. APS provide expertise, knowledge-based services, and process-specialized information for other service sectors and advanced manufacturers. Examples include financial service firms such as Price Waterhouse Coopers or KPMG, management consultancies such as Boston Consulting Group or Bain & Company, engineering firms like HochTief, architectural outfits such as Arup or Skidmore, Owings & Merrill (SOM), and logistics firms like UPS or FedEx . Because these services all generate, analyze, exchange and trade information, they are key intermediaries in the knowledge economy. The service they provide is enabled by internal links between APS offices all over the world as well as by manifold links with related companies and customers along their individual value chain. Additionally, because APS firms are expanding everywhere, flows of information within and between firms play a crucial role in linking cities to the global economy.

The High-Tech sector (including manufacturing) is defined by highly skilled employees, of which many are scientists and engineers, a fast rate of growth, a high ratio of R&D expenditures to sales, and a worldwide market for its products.

Advanced producer services and High-Tech firms constitute the main pillars of a knowledge-based economy. Cities are home to these operations, and hub cities play a key role as nodes in global knowledge networks, whether as intra-firm or extra-firm links.

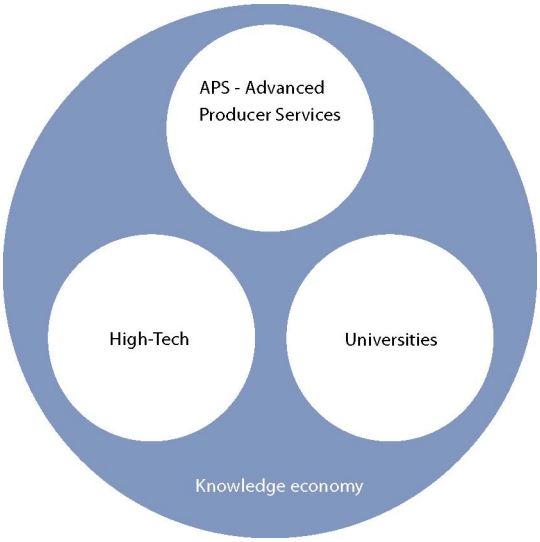

Figure 1: The three pillars of the knowledge economy

Source: Thierstein et al. (2006)

Knowledge is a key driver for the competitiveness of private companies as well as the urban and regional economies from which these companies are operating. Especially for privately held companies, knowledge is an important resource for innovation, which in turn, is a key driver for continued growth. Knowledge is a complex term offering different definitions and approaches, and therefore there is no commonly accepted definition (Lüthi 2011).

Following Polanyi's seminal classification, knowledge can be distinguished into codified or explicit knowledge on the one hand, and tacit knowledge on the other (Polanyi 1967). As opposed to tacit knowledge, explicit knowledge is codifiable, articulable, or storable – verbally, visually, or symbolically. New information and communication technologies offer the opportunity of increasingly codifying and commodifying knowledge and making it tradable across time and long distances, which means that codified knowledge becomes more and more de-territorialized. This enables

companies to outsource activities and inputs globally and to benefit from relational proximity and international knowledge spill-overs.

Once again, tacit knowledge is highly contextualized and not effectively transferable between individuals by certain media. With his well-known phrase 'we know more than we can tell' Polanyi (1967: 4) illustrates the fundamental idea of the distinction between explicit and tacit knowledge (Gertler 2003). Tacit knowledge in combination with personal experience is considered as an essential prerequisite in creative processes and innovation, and therefore as a foundation of the knowledge economy (Schamp 2003: 181).

Since the transfer of tacit knowledge requires direct face-to-face interactions, the findings of Michael Polanyi are not only important for firms, but also for regions. Innovative activities have been shown to be highly concentrated in a minority of urban regions (Simmie 2003). The main reason why these regions play an important role in the supply of knowledge is that firm networks benefit from geographical proximity and local knowledge spill-overs. Malecki describes this aspect as the 'local nature of knowledge' and highlights the necessity to accept knowledge as a spatial factor of competition:

> If knowledge is not found everywhere, then where it is located becomes a particularly significant issue. While codified knowledge is easily replicated, assembled and aggregated […], other knowledge is dependent on the context and is difficult to communicate to others. Tacit knowledge is localized in particular places and context […] (Malecki 2000: 110).

4.2 Significance of face-to-face activities and knowledge economy

The distribution and transfer of codified and tacit knowledge as well as the interplay between geographical and relational proximity forms a key basis for the development of polycentric Mega-City regions. Mega-City regions are the 'nodes of the global economy, location of creation of knowledge and also engines of the cultural development' (Goebel et al. 2007: 87). They bring into spatial proximity, dense spaces and diverse urban neighborhoods and other opportunities for information exchange. Increasingly, such places have popped up outside the traditional city centers. Following Hall and Pain's (2006) definition, a polycentric Mega-City Region is

> a series of anything between ten and 50 cities and towns physically separate but functionally networked, clustered around one or more larger central cities, and drawing enormous economic strength from a new functional division of labor. These places exist both as separate entities, in which most residents work locally and most workers are local residents, and as part of a wider functional urban region (FUR) connected by dense flows of people and information carried along motorways, high speed rail lines and telecommunication cables (Hall and Pain 2006:3).

In recent years airports have continued emerging as another powerful core with discernible impacts on urban structures. Edge Cities (Garreau 1991), City Ports (van Wijk 2007), Aerotropolis (Kasarda 2001), Airport Corridor (Schaafsma 2008) and Airport City (Güller and Güller 2003) are just a few of the expressions from an array of neologisms (cf. Lang 2000) that attempt to catch the new reality of polycentric spatial configurations. This newly defined spatial structure is based on two different but inter-related processes: agglomeration economies and network economies.

Agglomeration economies result from the clustering of knowledge-intensive firms in certain areas, enabling them to benefit from spatial proximity and local knowledge spillovers. Network economies, on the other hand, result from global sourcing strategies of knowledge-intensive firms leading to relational proximity and international knowledge spillovers. Based on this functional logic, we argue that polycentric Mega-city regions are the outcome of a spatial up-scaling of agglomeration economies and spatial re-concentration process of network economies. Figure 2 schematically depicts the inter-relationships between the knowledge economy, which follows a functional logic, and the emergence of Mega-City Regions, which are essentially the effect of a specific spatial logic at work.

On the one hand, the up-scaling process of agglomeration economies is determined by achievements realized in transportation and telecommunication technologies. The costs of certain modes of transport and communication have drastically declined, and, in some cases, speed and reliability have significantly improved. As consequence, polycentric Mega-city Regions are increasingly enabled to achieve agglomeration economies of comparable magnitude to those of large mono-centric cities.

On the other hand, the spatial re-concentration of network economies is determined by the location behavior of knowledge-intensive companies. In order to optimize their added value, knowledge-based companies need a set of local, supportive business conditions such as proximity to international gateway infrastructures, including airports and high-speed train nodes. In recent years, many international knowledge-intensive enterprises have already recognized the advantage of being located around airports and within the corridors between the airport and the former central city.

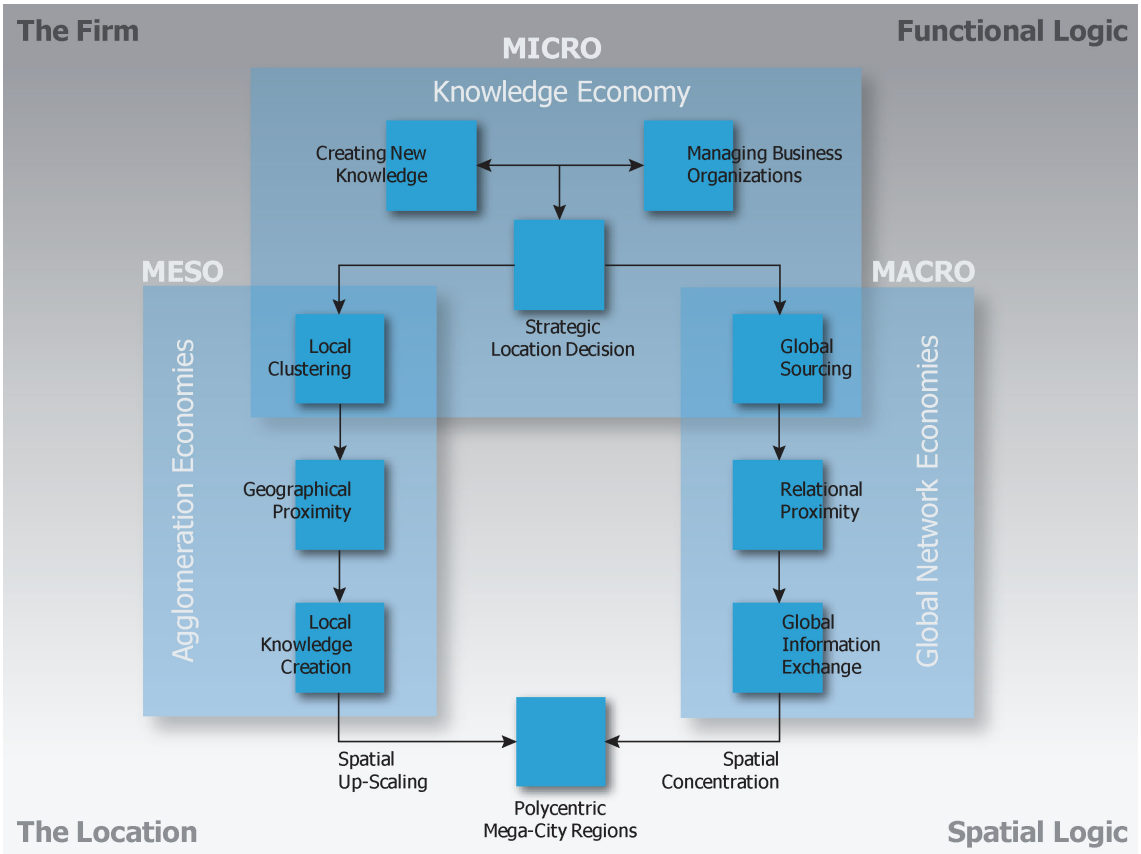

Figure 2: Agglomeration and Network Economies in the context of Mega-City Region development; Source: Lüthi et al. (2013)

The concentration of knowledge resources in particular Mega-city Regions influences the roles that these may play in the global economy. In addition, the dynamics of knowledge exchange within and between Mega-City Regions contribute to either the maintenance or change in roles within the functional urban hierarchy. This raises questions over the relative importance of regional versus international knowledge spill overs. Simmie (2003) shows that knowledge-intensive firms combine a strong local knowledge capital base with high levels of connectivity to similar regions in the international economy. Through this, they are able to combine and translate both

codified and tacit knowledge originating from multiple regional, national and international sources.

As previously stated, communicative devices facilitate the transmission of information. Through a cognitive performance new knowledge is generated. This creative process is not readily practicable via data transmission or by telephone. Instead, a common cultural, social or cognitive context and direct interaction are required, and very often the best medium is face-to-face communication. This is because the effective transfer of tacit knowledge necessitates the kind of trust built up through face-to-face interactions (Läpple 2001: 23).

> During the past half century, the faster pace of specialization, globalization, and technical change has profoundly altered companies, their customers, the supply chains around them, and, consequently, the nature of work within them and at their borders. The result is a dramatic increase in the volume and value of interaction (Beardsley et al. 2006: 2).

Research done by the consulting company McKinsey established that tacit interaction is central to economic activity and constitutes approximately 63 per cent of the employees' total work in insurance business, 60 per cent in securities companies, 70 per cent in healthcare, and 45 per cent in retailing.

4.3 Airports as network-infrastructure

Knowledge-intensive enterprises generate new knowledge locally through physical interaction. Generally, individual branches of a company are part of a global corporate network and are efficiently networked among each other. Short geographical distances between individuals, organizations or towns bring people together and enable them to

exchange tacit knowledge – the *je ne sais quoi* of any learning process –, which, once more, requires personal contact. The larger the distance between people or cities, the less chance there is of such exchanges occurring. Relational proximity, typified by people in far-flung locations collaborating on a shared project, is supported by a rich and diversified infrastructure of global travel and communication, including rapid and frequent trains and flights, sophisticated logistics networks. Nowadays continental high-speed trains and intercontinental hub airports fall under this category – to keep freight and people on the move, and provide easy access to a variety of facilities for real-time and interactive communication. APS and High-Tech firms involve a mix of geographical and relational proximity. Both proximities are counterparts of the knowledge economy and go hand in hand.

In this context, international airports and Mega-City Regions have become crucial for tacit interactions and international knowledge generation. Very often new and decentralized cores of urban activity have emerged close to areas of high accessibility such as high-speed railway stations or international airports.

Airports, especially those with a hub function, have evolved as locations where local, regional, national and global information exchanges overlap. Like no other infrastructure facility, airports integrate two locational qualities: worldwide connectivity by air and multimodal landside accessibility on a local, regional, national and sometimes international scale. With respect to the urbanization of airports and their hinterlands, landside infrastructure investments have become vitally important (Schubert and Conventz 2011). Once planned as simple airport train stations or a terminal stop of a single rail or metro line, the airport railway stations have become interchanges with key positions within the national and international high-speed train

systems, railway, and light rail networks (Güller and Güller 2003). According to Güller and Güller (2003: 131), the airport interchange can be defined as follows: 'Airport interchange is the airport railway station's function as node in landside traffic networks: it not only serves air traffic passengers and airports employees, but also uses to interchange between regional and national public transport networks (rail-rail, rail-subway, rail-bus, bus-bus…etc.)'.

5 The emergence of a new airport-linked office property landscape

Under the general framework of the global (time-based) competition, the potential and the locational advantages of airports as network- and service-infrastructure have become more integral than ever to cities, business models and the location decisions of a broad spectrum of industries. For cities, especially those exposed to global competition, urban competitiveness is highly determined by connectivity and networks (Jones Lang Lasalle 2002: 1, Taylor et al. 2011).

Cities increasingly set out to treat their airports not only as a 'foyer or entrée' to their urban area, but also as a way to provide a competitive advantage within the global competition for future-oriented enterprises and highly skilled employees, especially of the knowledge economy. In order to increase the attractiveness of airports and their hinterland as office sites to future service companies, many cities, airport authorities and other actors have started strategic develop of the locations in and around airports. One of the most prominent examples is Amsterdam's Schiphol airport, which was one of the first to discover and tap into the wide economic potential of the airport.

Owing to the unique locational qualities and advantages of airports described above, many knowledge-intensive enterprises have started to favor airports and their

vicinities as advantageous business sites. In the followingpaper, the new office locational patterns around two selected international hub-airports, Amsterdam-Schiphol and Frankfurt Rhine-Main, will be analyzed.

5.1 The case of Amsterdam-Schiphol

Under the conditions of globalization, the spatial outlines of Amsterdam as a city have been reconfigured. The urban system of Amsterdam and its growth pattern were once perceived as 'prototypical expansion of the mono-centric city' (Salet and Majoor 2005: 19). Beginning in the early 1960s and continuing into the present day, the historical inner city, characterized by channels, listed buildings etc., has not been able to fulfill the increased demand of large-scale leasing on the part of the rising service and knowledge economy. As a consequence, and as a result of new accessibility requirements, companies started settling in the surroundings of the urban ring road or sometimes even further away. Through this trend, the spatial formation of Amsterdam has gradually been transformed into a polycentric urban landscape. New concentrations of urban activities appeared for example at the southern edge of Amsterdam reshaping the area into a dynamic growth zone (Bontje 2005). In this context, Schiphol has become 'the most prominent growth engine […] and the largest employment concentration in the metropolitan area […]' (Bontje 2009: 193).

Amsterdam-Schiphol, located 17.5 km southwest of Amsterdam, is the Netherlands' main airport, Europe's 4th biggest airport and one of the world's major hubs in international air traffic. Moreover, Schiphol is one of the two hubs of Air France-KLM. Although named and recognized as Amsterdam-Schiphol, the airport is actually located in the neighboring municipality of Haarlemmermeer and not in the city

proper of Amsterdam. Through the different airline networks, virtually every major city or economic market in the world is reachable for Amsterdam-Schiphol. This integration of the airport into international air traffic is supplemented by an ideal landside connection through all means of transportation. By road, Schiphol is linked via two major highways – A4 and A9 – to downtown Amsterdam and the broader metropolitan area. By rail, Schiphol is directly connected to Amsterdam and to important western European business centers such as Brussels, Paris, Frankfurt, Cologne or Dusseldorf. Through only an eight minute train ride, the airport is also in close spatial linkage to the Zuidas, Amsterdam's rapidly developing business district where a new high-speed train station will be opened in the next years.

5.2 A new 'glocal' nexus of knowledge exchange

At the end of the 1980s, the master plan for Schiphol proposed for the first time the idea of realizing office projects in the central area within the loop of the access roads that bring people in and out of the airport area (Kloos and de Maar 1996: 82). Today, this strip is known as Schiphol-Centre and since the beginning of the 1990s, new office sites have gradually been built up (Kloos and de Maar 1996, Schiphol Group 2010). Currently, the total stock of lettable office space comprises nearly 200,000 m² of office space (Jones Lang Lasalle 2010: 9). In the future, the office stock at Schiphol-Centre will grow by another 8–15 per cent due to a number of projects in the pipeline, such as the extension of the Outlook Building (Jones Lang Lasalle 2009a: 11).

The construction activities of the office complexes were simultaneously accompanied by the construction of an increasing number of high-quality facilities such as hotels of different categories, or meeting and conference centers. Similar to the office

buildings, most of these premises are either directly linked to the terminal via walkways or promenades. All this helped to transform the location of Schiphol-Centre into a multifunctional and multimodal premium business site at the periphery of Amsterdam, which today is considered to be one of the top office locations in the whole of the Netherlands.

The high value of the airport sites is reflected in the office rents. In recent years, Schiphol-Centre has become the country's top office location, achieving the highest office rents countrywide. From 2004–2007, the recorded prime rents at Schiphol-Centre were at 350 €/m² per year (Jones Lang Lasalle 2009b 2010: 10). At the end of 2009, the annual top rent was around 365 €/m² (Jones Lang Lasalle 2010: 10). That was a decrease by 3 per cent compared with 2008 where a maximum of around 375 €/m² was reached (Jones Lang Lasalle 2010: 10). Since then, contractual agreements with maximum rents of 390 €/m² per year or even above have been registered (DTZ Zadelhoff 2009). In comparison to this, the South-Axis (Zuidas), the actual central business district of Amsterdam – halfway between city center and Schiphol Airport – reached rents of approximately 335 €/m² per year in 2009. In the city center itself, a prime rental value of around 255 €/m² was realized at the end of the fourth quarter of 2009 compared to 280 €/m² in 2008 (Jones Lang Lasalle 2009b 2010: 10).

Accordingly, two conclusions can be drawn: First, in the Amsterdam office market, contrary to what one might initially presume, it is not the city center which is the most expensive office location, but Schiphol-Centre at the city's edge. This is a remarkable difference when compared to other selected European top office locations such as London, Paris or Frankfurt.

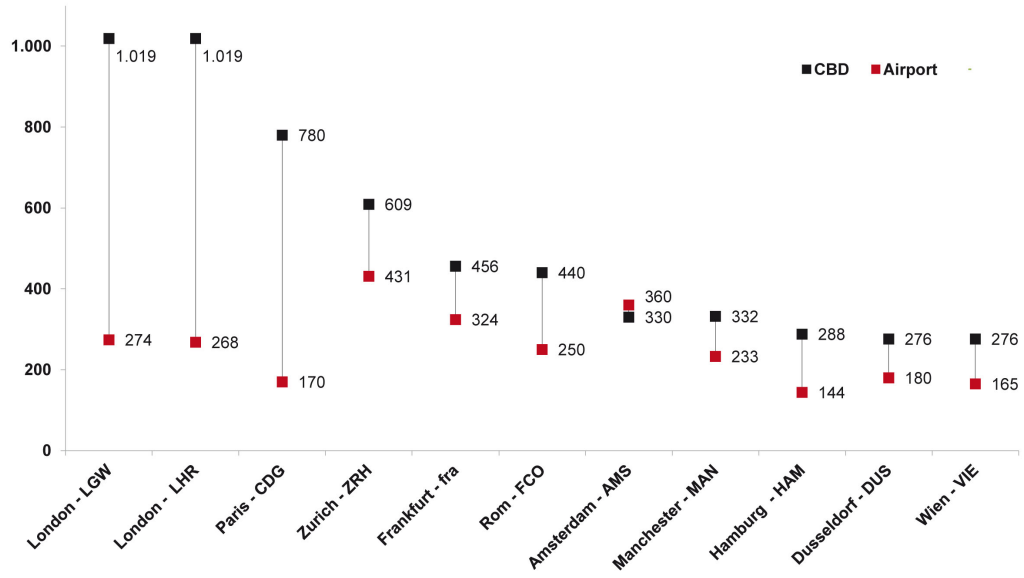

Figure 3: Selected annual prime rents for 2009 in €/m²

Source: own illustration, modified according to CB Richard Ellis (2009, 2010)

Second, despite the considerable turbulences, which have affected the real estate markets over recent years, the prime rents at Schiphol-Centre have remained relatively stable.

From the very beginning, the main strategy of the Schiphol Group was to attract companies that were either airport-related or had a strong affinity to the aviation business. However, scientific literature does not offer a standard definition for either of these terms. One approach defines airport-related companies as companies 'that have their business at the airport (such as airlines) or use the airport intensively (such as the head offices of international companies)' (Schaafsma 2008: 71). Indeed, Schiphol has been very successful in attracting internationally oriented companies offering superior business services, which have located their international or European headquarters at the airport. The demand for office space is generated from a broad spectrum of business

sectors such as finance, consultancy, traffic and transportation, government or healthcare. Among the office space occupiers are prominent companies and institutions such as the American Chamber of Commerce, AXA Investment Managers, Citibank International, the Dutch Infrastructure Fund and Delta Hydrocarbons (WTC Schiphol 2010). Hence, the demand comes from enterprises that are not directly related to the aviation business. Today, this submarket has reached a certain level of maturity that is characterized by a manageable amount of high quality office properties with different locational qualities and price ranges. Basically, the closer the office is to the passenger terminal, the higher the office rent is. Future prospects expect a further densification of the strip and new office constructions, such as for example the Gateway building (Conventz 2008).

5.3 The case of Frankfurt Rhine-Main

Frankfurt am Main is Germany's fifth-largest city and the center of the Rhine-Main Metropolitan Region. Furthermore, it is continental Europe's leading financial center harboring more financial institutions than any other continental European city. With its two long-distance train stations – Central Station and Frankfurt airport – the city takes a key a position within the Trans-European railway network. Worldwide, Frankfurt is known for its international hub airport which, with its more than 53 million passengers a year, is ranked in the world's top ten busiest airports. According to the summer flight schedule of 2011, Frankfurt Rhine-Main airport serves 298 destinations in 110 countries, which is more than any other airport in the world. The airport serves as hub for Lufthansa and Condor Flugdienst. Within the Rhine-Main Metropolitan region, the

airport is centrally located and only 12 km away from Frankfurt's city center. From the landside accessibility standpoint, the airport is connected by road, rail and bus.

5.4 Frankfurt airports as prime knowledge hub

In recent years Frankfurt Rhine-Main Airport and the premises around the airport have become prime sites for knowledge-based activities. Despite its peripheral location, the airport largely resembles the inner cities' prime rents. Only 6 minutes southwest of the office city of Niederrad and 15 minutes south of Frankfurt's CBD by public transit, the airport location collects a top rent of approximately 360 €/m² (BNP Paribas Real Estate 2011). Occasionally, contractual agreements with maximum rents of over 420–480 €/m² have been registered (Immobilienzeitung 2011).

The dynamic real estate and infrastructure developments as well as the increase in letting success have contributed to the circumstance that the airport and its vicinity are considered as prime commercial locations for knowledge-based services as well as conference and exposition sites. Currently, 366,000m² of office stock is available on the airport grounds alone. Including the locations surrounding the airport, the office stock comprises more than 576,000 m² gross floor area. The demand for office space is mainly generated by knowledge economy industries such as human resources, traffic and transportation, IT & telecommunications, computer industries, accounting and consultancies or healthcare. Today, leading companies in these fields, such as Arthur D. Little, KPMG, Dell, Oracle, Nortel or MasterCard, have already settled in or around the airport. Other enterprises, such as the logistic companies DB Schenker or Imtec, have contractually assured their intention to move to the airport. Today's office locations are the Frankfurt Airport Centre (FAC) I and II, Cargo City South, Air Cargo Centre /

Airbizz and Cargo City North, all being localized on the airport premises. In addition, there are office property sites that already exist, or are currently in the implementation phase, which are in close spatial linkage and sometimes within walking distance to the airport. Such locations are for example the Main Airport Centre (MAC), the Square, formerly known as AirRail Centre, and Gateway Gardens. Furthermore, there is office space projected at the Mönchhof Area and at the Airport Office Centre (Fraport 2012).

New office real estate developments like The Winglet, The Cockpit or The Propeller will provide for a substantial contribution to the revenues of Fraport, the owner and operator of the airport, as well as to the locations' reputation as knowledge hub. According to Fraport, the need of airport office space due to the airport expansion is expected to increase from around 500,000 m² currently to approximately 650,000 m² in the year 2015. Office stock that is out of date or not in line with the market requirements will be taken out of the market (Hommerich 2006). Consequently, the current office stock will decrease by the year 2015. At the same time, modern office estates will gradually substitute this dated stock. These construction activities reflect the location's high dynamics as a new place for knowledge-based activities.

6 Discussion and conclusion

Just as much as people were attracted to ports, railway stations and motorway intersections in centuries of the past, airports have rapidly become new urban growth generators, hubs of information and knowledge exchange, and centers of competence. The accessibility profile of international hub airports again induces a multitude of economic and regional catalytic effects such as settlement of companies, employment development, or stimulation of innovation, etcetera (ECAD 2007: 4). In recent years

airports have become vital growth poles for urban and regional economies and centers of a new post-industrial spatial structure. As fundamental nodes of the networked post-Fordist knowledge society, airports take center stage within the knowledge creation and the organization of chains of economic value added. Once planned as spatially seldom-integrated solitaires at the cities edge, airports have morphed into network and service infrastructures and places of highest centrality and accessibility. Like no other infrastructure facility, many European airport locations integrate two cores, contemporary spatial qualities: worldwide connectivity by air and multimodal landside accessibility on local, regional and national scales.

As the examples of Schiphol and Frankfurt illustrate, airports are no longer mainly perceived as transportation nodes, but more generally as advantageous business sites. Multimodality of transportation infrastructure combined with an extensive business infrastructure is understood as a crucial competitive and developmental advantage within the international time-based competition. With the expanding floor space for office-based services in and around international airports, a new urban locational pattern is evolving. This kind of locational quality is exactly tailored to the locational requirements of knowledge-intensive companies. The willingness of those customer groups to pay top rents, i.e. far above the average, reflects the demand for such locations.

The recentralization of new functions formerly localized in the central city and the shifting perception of airports enable airports to appear as a modern kind of marketplace (Gottdiener 2001, Edwards 2005) where people can convene, exhibit, trade and change information. Thus, airports are in no way inferior to historic marketplaces of

the medieval city such as Brussels' Grand Place. Hence, with the history of airports, the history of markets is repeated.

Although Airports have grown out of their niche as pure infrastructure facilities and morphed into attractive real estate sites, the complex dynamics that are taking place in and around international airports represent a crucially understudied element in the post-industrial restructuring of urban and regional systems. From our point of view, one of the most important keys in understanding these processes and dynamics are the locational requirements and changing internal and external value chains of knowledge-intensive companies. Thus, future research activities must deal with the following specific aspects. Firstly, in order to understand the spatial alteration around airports more thoroughly, we need a conceptual-analytical approach – an impact model – that combines the complex and multi-sided interplay between location strategies of knowledge enterprises, geographical proximity, airport-linked real estate developments and the way airports are used within the process of knowledge creation. Secondly, future research must place a special focus on intra-firm and extra-firm linkages of APS and High-Tech firms that are settled in the vicinity of airports. Thirdly, an additional qualitative investigation needs to be carried out, for example by means of qualitative network analysis. The combination of these approaches makes it possible to identify the role an airport plays and the potential it has within the site selection and the organization of value chains of knowledge-based companies.

Lastly growing inter-relatedness between hub airports, urban development and the knowledge economy certainly can have drawbacks. They may consist of an overly high degree of mutual dependency. Therefore a serious challenge for analysis, as well as for urban planning, is how to integrate urban functions more wisely in order to render

the emerging structures more robust against the volatility of either natural disasters or external economic shocks. And, finally, new methods of analyzing and visualizing airport-linked spatial developments need to be established in order to show and understand the changing role and potentiality of airports. Raising awareness of the spatial drivers is a prerequisite for sustainable and forward-looking planning at urban and regional level.

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