PHD THESIS

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MATERIALIZED FLOWS OF KNOWLEDGE: AIRPORTS AS NEW NUCLEI OF A NETWORK-BASED OFFICE LANDSCAPE

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Materialized flows of knowledge:
Airports as new nuclei of a network-based office landscape

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Cover picture (above):

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The interplay between airports and spatial reconfiguration processes has dominated my research activities in the recent past. Of particular interest was the changing role of airports within the knowledge economy context. The current dissertation represents the conclusion of these research endeavours.

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In total, the current publication-based dissertation consists of four articles that are already published. These publications have been chiefly compiled by the doctoral candidate. In this regard, the performance contribution of the PhD-candidate encompasses the development of the research concept, the interpretation of the empirical findings and finally, the structuring and writing of the papers. Within this process, Prof. Dr. Alain Thierstein served as adviser, commentator and discussion partner.

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Summary

English

Beginning with the emergence of urban systems, cities have evolved in a mutually inter-dependent process of socio-economic dynamics and transportation linkages. Historically, urban centers have emerged at the convergence of lines of communication: port-cities at navigable rivers or shorelines, highway-cities along motorways, and railway-cities at suburban railways or main lines. Throughout history urban competitiveness, growth, and economic prosperity of cities have been highly influenced by their connectivity and hierarchical positions within city networks.

Most recently airports have emerged as another powerful focal point of spatial development with a center of competences distinguished by their unique accessibility and connectivity profiles. Formerly planned as stand-alone facilities in city peripheries, airports – particularly those with a hub function – have far surpassed the stage of being simply infrastructural facilities and service providers for airlines. Instead airports have and continue to morph into attractive real estate sites and centers that increasingly resemble urban patterns. Hence, air transportation is gradually creating a completely new spatial pattern, as other kinds of transportation modes did in the past. In this context, two interwoven processes can be identified as the stimuli to the transformation of airport space and its adjacent areas. The first momentum stems from the changed operational environment of airport operators and the shrinking revenues associated with the traditional core businesses. Worldwide, the business environment of airports has fundamentally changed so much that airport operators have been forced to reorient their business areas in consequence.

The second – and here more important – momentum can be traced back to the growing importance of the knowledge economy and the way in which knowledge-intensive companies generate new knowledge. The manifold process of knowledge generation requires places that stimulate interaction. Where accessibility is highest and agglomeration advantages unfold their positive cumulative causation, the likelihood increases that people meet other people, interacting, exchanging information, learning from each others successes and failures, and eventually generating knowledge through personal interaction. Set on the stage of increased global competition and the development of new businesses, the potentiality and the locational advantages of airports as network and service-infrastructure have become more integral than ever to such changes.

The aim of the present dissertation is to gain a new understanding of airports within knowledge economy context and the role which airports play within the reshaping of real estate markets. The reasons why knowledge-based activities located at and around international airports have not been understood up until now. It remains to be clarified if and how knowledge-intensive companies support the transformation of airport space through their location decisions. What are the reasons that make airports and their adjacent areas attractive locations for knowledge-intensive companies? Which general relationship exists between international airports and companies from the knowledge economy? Which role do international airports have within the knowledge creation process as well as the business

practices and optimization of firm-internal and firm-external value-added chains?

The dissertation postulates a systematic linkage between three basic components: 1. the existence of an airport which in the best case offers a hub function, 2. location requirements of knowledge-intensive companies, and 3. the development and qualification of urban structures. Suspended in this triad a cumulative transformation process is initiated in which physical proximity, relational proximity, accessibility advantages and locational qualities for knowledge-intensive companies and their employees go hand and hand and are mutually supportive.

In order to answer the questions raised above, a new and innovative methodological approach was elaborated to provide an entry point into the discussion. This methodological approach is comprised of both quantitative and qualitative research actions, such as an Interlocking Network Analysis, a value chain analysis and a series of qualitative interviews with decision makers. The qualitative interviews make an important contribution to the quantitative research steps and provide more analytical insights. Four thematic cores have been of particular interest during the interviews: the location strategies and dynamics, the intra- and extra-firm linkages along the value chain, the communication habits, and the role of spatial and relational proximity.

The results of the dissertation show that the complex ways of knowledge generation are contributing to the reshaping process of spatial units. In order to stay competitive, knowledge-intensive activities are increasingly forced to source their knowledge from different spatial scales. Today, knowledge exchange is happening across multiple locations and the passage of time has diversified the ways in which knowledge is generated, both firm-internal and firm-external. Improvements in transport and telecommunication technology have led to profound improvements in terms of the formation of new networks and the interaction within established networks. In this context and heavily influenced by these advancements, airports have increased in significance due to their role as an interface between landside and airside means of transport. In contrast to other traffic infrastructure facilities, airports integrate two locational qualities: worldwide connectivity by air and multimodal landside accessibility on a local, regional and national scale. The results indicate that multimodal integration of the airport and its adjacent areas into powerful means of transport in combination with efficient service infrastructures, have raised the status of airport locations for knowledge-based activities. From a strategic vantage point, knowledge-based firms – especially those who consider geographical and relational proximity as crucial within the optimization of their value chains – make use of the accessibility and infrastructure advantages of the airports and their surroundings. Specifically, the results indicate that the airports of Amsterdam, Frankfurt, Munich and Düsseldorf are more and more perceived as advantageous business sites by knowledge-intensive enterprises. Through locational choice for the benefits provided by airports and their adjacent areas, the knowledge economy has emerged as an important spatial driver within the transformation of airports and their vicinities.

Summary

German

Städte befinden sich heute in einem räumlich weit ausgreifenden Wettbewerb. Die Kompetitivität von Raumeinheiten, wie zum Beispiel Städten oder Regionen, wird in hohen Maße durch ihre Integration in Netzwerke bestimmt. Die erleichterte Durchlässigkeit nationaler Grenzen für Güter, Dienstleistungen, Personen und Kapital hat genauso dazu beigetragen wie die in den letzten Jahren sukzessive gesunkenen Preise für die Nutzung von Mobilitätsangeboten und -infrastrukturen. Vor dem Hintergrund der wachsenden Bedeutung der Wissensökonomie sind wissensintensive Prozesse und Dienstleistungen zum zentralen Wettbewerbsfaktor für Unternehmen und Wirtschaftsregionen geworden. In der Wissensökonomie wird wissenschaftliches Wissen systematisch zur Schaffung von neuem, anwendungsorientiertem Wissen eingesetzt. Dadurch wird die Ressource „Wissen“ zu einer dominanten Triebkraft für die Entwicklung neuer wirtschaftlicher Gravitationszentren.

Flughäfen regeln als raumgebundene Infrastruktur in erster Linie den reibungslosen Ablauf des Luftverkehrs. Diese verkehrstechnisch zwar zutreffende Kurzbeschreibung von Flughäfen greift jedoch im Hinblick auf die gegenwärtigen Entwicklungen an internationalen Flughäfen zu kurz. Flughäfen entfalten heute verstärkt stadtbildende Kräfte und verdichten sich zunehmend zu Interaktionsräumen wissensintensiver Aktivitäten sowie zu Informations-, Geschäfts- und Wissensdrehscheiben. Diese Entwicklungsprozesse und Dynamiken umfassen nicht mehr nur das unmittelbare Flughafengelände, sondern strahlen weit in das Umfeld der Flughäfen aus. Ehemals solitär verortete Flughäfen bewegen sich zunehmend auf ihre „Mutterstädte“ zu, welche wiederum die Potentialität ihrer Flughäfen und deren Umfelder erkennen und beginnen, diese strategisch zu planen.

Am deutlichsten zeigt sich der Wandel des Standortkomplexes Flughafen an den großen internationalen Drehscheibenflughäfen wie zum Beispiel Frankfurt oder Amsterdam, wobei auch sogenannte Sekundärflughäfen wie Düsseldorf eine solche räumliche Entwicklung erkennen lassen. Was als Standortstrategie und Investitionsentscheidung einer einzelnen wissensintensiven Unternehmung daherkommt, ist in der Summe Auslöser und Treiber einer neuen räumlichen Dynamik. Flughäfen haben damit den Entwicklungspfad eingeschlagen wie in den zurückliegenden Jahrhunderten bereits Bahnhöfe, See- und Binnenhäfen oder Autobahnkreuze.

Das Ziel der vorliegenden Dissertation ist es, ein neues Verständnis für Flughäfen im wissensökonomischen Kontext und ihre Auswirkungen auf Immobilienstandorte zu gewinnen. Die kleinräumigen Auswirkungen dieses Prozesses auf die Raumstruktur sind bislang wenig erforscht. Es ist zu klären, ob und wie wissensintensive Unternehmen mit ihren Standortanforderungen die Transformation von flughafennahen Immobilienstandorten unterstützen. Welche wissensökonomischen Raumstrukturen lassen sich an den Flughäfen Frankfurt, München, Düsseldorf und Amsterdam erkennen? Worin begründet sich die Attraktivität dieser Flughafenstandorte für wissensintensive Unternehmen?
Die Dissertation postuliert hierbei einen Wirkungszusammenhang zwischen drei Grundkomponenten: 1. Anwesenheit eines (Hub)Flughafens, 2. Standortanforderungen von

wissensintensiven Unternehmen und 3. Entwicklung und Qualifizierung von urbanen Strukturen. In dieser Konstellation wird ein rückgekoppelter, sich selbst vorantreibender räumlicher Transformationsprozess in Gang gesetzt, in dem physische Nähe, relationale Nähe, Erreichbarkeitsvorteile sowie Zugänglichkeiten zu Lagequalitäten für Unternehmen und deren Beschäftigten sich gegenseitig in die Hand spielen.

Zur Beantwortung der untersuchungsleitenden Fragen wurde eine innovative Methodenkombination erarbeitet, welche einen Zugang zur Thematik bietet. Dieser Ansatz umfasst neben der Analyse firmeninterner Standortnetze mit Hilfe des Interlocking Network Modells gemäß Taylor auch die Analyse von firmenexternen Standortnetzwerken. Qualitative Interviews ergänzen die quantitativen Untersuchungsschritte und liefern weitere analytische Erkenntnisse. Vier Schlüsselthemen stehen im Rahmen der Interviews im Vordergrund: 1. Standortstrategien und räumliche Organisationsstrukturen wissensintensiver Unternehmen, 2. lokale, regionale, nationale, europäische und globale Netzwerkstrukturen der Unternehmen entlang der Wertschöpfungskette, 3. persönliche Netzwerke der Interviewpartner, Interaktionen und Kommunikationsgewohnheiten sowie 4. die Rolle des Flughafens im Rahmen des Standortentscheidungsprozesses.

Die Ergebnisse zeigen, dass der Einsatz von Wissen im Sinne einer Kombination von wissenschaftlichem und erfahrungsgestütztem Wissen in den unternehmerischen Wertschöpfungsprozessen zur Re-Konfiguration von Standorten und Standortmustern beiträgt. Die sich verstärkende Globalisierung zwingt Unternehmen zur feingliederigen Arbeitsteilung mit räumlich funktionalen Wertschöpfungsketten. Dabei greifen wissensintensive Unternehmen auf weltweite Wissensquellen zurück. Austauschbeziehungen über mehrere Standorte hinweg sind dabei sowohl innerhalb der Unternehmen als auch zwischen den Unternehmen in den letzten Dekaden vielfältiger geworden. Begünstigt werden Netzwerkbildung und -organisation durch die tiefgreifenden Verbesserungen von Netzwerkinfrastrukturen in den Bereichen Verkehr, Information und Kommunikation. Vor dem Hintergrund der wachsenden Bedeutung der Wissensökonomie haben Flughäfen aufgrund ihrer Schnittstellenfunktion zwischen Luftverkehr und terrestrischen Verkehrsträgern und ihrer Netzbildungsfähigkeit an Bedeutung gewonnen. Das einzigartige Zusammenspiel aus multimodaler Integration in diverse leistungsfähige Verkehrsträger sowie die Schaffung einer hochwertigen Dienstleistungsinfrastruktur hat die Standortwertigkeit von Flughäfen und deren Umfelder für wissensintensive Unternehmen erheblich erhöht. Wissensbasierte Unternehmungen – vor allem jene für welche sowohl relationale als auch geographische Nähe im Rahmen der Optimierung ihrer Wertschöpfungsbeziehungen entscheidend ist – nutzen heute gezielt die Erreichbarkeits-, Zeit-, Kosten- und Infrastrukturvorteile der Immobilie „Flughafen“. Die Ergebnisse verdeutlichen, dass die Flughäfen in Frankfurt, München, Düsseldorf und Amsterdam nicht mehr als einfache Infrastruktureinrichtungen wahrgenommen werden, sondern als vorteilhafte Geschäftsstandorte. Durch die Standortwahl zugunsten von Flughäfen und deren Umfelder entwickelt sich die Wissensökonomie zunehmend zu einer treibenden Kraft innerhalb des Transformationsprozesses von Flughäfen und deren Umfelder.

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1 Introduction

At the beginning of the first decade of the 21st century, it was proclaimed that “airports are not just airports any more” (Güller and Güller, 2003). And indeed, since the first introduction of the airport concept, airports have gone through a transformation process from small terminal facilities with planned arrival and departure halls into complex technical, commercial urban and regional activity centres. The reasons for this constant process of development are manifold and result from the progress made in the area of aviation technology since the 1960s, and the concomitant increase in the carriage of goods and passengers along with the changed market environment of airport operators.

While the novelty of flight and flying has faded for the majority of travellers, air transportation is still one of the most critical methods of travel, continuing to bring people and commodities one step closer to their respective destination, but never being the sole destination itself. In economic terms, it is demand derived from the ubiquitous deployment of internet access that has increased the need for face-to-face contact with other people in other places. Airports serve as interfaces between landside activities and airside passenger or cargo services, but in the recent past and continuing into the present, airports have become more than purely infrastructural facilities. In particular, hub airports function as international network and service infrastructures (Conventz and Thierstein, 2013), which have a decisive impact on nearby firms competitiveness and the stimulation of the surrounding urban development. Worldwide, airports have morphed into new focal points of spatial and economic development (Airports Council Europe, 2004; Ernst Basler + Partner AG, 2010; Schaafsma et al, 2008) serving as a “gateway of the metropolitan economy” (Roost and Volgmann, 2013), “network magnets” (Budd, 2011), “city branding hotspots” (Freestone and Baker, 2011a) or simply as “windows to the world” (Foster and Abel, 2010).

Airports are among the largest infrastructural investments cities and regions can make and are “perhaps the most important, single piece of infrastructure in the battle between cities and nations for influence in, and the benefits of, growth and development” (O'Connor and Scott, 1992: 241). Like no other means of transport, airplanes embody velocity and agility, a basic condition for companies operating in a time-driven global economy. In the context of the growing knowledge-economy, airports provide not only the connection to other places but also the ability to bring in knowledge carriers to a certain city or region from virtually any place on earth. Without airports, the dimension and quality of globalization as we are experiencing it today would be hardly conceivable (cf. Urry, 2007).

Although airports in the early days of aviation were symbols of progressive thinking and a starting point for utopian urban planning (Gordon, 2004; Le Corbusier, 1987), and although the deep impacts of airports on spatial structure have been known since the 1950s (Taaffe, 1956), for a long time since, research on airport-linked spatial development has not attracted much attention within space-related disciplines such as economic geography. This is somewhat surprising, as airports continue to morph into urban-like entities and sites of permanent or temporary knowledge generation. This transformation process has been

ongoing for some time now. Kunzmann thus states that airports are among the places where the transformation process of metropolitan regions becomes most apparent (Kunzmann, 2001: 216).

The present dissertation adds to the emerging body of literature related to airport-linked spatial development and reflects the changed role of airports from a knowledge economy perspective.

The remainder of this introductory chapter is organized as follows. Firstly, in order to gain a deeper understanding of the subject matter, it is helpful to look briefly at the complex interplay between technological changes in modes of transportation and their impacts on rewriting urban and metropolitan geography. Secondly, I will discuss the morphogenesis of airports from pure infrastructural facilities into multifunctional real estate sites and new foci of spatial development. Thirdly, the literature will be reviewed. In this part, special attention is paid to literature focusing on the economic impacts of airports on different spatial scales, as well as on literature dealing with new spatial patterns and spatial uses at and around airports. Based on the literature review the research gap is identified in section five. Section six provides an overview of the aims of the dissertation, the research design, the research questions and hypotheses. The research methods will be discussed in section seven, while the eighth and last section of this introductory chapter presents the outline of the current dissertation summarizing the content of the individual chapters.

1.1 The past as prologue

From the beginning of the incurrence of urban systems there has been a mutual interplay between technical improvements on the one hand and spatial development on the other hand. This holds especially for advances in transportation technologies. Since ancient times traffic junctions have served as starting points for the development of human settlements, transhipment points and as platform for social interaction and communication (Conway 1993).

The invention of different forms of mass motorization like the ship, the railway, the streetcar or commuter trains and finally the invention of the automobile at the beginning of the 20th century brought all new breaks in the relationship between transport technology and urban configurations. Simultaneously with the emergence of these transport carriers the correspondent infrastructure systems – that is to say the harbor, the railway station, the street car stop etc. – have evolved as new focal points from where spatial development processes have started to radiate into the hinterland. Whether in the past or the world of today, one thing has not change: traffic junctions and land-based transportation infrastructures are drivers of spatial development and economic prosperity (Conway 1993).

In this context the invention of airplanes has opened a new chapter and similar to land bounded means of transport the impacts of airplanes and air transport on the built environment have been tremendous. Especially in the period after World War II the airplane and air traffic have experienced a great dynamic which has been mainly stimulated by a process often referred to as “the democratization of air transport”. This has been catalysed

by commercial jetliners since the late 1950s and 60s. Deregulation and price discounting in the 70s, 80s and 90s all helped to make transoceanic and transcontinental air travel commonplace. With reference to airports, Edward J. Taaffe stated in the mid 1950s that: “Canals, railroads, and highways, channelling the flow of traffic, have created new urban alignments, hinterlands and nodal points. Now air transportation promises to become a vital factor“ (Taaffe, 1956: 219). How accurate 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 urban-like entity will be discussed in the next section.

1.2 Airports as centres of a new spatial entity

The metamorphosis of airports over the last one hundred years from basic airstrips into the complex airport buildings of the latter half of the twentieth century was hardly predictable. In the pioneering days of aviation, simple cow pastures, so called Aerodromes, such as the famous Huffmann Prairie near Dayton (Ohio) sufficed as “airports” (Pearman, 2004). Since that time, the development of airports has gone through different phases never remaining in a fixed form for long (Wijk et al., 2011). While the pre-World War II airports were situated in close spatial linkage to urban structures – for example Berlin Tempelhof, Nuremberg or Hamburg – the situation changed in the “Jet-Age” of the late 1950s. A fundamental redesign of airports was required and operational and safety concerns dictated that they be relocated to the urban fringe, where they became mechanistic functional solitaires characterized by massive land consumption (Pearman, 2004). Over the last few decades, however, the role of airports has changed significantly from pure service providers for the aviation industry into multi-layered network and service infrastructures serving every sort of passenger and non-passenger target group (Conventz and Thierstein, 2013). According to van Wijk et al. (2011) and with reference to Hartwig (2000) the development of airports into more urban-like entities has occurred in four steps starting “from an air-station (1960s) with a shopping center (1970s) to a business centre (1980s) and an entertainment and leisure centre in 1990s” (Wijk et al., 2011). In this context, Knippenberger speaks of the discovery of “airports as real estate” (Knippenberger, 2012: 11), a circumstance which can be traced back to the new general conditions within the international aviation industry (Jarach, 2001). Such new general conditions are, for example, the liberalisation and deregulation of the aviation sector.

As a result of this new market situation, airport operators have been forced to re-examine their strategic alignments. Moreover, they have been forced to identify and to implement new business models in order to generate additional non-aviation revenues. In this context, airport authorities have shifted their focus from the airside of the terminal to the landside, and have pushed commercial real estate developments, especially in the field of retail and offices (Oechsle, 2005; Schubert and Conventz, 2011). Jarach (2001) identities five main activity fields of non-aviation revenues: Commercial services, tourist services, meeting and incentive services, logistic services, and consulting services. Occasionally, as for example clearly demonstrated in the cases of Oslo, Copenhagen, Munich, Frankfurt or London airports, non-aviation activities already contribute around 50 per cent or more to the airport operators’ profits (Warschun, 2007; Fraport, 2012; Flughafen München GmbH, 2012).

1.2.1 The airport city

Today's airports increasingly resemble urban-like entities, often circumscribed with the term "airport city". According to Güller and Güller, the term 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).

Following Jarach, the evolution of airports towards "a multi-point, multi-service, marketing-driven firm" is a gradual process based on two momentums (Jarach, 2001). The first momentum is the integration of the airport into landside traffic systems and thus the development of the airport from a mono-modal infrastructure facility to a "multimodal hub" (Jarach, 2001). In the best-case scenario, airports become what Güller and Güller call an airport interchange (Güller and Güller, 2003: 131). In their view, the airport interchange can be defined as follows: "airport interchange is the airport railway station's function as a node in landside traffic networks: it not only serves air traffic passenger and airport employees, but is also used to interchange between regional and national public transport networks (rail-rail, rail-subway, rail-bus, bus-bus, etc.) […]. Airport interchange requires the convenient interconnection of all modes of transport" (Güller and Güller, 2003: 131). Best practice examples, when dealing with European examples, include Frankfurt Rhine-Main, Amsterdam Schiphol or Zurich Kloten, where the airports have achieved key positions within the national and international high-speed train systems, railway, and light rail networks. Frankfurt, however, is largely unique and can be considered the most ideal-typical example of a multimodal hub. Like no other place in the world, Frankfurt airport benefits from the synergetic interplay between landside and airside transport carriers. While the airport as one of the major international transfer airports functions as hub on the airside, the airport train station as one of the country's top high-speed railway stations fulfils the hub function on the landside. This unique double hub function has made Frankfurt airport and its adjacent areas as one of the best-connected places in the world.

Multi-modal integration of the airport is an essential perquisite for the second momentum; the establishment of the airport as multifunctional service infrastructure or as "multipoint service-provider firm" (Jarach, 2001). In developing the airport in this way, airport operators exploit new target groups beyond the traditional airport user groups, such as local community residents, firms and firms' employees directly or indirectly operating inside the airport's catchment area, tourists, or aviation enthusiasts (Jarach, 2001: 123).

Despite the popularity of Güller and Güller's definition of airport city (2003), no commonly accepted definition has been elaborated in academic research, media or the real estate industry up to the present day. There are airport city definitions that differentiate with regard to the specific characteristics of airport cities but also definitions that differentiate with regard to the spatial extension (Schubert and Conventz, 2011). In terms of spatial extension, the existing literature distinguishes between an airport in a narrow sense and an airport city definition in a wider sense. Airport city definitions in a narrow sense only include commercial developments on the airport platform itself. In some cases, smaller annexes that are logistically, functionally and organisationally linked to the airport may also be included. By contrast, the wider definition of airport cities includes, in addition to the airport platform and some additional areas outside the airport fence, the adjacent city or the whole region (Schubert and Conventz, 2011).

1.2.2 The aerotropolis

In recent times, many international airports – especially those with hub competence – and their operators have been extremely successful in attracting companies from a broad spectrum of industries, for example, finance, retail, healthcare, consultancy, media and advertising, engineering, information and telecommunication, accounting, or real estate development (Conventz, 2010). With the increasing settlement of businesses near airports and along corridors radiating from them, a new spatial entity within the metropolitan geography – the aerotropolis – is emerging (Kasarda, 2000, 2004; Kasarda and Lindsay, 2011). First coined by Kasarda, the aerotropolis concept describes a new urban form "with the airport and its immediate area serving as a multimodal transportation and commercial nexus, strings and clusters of aviation-oriented business parks, logistics parks, industrial parks, distribution centres, information-technology complexes, and merchandising marts are forming along connecting transportation corridors stretching as far as 15 miles (24 kilometres) from the airport itself" (Kasarda, 2004: 92). Similar to traditional cities, which are centred around city cores, the aerotropolis is anchored by the airport city (Freestone and Baker, 2011). Kasarda argues that the aerotropolis is nothing less than the spatial articulation of what Toffler (1990) once defined as the new dictum of the "survival of the fastest" within a continually faster moving global economy: "Since the end of World War II the world has become split between capitalist and communist, North and South. Today, as these old divisions fade in significance, a new one arises. […] In fast economies, advanced technology speeds production […]. Even now, however, well before real-time operations are achieved, time itself has become an increasingly critical factor of production" (Toffler, 1990: 389). With regard to the growing time sensitivity of economic activities, Kasarda predicts that accessibility will grow in importance as the most important site selection criterion (Kasarda, 2004: 95). Most recently, aerotropolii developments have been initiated around the world, including examples such as Denver, Washington Dulles or Memphis in the United States, Beijing, Singapore or Seoul Incheon in East or Southeast Asia, Dubai in the Middle East, or Amsterdam-Schiphol and Helsinki-Vantaa in Europe (Aerotropolis-Website, 2014). In the recent past, however, the open-space related concept of aerotropolis has faced a growing number of critiques. In particular, Charles et al. (2007) raise serious critical questions. They particularly stress the unsustainability of the concept as a result of its strong focus on the aviation industry and the sprawling character of the aerotropolis development. Moreover, the question as to what extent the aerotropolis model is helpful for sustainable development of airport induced spatial patterns, for example, in other spatial contexts like Europe is controversial (cf. Braun and Schlaack, 2014).

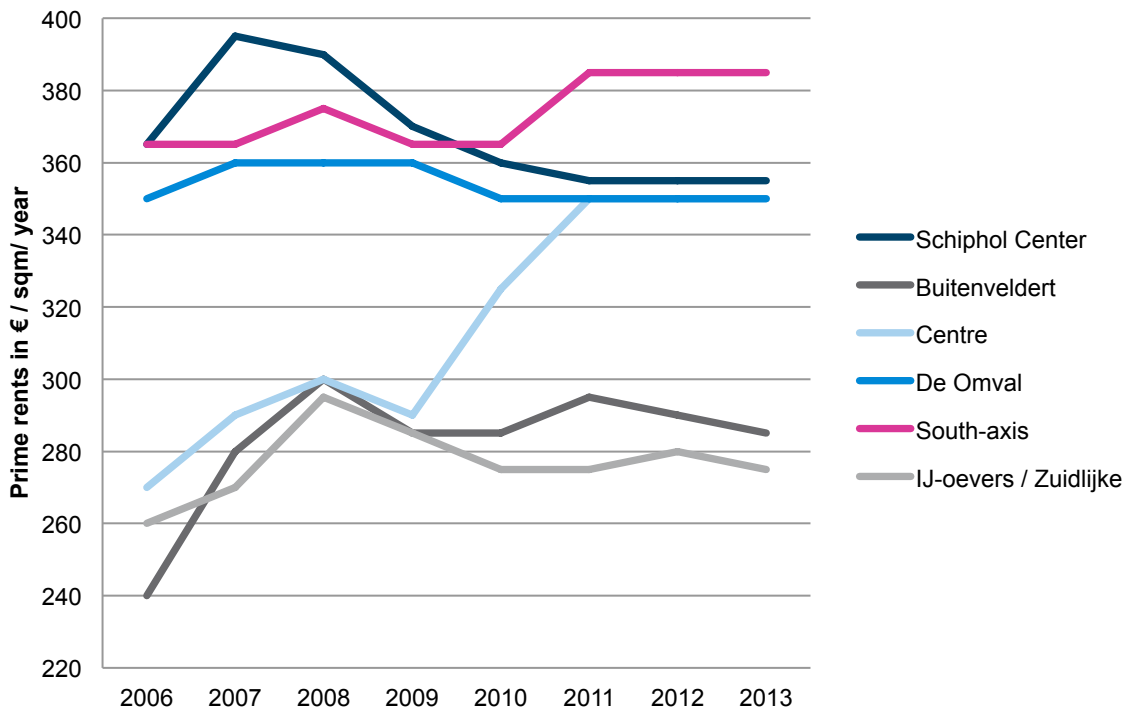
1.2.3 The airport corridor

In contrast to the airport city and aerotropolis concepts, the airport corridor concept is a linear concept, which contains the area between the city center and the airport (Schaafsma, 2003: 35). The airport corridor concept has its origin in the airport city model in Dutch planning and practice and literature (Machedon, 2012: 12). Airport corridor developments are the spatial manifestations of the interaction between “global flows and players and local conditions” (Schaafsma et al., 2008: 106). In many cases, this spatial entity has evolved as a powerful economic unit and one of the main drivers within city regions (Schaafsma et al., 2008). Following Schaafsma et al. (2008), airport corridor development depends on a range of factors. These are: Size of the airport, institutional setting, location and context, structure of the regional economy and landside transportation networks (Schaafsma et al., 2008: 103). Airport corridor developments take place worldwide. The most prominent airport corridor examples in Europe are in Amsterdam, Copenhagen, Helsinki or Zürich. In the United States and Asia airport corridor developments have been initiated in Denver, Washington, D.C., Dallas, Seoul, Kuala Lumpur or Hong Kong. According to Schaafsma (2010) the following challenges are present for airport corridor development: Synergy, spatial integration and governance (Schaafsma, 2010: 177). Synergy refers to the different actors such as cities, airlines and airport and their respective interests. The main challenge is to develop the synergies between the different actors. Spatial integration concerns the fact that airport corridors are very often “spatial enclaves”, which need to be better connected to their direct environment, both physically and socially. Finally, all stakeholders located within the city or the region should be involved in the decision making process.

1.3 Airports as new centres of office locations

Amsterdam Schiphol is one of the most notable examples and generally considered as the pioneer in aviation-linked spatial development and adopting the airport city model (Ashford et al., 2011). Since the late 1980s, the premises of Schiphol and its immediate surrounding have become home to myriad global-operating knowledge-intensive companies, some of them with regional headquarters function for Europe (Wijk et al., 2011: 266). The most convincing factors were and still are the location's multimodal accessibility, and high demand has driven real estate prices for office and warehouse space up. The economic success has led to an interesting empirical observation. Schiphol is part of the Randstad office market, which is the largest and most sophisticated office market in the Netherlands. Within this market area, Schiphol is – in conjunction with the South-Axis (Zuidas) – considered as the absolute prime office site. For years, Schiphol and its adjacent areas were considered as the top office location in the Netherlands with, annual top office rents of around €390 per sqm. This situation changed in 2010 when Schiphol-Centre lost its top position and was overtaken by the South-Axis the actual CBD of Amsterdam, see Figure 1.

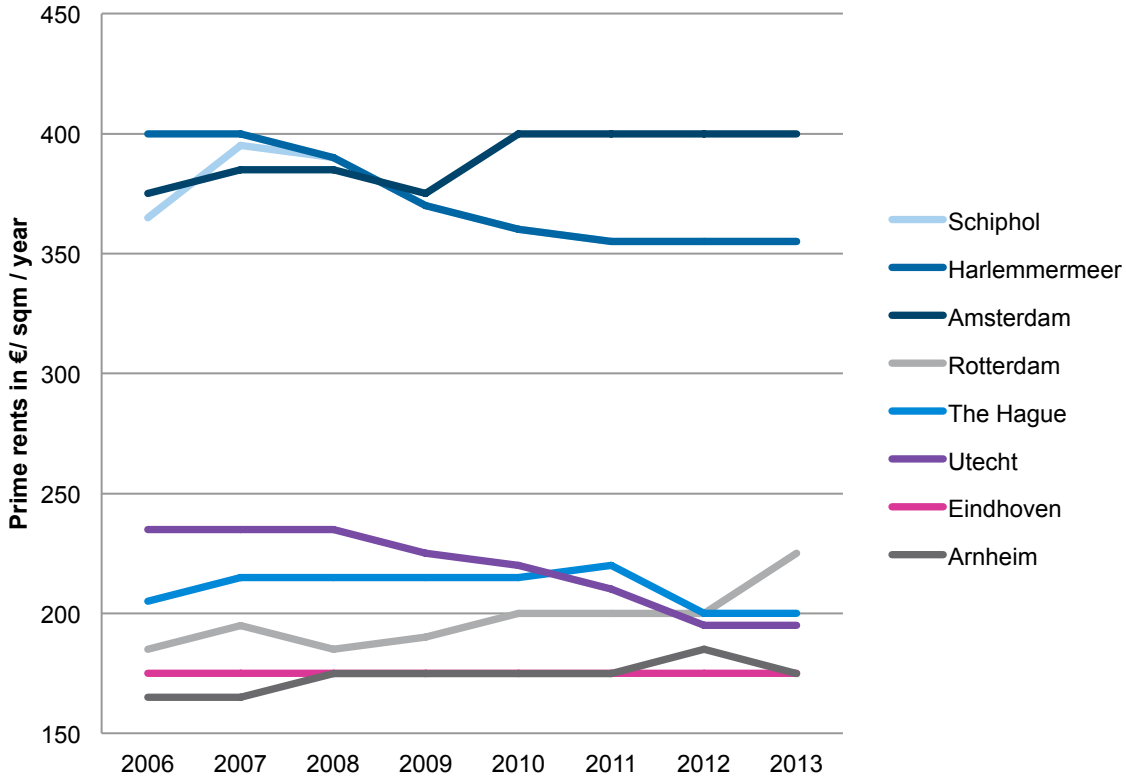
Figure 1: Annual prime rents of Schiphol in comparison to selected office submarkets in Amsterdam (2006 – 2013)



Author's figure, 2014
Data source: DTZ-Zadelhoff, 2006 - 2013

Despite the minor shake-ups in the Randstad office rent landscape, Schiphol – located in the local market of Harlemmermeer – is still at the top end of the office rents market in the Netherlands (DTZ Zadelhoff, 2014), see Figure 2. Thus – and contrary to what one might assume – it is not Amsterdam's city centre that is the most expensive office location but the suburban office locations at and around Schiphol airport and at the South-Axis (cf. Conventz 2010).

Figure 2: Annual prime rents of Schiphol in comparison to selected office locations in the Netherlands (2006 – 2013)

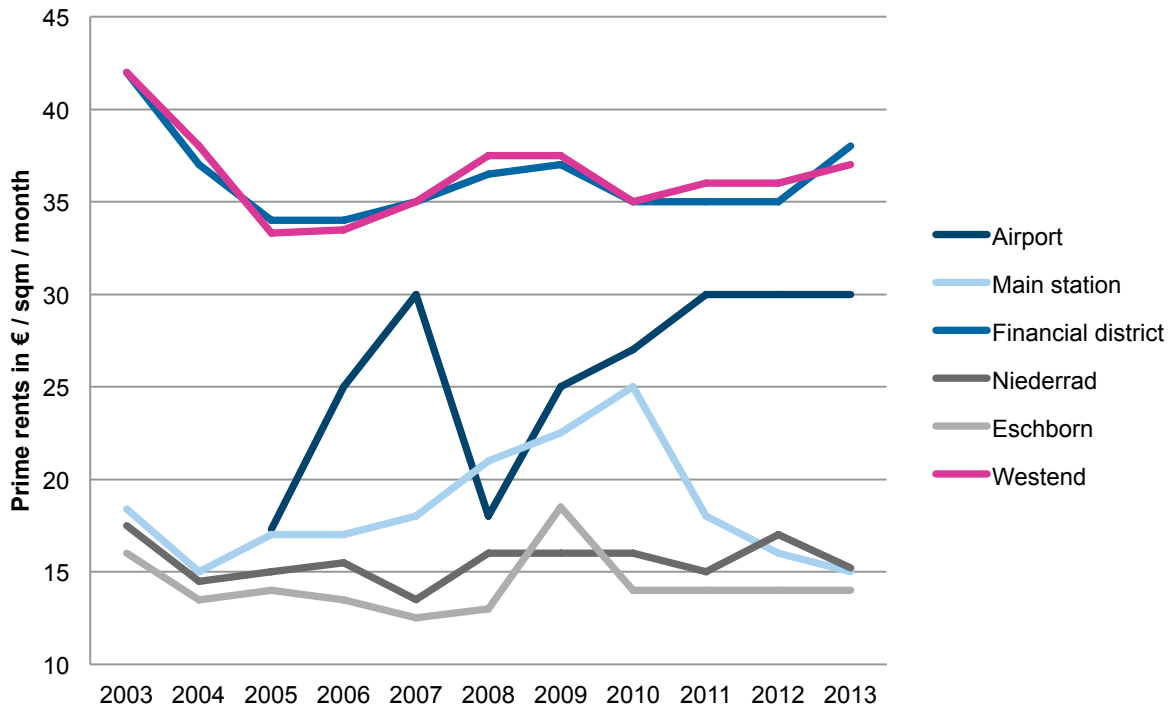


Author's figure, 2014
Data source: DTZ-Zadelhoff, 2006 - 2013

It is not only Schiphol airport and its immediate surroundings that have been successful in attracting office-based activities. Similar spatial developments are becoming increasingly visible around other European airports, such as Frankfurt (Conventz, 2008), Munich, Düsseldorf, Zurich (Hürzeler and Rühl, 2011), Helsinki or Copenhagen. According to the analysis of the Research Network Airport Cities conducted by IVG, the prime rents for office space in certain 'Airport Cities' approximate to the rent levels of those office sites located in the traditional CBDs of the core cities (IVG, 2011: 2). Generally, the rents between the sites at the airport and the host city differ from between 5 to 20 per cent (IVG, 2011: 2).

In Germany, for instance, the airports of Frankfurt and Düsseldorf, are good examples of how the interplay between high-quality site characteristics on the one hand and high demand on the other has led, in some areas, to an increase of office rents. Occasionally, the rents for office space located at these German airports are already approximating to the top rents for more traditional office locations, for example, within the core cities. In the cases of Frankfurt and Düsseldorf the pace of development and the demand for office floor space by knowledge-intensive firms have reached such dimensions that the sites at and around these airports are among the top performing locations in the local total market area, as shown in Figures 3 & 4. For example, the office floor space at and around Frankfurt has risen in prices. Within the last eight years the prime rent has increased from €17.30 per sqm in 2005 to €30 per sqm in 2013. In contrast to this, the premium rent in the financial district and the Westend, the top office locations in the core city, were around €34 per sqm in 2005 and around €35 to €36 per sqm at the end of 2013 (BNP Paribas Real Estate Consult, 2013).

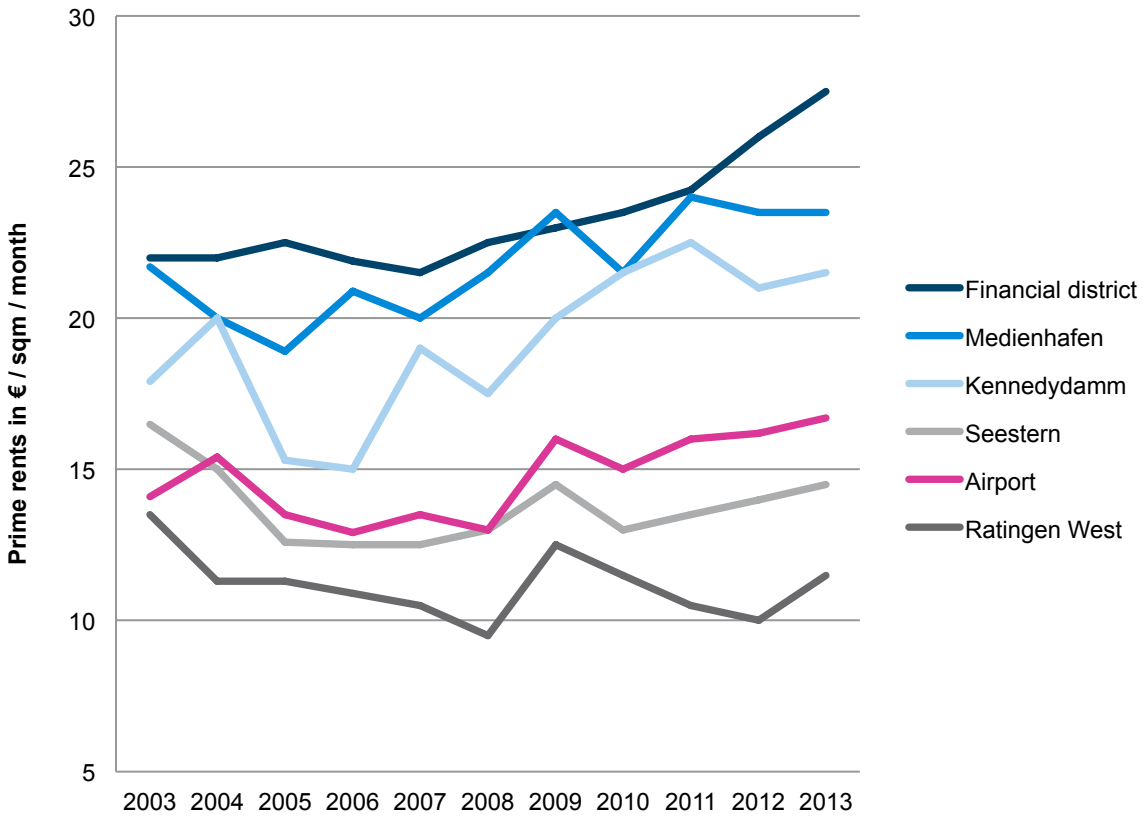
Figure 3: Monthly prime rents of Frankfurt airport in comparison to selected office submarkets in Frankfurt (2003 – 2013)



Author's figure, 2014
Data source: BNP Paribas Real Estate Consult, 2003 - 2013

Office rents have not only increased around major international hub airports like Amsterdam or Frankfurt but also around smaller airports like Düsseldorf, as shown in Figure 4. Since 2003, the monthly prime rents for office space at and around Düsseldorf's airport have grown steadily from €14.10 per sqm in 2003 to €16.70 per sqm at the end of the year 2013. Today the airport of Düsseldorf is among the top performing office locations within the total market. Only within the submarket of financial district Medienhafen and Kennedydamm, the prime rents for office floor space were higher than those for office space at and around the airport. At the end of 2013, the rents at those office sites were fluctuating between €21.50 per sqm at Kennedydamm, and €27.50 per sqm in the financial district.

Figure 4: Monthly prime rents of Düsseldorf airport in comparison to selected office submarkets in Düsseldorf (2003 – 2013)



Author's figure, 2014
Data source: BNP Paribas Real Estate Consult, 2003 - 2013

However, office rents around airports have not increased to the same extent everywhere, as the case of Munich shows. In Munich, only office space located at the airport premises realizes more or less the same prices compared with the downtown area. In 2013, the monthly top rents in the Munich market area were approximately €33 per sqm (BNP Paribas Real Estate Consult, 2013), while the prime rents for airport office floor space per month and square meter were approximately at €23 per sqm (Immobilienscout24, 2014). In contrast to this, the monthly office rents in the surrounding municipalities of Eching, Garching,

Hallbergmoos, Ismaning, Neufahrn, Oberschleissheim, Unterföhring and Unterschleissheim were between €6.00 in Neufahrn and €13.00 per sqm in Unterschleissheim (Ritter Immobilien Management, 2013: 3). Table 1 summarizes the rental price ranges for office space differentiated by municipality for the year 2013.

Table 1: Rental ranges for office-floor space at selected municipalities around Munich airport (2013)

Municipality	Rental price range for office space in € / sqm and month
Eching	6,50 - 9,50
Garching	7,00 - 12,50
Hallbergmoos	7,50 - 11,50
Ismaning	7,00 - 11,00
Neufahrn	6,00 - 8,00
Oberschleissheim	7,50 - 10,00
Unterföhring	8,00 - 12,50
Unterschleissheim	8,00 - 13,00

Author's figure, 2014
Data source: Ritter Immobilien Management, 2013

Hence, in contrast to other German cases like Frankfurt or Düsseldorf, the office rents around Munich airport are relatively low. As there are various reasons for this, the most important seems to be the weaker landside integration of the airport and its surroundings into rail-bounded traffic systems and thus the lower accessibility advantages. Another reason for the comparatively lower office rents at and around Munich airport arises from an outdated quality of office floor space (Ritter Immobilien Management, 2013: 3).

Overall, it can be asserted that airports are increasingly emerging as new sub centres within urban-regional systems, variously referred to as airport city (Güller and Güller, 2003), aerotropolis (Kasarda, 2000a) or aeropolis (Kujath et al., 2010). A famous quote outlines the development of airports in recent decades in the following way: "The airport tends to leave the city. But the city follows the airport. And the airport becomes a city" (Schaafsma et al., 2008: 82). The centralization of new functions formerly localized in the central city and the shifting perception of airports (cf. Conventz and Thierstein, 2014) enable airports to appear as modern kind of "market square" (Sudjic, 1992) where people can convene, exhibit, trade and exchange information and knowledge. In the knowledge economy context, airports have outgrown the role of being simple infrastructural facilities and service providers for airlines. Instead, airports have morphed into places of knowledge-intensive activities and centres of

permanent and temporary knowledge exchange. The growing number of knowledge-intensive companies that have been located at and around airports has made this transformation process and the changed role of airports as urban generators more and more physically visible. At the same time, the locational qualities of airports, especially in terms of intermodal accessibility, have generated demand, which in turn has caused prices for office floor space to rise. Frequently, the prices for office space are approaching those of the premium office locations in the inner city areas. In the Netherlands, the airport and its adjacent areas – for more than a decade the most expensive office location in the country – are among the top performing office locations nationwide.

1.4 The changing role of airports

Although international airports and their immediate areas have been subject to fundamental changes for some decades now, and despite their role as "users and producers of spatial developments within their region" (Knippenberger, 2010: 210), little attention has been paid to airports as an object of research per se. There is, however, a growing body of literature devoted to the topic (Hesse, 2013; Conventz et al., 2014; Freestone, 2009; Schubert and Conventz, 2011; Sonneburg, 2014; Braun and Schlaack, 2014; Alkaabi et al., 2013). This goes beyond disciplines such as urban transportation planning or economics, where airports have always been part of the research interest (Freestone and Baker, 2011a: 263). In the following parts of this section, the most important airport-based literature in space-related disciplines will be reviewed. This includes scientific works from disciplinary backgrounds such as economics, architecture, economic and urban geography, spatial planning, and real estate economics. The first part of the literature review will briefly reflect on the role of airports against the backdrop of emerging global urban hierarchies. The second part focuses on the economic impacts of airports. Next, in the third part, specific spatial uses that have sprung up around airports are focused on. Following this, a gap in the current research will be identified in section five.

1.4.1 Airports and the global urban hierarchy

Airports are at the center "in our ever more connected and spiky global economy" (Florida et al., 2012: 15). On the one hand, they play a decisive role in the way our global economy is organized. On the other hand, airports are gaining importance in the present context of growing global competition among locations. The growth and the economic prosperity of cities is related to their integration into transport networks (Colin Buchanan and Partners, 2009: 9). A recent example of the way in which improved connectivity and infrastructural accessibility are related to locational patterns and growth of cities can be observed in the Arabian Peninsula. The emergence of cities like Dubai, Doha or Abu Dhabi is strongly linked to their improved position within aviation networks.

According to Castells (1996), cities are not self-sustaining systems, but interconnected in a wider "space of flows". They are organized within a hierarchical architecture of global or world cities (Sassen, 1991; Taylor and Knox, 1995; Taylor, 2004) which are well connected to each other (Taylor et al., 2011). The apex of this hierarchy of global cities is formed by a relatively stable group of cities, namely New York, London, Paris and Tokyo as research by

Derudder et al. shows (Derudder et al., 2010). This global urban hierarchy is far from being static and in the recent past, newly emerging cities around the world have been challenging established interrelationships (Hales and Pena, 2012). At the same time, new networks have emerged. According to research conducted by Neal (2011), "a city's economic fortunes are closely tied to its position in networks of interurban exchange, with cities occupying more central positions experiencing relatively greater growth and stability" (Neal, 2011: 167). This view is shared by others researchers, who also recognize a relationship between a strong hierarchical position and good accessibility. In order to gauge the network position of a city or a region appropriately, many researchers have used airline traffic data (cf. Irwin and Kasarda, 1991; Shin and Timberlake, 2000; Matsumoto, 2004; Derudder and Witlox, 2005; Derudder and Witlox, 2008; Neal, 2010). Others have used data on international airline schedules from the Official Airline Guide (OAG) (cf. Bowen, 2002) or physical distance, time and cost to cities via airline traffic (cf. Zook and Brunn, 2006). Despite the different approaches in analysing urban networks, all studies underline the significance of airports and airline traffic for the networking process on a global scale. "Air transport is the preferred mode of inter-city movement for the transnational capitalist class, migrants, tourists, and high-value, low bulk goods" (Keeling, 1995: 118), and is closely related to the knowledge economy (Kujath, 2010) and creative occupations (Neal, 2012). Airports have thus become of paramount importance and are increasingly functioning as nodes within globally organized knowledge networks (Kujath, 2010).

1.4.2 Airports and economic development

Airports are not only the gateways to cities, regions and nations. Airports are also strategic infrastructure facilities that constitute a prerequisite for many economic activities, be it on a local, a regional, or a national spatial scale. The effects of airports are diverse and range from direct, indirect and induced effects to catalytic effects (Graham, 2008). Direct effects include the employment and generated incomes that are directly related to the airport (Airports Council Europe, 2004: 5). By contrast indirect and induced effects are removed from the actual activities on the airport platform. Indirect effects are the results of "backwards linkages" (Hakfoort et al., 2001: 597) and include the "employment and income generated in the economy of the study area in the chain of suppliers of goods and services" (Airports Council Europe, 2004: 5). Induced impacts or "forward linkages" (Hakfoort et al., 2001: 597), again, are the "employment and income generated in the economy of the study area by the spending of incomes by the direct and indirect employees" (Airports Council Europe, 2004: 5). Finally, there is a fourth group of effects, which are not easy to measure and quantify – catalytic effects (Bowen, 2010: 233). These are the increased economic benefits arising from air transportation accessibility. Catalytic effects can be defined as "the employment and income generated in the economy of the study area by the wider role of the airport in improving the productivity of business and in attracting economic activities such as inward investment and inbound tourism" (Airports Council Europe, 2004: 5).

Today, there is a vast array of scientific literature as well as a number of studies from academic research institutes, university-affiliated associations and consulting firms that focuses on the complex interplay of airports and economic development (see for example: Green, 2007; Florida et al., 2012; Röhl, 2007; Ernst Basler + Partner AG, 2011;

Bundesverband der Deutschen Luftverkehrswirtschaft, 2013; Airports Council Europe, 2004). Most of these studies provide multipliers indicating the relationship between newly created direct, indirect and induced jobs per increase in passenger volumes. Hart and McCann (Hart and McCann, 2000), for example, find that an increase of 560 to 1000 passengers creates one new on-site job at airports mostly serving domestic and business passengers. At bigger airports with high proportion of passengers flying transcontinental, and in particular airports with a hub function, the ratio between passenger growth and the creation of new direct jobs decreases due to the economies of scale. On average, every annual increase in passengers of 1,350 to 2,170 creates one new direct job at airports in this category (Hart and McCann, 2000: 878). For European airports, the Airport Council International assumes a ratio of approximately 0.95 direct jobs per 1,000 passengers (Airports Council Europe, 2004: 8). This is equivalent to just under a ratio of 1.0 new on-site job per 1,000 passengers per annum, which is assumed for Germany (Initiative Luftverkehr 2006: 12). Currently, it is estimated that approximately 324,500 people are directly employed at German airports. Another 352,700 employees work in indirect jobs while approximately 145,900 employees work in jobs that were created by the consumer spending by directly and indirectly employed workforces (Bundesverband der Deutschen Luftverkehrswirtschaft, 2013: 14). In most European cases, the multiplier relating the number of indirect and induced jobs combined to on-site employment at airports was almost greater than 2.0 (Hakfoort et al., 2001; Röhl, 2007; Hart and McCann, 2000; Airports Council Europe, 2004).

Some of the earliest pieces of research on the impacts of airports on economic development – and according to Green (2007) one of the first studies in the field – were provided by Benell and Prentice (1993) and by Brueckner (2003). The renowned study by Brueckner (2003), for example, provides evidence on the link between transportation and economic performance in terms of employment in US metropolitan areas. He finds that “a 10 per cent increase in passenger enplanements in a metro area leads approximately to a 1 per cent increase in employment in service-related industries” (Brueckner, 2003: 1455). Moreover, there was a less pronounced impact of airline traffic “on manufacturing and other goods-related employment, suggesting that air travel is less important for such firms than for service-related businesses” (Brueckner, 2003: 1467). This finding can be explained with reference to Button and Taylor’s (2000) reconfiguration process of the economy and the need for frequent personalized interaction. Employees associated with “new economy sectors” fly over 1.6 times as often compared to employees in more traditional industries. In contrast to traditional industries, these activities require considerably more inter-personal contacts, which in turn drives the demand for air services (Button and Taylor, 2000: 213). They also find that 90 per cent of jobs related to new economy sectors are located within US metropolitan areas. Approximately 70 per cent of these employments are located in 50 Metropolitan Standard areas out of 321 (Button and Taylor, 2000: 213). Metropolitan areas providing good airport infrastructure are particularly successful in attracting offices with hub function, as research by Strauss-Kahn and Vives (2009) for US metropolitan regions indicates. According to their results, headquarters make their location choice in particular to the benefit of metropolitan areas that are characterized by “good airport facilities, low corporate taxes, low average wages, high levels of business services, same industry specialization, and agglomerations of headquarters in the same sector of activity” (Strauss-Kahn and Vives, 2009: 179).

A more recent study on the impact of airports in regional economic development has come from Appold and Kasarda (2012). They take a specific look at employment patterns around

the 25 major US airports. By comparing the airport locations and the employment patterns within a radius of 2.5 miles around the terminal with those of the corresponding CBDs, Appold and Kasarda indicate that “employment on and around the edges of mayor airports (…) is on average half as large as CBD-centered employment” (Appold and Kasarda, 2012: 17). In addition, Appold and Kasarda are able to show that – for the time period between 1995 and 2002 – employment in the immediate surroundings of the airports increased at over twice the rate as in their corresponding CBDs, and faster than in the suburban rings (Appold and Kasarda, 2012: 17).

For Munich, Droß and Thierstein (2011) have analyzed the economic development around Munich airport through the lens of the growing knowledge economy. Their empirical findings show that the corridor between Munich’s city center and the hub airport of Munich creates more and more urban-like landscapes. The corridor has become increasingly attractive for knowledge-based activities, especially in the High-Tech sector among automotive, aerospace or information and telecommunication firms. At the same time, the axis between the city center and the airport has evolved into one of the most dynamic spatial entities in Bavaria with respect to economic and demographic development, benefiting from local and global accessibility alike (Droß and Thierstein, 2011). This confirms earlier findings by Button et al. (1999). They investigated the structural advantages of those local economies having access to a major hub airport. Button’s results make clear that proximity to a hub airport provides an important “structural advantage for local economies” and “a stimulus for High-Technology jobs to grow” (Button et al., 1999: 59). Metropolitan areas with access to a hub airport show on average 12,000 more High-Tech jobs compared to those metropolitan areas without access to a hub airport (Button et al., 1999: 56).

Airports also create favorable conditions for scientific and artistic innovation, as research by Kramer and Suitner (2008) for the Austrian airports of Vienna, Graz, Linz, Salzburg, Klagenfurt and Innsbruck indicates. According to their findings, the patent density in the immediate surroundings of all six airports is higher compared to those in the corresponding core city. Locations between airports and core cities seem to create a particularly beneficial environment for development of scientific innovations, as these places combine the advantages of accessibility on the one hand and urbanization effects on the other (Kramar and Suitner, 2008: 95).

1.4.3 Airports and the spatial structure

Airports are not only engines of economic growth. Increasingly, airports have morphed into centers of airport-driven urbanism. This spatial development is taking place worldwide (Freestone, 2009; Schaafsma et al., 2008; Güller and Güller, 2003; Kasarda and Lindsay, 2011; Roost, 2013).

One of the first in Germany to analyze the spatial patterns around selected western European airports was Hilsinger (1976). Hilsinger’s research – conducted in the mid-seventies and based on extensive mapping works, statistical analysis and surveys of companies – aims to understand better the site selection process of companies located near airports. In Germany, Hilsinger selects the cases of Frankfurt and Stuttgart. The spatial patterns around Frankfurt are characterized by a high concentration of aviation-related

companies – mostly in the field of import-export businesses – and by a number of company headquarters mostly located in the office city of Niederrad (Hilsinger, 1976: 59). Based on Hilsinger's results, the main locational advantage arises from the intermodal interplay of landside and airside transport carriers and thus from the accessibility to buying and sales markets (Hilsinger, 1976: 65). An entirely different picture emerges in Stuttgart. Although the area surrounding Stuttgart airport also hosts a large number of companies, the airport as locational factor plays practically no role. In contrast to Frankfurt, only a minority of companies have deliberately chosen to locate in close spatial proximity to the airport of Stuttgart. Moreover, most companies operate only on the local level, that is to say, Stuttgart (Hilsinger, 1976: 73). Added together, the spatial patterns around western European airports reveal similar spatial structures with a high concentration of airport-affiliated business, such as removers, airline offices, insurance companies and sales agencies as well as suppliers for the aviation industry (Hilsinger, 1976: 103). In addition to this, most airport surroundings are distinguished by a number of mostly foreign companies, whose locations sprawl around the airport terminals (Hilsinger, 1976: 103).

Hartwig (2000) discusses the new urbanization process of airports within the German urban-regional context in greater detail. With reference to Sievert's concept of the "Zwischenstadt" (Sieverts, 1997), Hartwig analyzes evolving urban patterns around the airports of Frankfurt, Hannover, Leipzig and Munich, and concludes that the airport's integration as highly dynamic entity into the urban-regional systems is still deficient (Hartwig, 2000: 193). This circumstance will pose a future challenge for urban and regional planning. In order to face this challenge, Hartwig recommends improvement in the planning process and stronger organization of involved stakeholders (Hartwig, 2000: 189). At about the same time as Hartwig, Güller and Güller (2003) wrote one of the most notable books in the field of airport-linked spatial development, entitled "From Airport to Airport City". They have promoted the term "airport city" and have sensitized researchers to the fact that airports are "no longer simple traffic machines" (Güller and Güller, 2003). Using nine case studies from European regions, Güller and Güller focus on the morphological transformation of airports and their surroundings, showing that airports are among the most characteristic elements of metropolitan regions and one of their strongest drivers. In an unprecedented study and based on a GIS-supported commercial real estate analysis on the 19 biggest German airports, Einig and Schubert (2008) take a closer look at the evolving spatial patterns at the airport terminal itself, and a narrow periphery of five kilometers around the terminal building. Their research is guided by the question to what extent aerotropolii developments can already be observed in Germany. The results reveal that previous structural land use in the narrow periphery of German airports is less characterized by business than would be expected. While business from the logistics branch can be clearly identified, office-based activities, for example, are underrepresented. This point of departure, however, is changing, as the dynamic and dimension of real estate developments at and around the analyzed airports clearly show.

Besides these more general studies analyzing the impacts of airports on the spatial structure and the way airports are contributing to the reshaping process of spatial configurations, a body of literature has emerged specifically focusing on certain elements of airport city or aerotropolis development, such as logistics or cargo, retail, leisure or offices. Traditionally, one of the most dominant spatial users to be found at airports is the logistic or cargo sector (Knippenberger, 2010: 209). This especially applies to logistic companies dealing with time-

sensitive goods (Haas and Wallisch, 2008: 35). Generally, this spatial use is highly influenced by market structures in airfreight transport. Neiberger (2008), for instance, researches the spatial consequences of the reorganization process of the airfreight sector, and the site selection process of logistic companies. She finds that in the course of deregulation, logistic companies are able to increase their operational efficiency and to offer new services (Neiberger, 2008: 249). In order to meet this new market environment, airport operators again are forced to react and to occupy larger areas and to provide space for expansion for logistic-based uses. By doing so, airports "make a greater impact on the environment, especially through growing road traffic and night flights" (Neiberger, 2008: 254). Warffemius (2007) concentrates on Amsterdam-Schiphol and aims to explain why European Distribution Centers (EDC) locate around Amsterdam's airport. He identifies location endowments and economies of agglomeration as the main factors attracting EDCs (Warffemius, 2007: 241). However, Warffemius also notes "that almost 40% of the warehouses representing the EDC population in the SADC area are non-Schiphol-dependent" (Warffemius, 2007: 241). For these companies, the predominant reasons for locating at and around Schiphol airport were agglomeration advantages and factors such as availability of space for expansion, access to the sea, land prices, transportation costs, or labor cost (Warffemius, 2007: 148).

Oechsle (2005), again, puts the role of the gradually growing non-aviation sector at the center of his research. By using selected European airports and by paying particular attention to the airport of Munich, Ochsle finds that airports are increasingly forced to open up new business fields as a direct consequence of deregulation processes within the international aviation business and the shrinking revenues within the core business. By pushing the non-aviation sector, airport authorities transform airports into multifunctional spatial entities and attractive retail and leisure-destinations. Similar findings have been made by Brust (2005) for the airport of Hannover.

Appold and Kasarda (2006) as well as Thompson (2007) take a closer look at terminal-based retail activities at airports in the United States and the United Kingdom. They find that airport retailing is among the airport operators' most profitable non-aviation activities. According to Appold and Kasarda "terminal-based stores can generate annual sales of $800 – 1200 per square foot. The average regional mall, by comparison, produces around $300 per square foot" (Appold and Kasarda, 2006: 277). The attractiveness of airport retailing has motivated airport operators to enlarge their facilities in order to generate further revenues from retailing (Appold and Kasarda, 2006). Voigt (2013) puts the airport city of Frankfurt as new site for consumption at the core of his research and finds that the user groups of airport retailing are much more complex and go far beyond airline passengers. Beside this traditional customer group, Voigt finds that airport retail establishments are increasingly frequented by airport city visitors and airport city employees. Moreover, his results show that especially for the latter, retail facilities are of growing importance for daily shopping, which in turn incentivizes airport operators to realize an attractive offer tailored to the need of airport city employees. In this way, airport operators are not only exploring new revenue sources but also enhancing the attractiveness of the airport city as place of work (Voigt, 2013: 158).

Another important spatial use contributing to the emergence of multifunctional spatial patterns at and around airports are office-related developments (e.g. Conventz 2008). Conventz (2010) specifically concentrates his research focus on office developments and

knowledge-based activities at and around the hub airports of Frankfurt and Amsterdam. He demonstrates that with the expanding floor space for office use at airports, a new urban-locational pattern is emerging. Beside the traditional office space occupiers like logistics or companies from the travel industry Amsterdam and Frankfurt airport are more and more attracting companies from other branches like legal advice, tax accountancy, advertising, real estate development and such like. In the context of airport city development office real estate developments have emerged as a second important pillar next to retail developments.

Like Conventz, Yigitcanlar et al. (2008) focus their research on knowledge-based patterns around airports. In order to understand these knowledge-based spatial patterns and the conditions for the emergence of "airport knowledge prescient" more thoroughly, Yigitcanlar et al. (2008) develop a research framework based on an effective policy analysis model.

Apart from this, an array of literature has been published in recent years focusing on governance-related matters, mediatory dialogs, institutional arrangements or the development of airport regions (Knippenberger, 2012; Wijk, 2007). Most of these contributions are single case studies focusing on a certain city or region (Knippenberger, 2011; Wijk, 2011; Jöchlinger, 2011; Mack, 2011). This body of literature will not be discussed in detail here. However, for the sake of completeness, it is mentioned in passing.

1.5 Identifying the research gap

The literature review reveals a growing body of academic work on airport-related topics in space related disciplines. The role of airports as driving force within the networking process of the global economy, and the impacts of airports on local, regional and national economic development have been analysed in depth and are well understood. However, when it comes to airports in the context of the knowledge economy, and more particularly to airport's impact on office real estate developments, the literature is still minimal. Until now, the drivers of the growing segment of office space at and around airports, such as for example Amsterdam or Frankfurt, as well as the ongoing transformation process of airports into "knowledge precincts" (Yigitcanlar et al., 2008) and places of permanent and temporary knowledge exchange have not been widely examined. Although office real estate developments are occasionally thematized (cf. Wijk et al., 2011; Hartwig, 2000; Yigitcanlar et al., 2008; Appold and Kasarda, 2012), existing literature is on the whole descriptive, and fails to provide an adequate answer as to the reasons for locating office-based activities near airports. Without focusing on knowledge-intensive companies in particular, and without empirical proof, Appold and Kasarda (Appold and Kasarda, 2012) make a few assumptions about possible reasons for locating firms closer to airports. According to them, one reason why airports are increasingly attracting enterprises might be the firm's need to improve the efficiency of their operation through improved access to accessibility nodes. Another reason for the growing number of firms located at or near airports might be the fact that firms want to enjoy the advantages of the availability of commercial floor space created by real estate developers (Appold and Kasarda, 2012: 15). The attractiveness of the location could also arise from the global image of the airport and its vicinity. Airports are the spatial manifestation of the "hyper global" (Koolhaas et al., 1995: 1251). They represent mobility and flexibility. In this sense, firms locate there because airport area business locations "lend a cosmopolitan image reflecting a need for frequent long-distance travel" (Appold and Kasarda, 2012: 15)

In summary, it can be concluded that the reasons for locating a knowledge-intensive company at and around airports have not yet been empirically investigated. Thus, why they do so remains unclear. Moreover, it remains unclear whether the airport plays a pivotal role in the context of the site selection process or if companies select their office location independently of consideration of the airport's existence. The present dissertation will contribute to answering the "why" and to closing this research gap.

1.6 Research design, case selections, research hypotheses & questions

As stated above, the role of airports in the knowledge economy context and the role of knowledge-intensive companies within the spatial reshaping process of airports and its immediate surroundings into urban-like entities have not been scrutinized and empirically investigated. Thus, the overarching aim of this dissertation is to nuance our understanding of the newly emerged spatial configurations and commercial real estate patterns that have sprung up at and around international airports, and their underlying spatial drivers. In pursing this aim, special attention is paid to the locational requirements and the internal and external value chains of knowledge-based companies. In our view, these are the keys to understanding the transformation process of airports and their adjacent areas into sites of knowledge-based activities.

1.6.1 The case study approach

In order to fulfill these research aims, a multiple-case study design was employed. In general, a "case study is a research strategy which focuses on understanding the dynamics present within the single setting" (Eisenhardt 1989: 534). Yin (2009) defines the case study as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2009: 18). The case study moreover "copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis" (Yin, 2009: 18). Very often case study selection is subject of a pragmatic approach, which is determinated for instance by the availability of time and financial resources, but also by the accessibility to sources of information or interviewees.

1.6.2 Selection of the case studies

The spatial focus of this dissertation is on continental Europe, and more precisely on continental Western Europe. In contrast to other parts of the world, such as North America or southeast Asia, Western Europe is distinguished by its spatial density, and a long tradition with respect to the development of land-based traffic systems. This especially applies to Germany and the Netherlands which, boast some of the best traffic systems in the world. These two countries are the focus of the present dissertation. The research interest in these two countries and their airports arises from previous research conducted in 2008 (Conventz, 2008). In terms of airport category, this dissertation pays particular attention to hub airports. In the knowledge economy context, hub airports are specifically interesting because they offer more flights and serve more destinations than any other airport category.

The comparability of cases is one essential precondition for the research. Germany and the Netherlands belong to the most important aviation locations worldwide. They are home to two of the world's most important hub airports in civil aviation, namely Frankfurt and Amsterdam. In 2012, both hub airports were ranked by passengers among the top 20 busiest airports worldwide in the annual Airports Council International (ACI) ranking (Airports Council International, 2012). According to ACI, Frankfurt is ranked in 11th position with 57,520,001 million passengers and Amsterdam is ranked in 16th position with 51,035,590 million passengers (Airports Council International, 2012). Thus in terms of the selection criteria "passenger volume", both airports are comparable. They are also comparable in terms of the selection criteria "network integration". As of the end of 2012, Frankfurt was integrated into the networks of 107 airlines serving 295 destinations in 107 countries (Fraport, 2012). Amsterdam was integrated into the networks of 101 airlines serving 317 destinations (Schiphol Group, 2012). They are also comparable in terms of the selection criteria "landside accessibility" and "distance to the host city". Both airports are connected to powerful ground transportation systems, such as highways or local, regional, national and international rail traffic. Moreover, Frankfurt and Amsterdam are both integrated into high-speed train networks. Thus, Frankfurt and Amsterdam are characterized by multimodal accessibility. Finally, the two airports are comparable with regard to their spatial situation. Both airports are located in the suburban areas of Frankfurt and Amsterdam respectively. While Frankfurt airport is located approximately 12 kilometers outside central Frankfurt, Amsterdam is situated about 9 kilometers outside Amsterdam's city center.

In addition to Frankfurt and Amsterdam, Munich airport was selected as a third case study. Although Munich is considered one of the busiest international hub airports with more than 38,360,604 million passengers in 2012 (Airports Council International, 2012) – served by 101 airlines connecting 242 destinations in 68 countries – Munich differs from Frankfurt and Amsterdam. This especially applies to the selection criteria of "landside accessibility" and "distance to the host city". In comparison to Frankfurt and Amsterdam, Munich is characterized by weak integration into a railway system. More than 20 years after its inauguration, Munich airport is not integrated into long-distance and high-speed railway systems. The airport has only one terminal stop connecting the airport with the city of Munich and the region. The biggest difference, however, is the spatial situation of the airport, which is located approximately 30 kilometers out of Munich in a rural area.

Finally, Düsseldorf airport – Germany's third biggest airport – is selected as a fourth case study. By definition, Düsseldorf is not a hub airport, but rather an airport with a hub-like quality characterized by sophisticated network quality. Currently 63 airlines connect Düsseldorf with 189 destinations in 51 countries (Flughafen Düsseldorf, 2012). At the end of 2012, approximately 21 million passengers were handled (Flughafen Düsseldorf, 2012). Similar to Frankfurt and Amsterdam, Düsseldorf is distinguished by strong multimodal landside accessibility, including two railway stations connecting the airport location to local and regional train services and to the national and international high-speed railway system. Moreover, the airport has its own motorway intersection. The airport is approximately seven kilometres north of downtown Düsseldorf and can thus be considered an urban airport. Although not a hub airport, the selection of Düsseldorf as fourth case studies is justifiable for two reasons: Firstly, because of its hub-like quality and its strong integration into landside transport carriers. Secondly, similar to the hub airports of Frankfurt, Amsterdam and Munich, Düsseldorf airport and its adjacent areas have become a centre for knowledge-based spatial development and one of the most successful office locations within the broader local office market. In order to show that the transformation of airports and their surroundings into centres of knowledge-based activities is not only taking place around existing hub airports, Düsseldorf was chosen as fourth example.

Drawn together, the dissertation is based on four case studies, three in Germany and one in the Netherlands. This reflects the importance of Germany within European and international aviation. Within these countries, the dissertation concentrates particularly on hub airports. The case study of Düsseldorf airport was chosen because it is characterized by strong network integration and a growing significance as third hub airport within the German airport landscape. With regard to landside accessibility and distance to the host city, the case of Düsseldorf is comparable with the case of Amsterdam and the case of Frankfurt. The case of Munich again is comparable with the cases of Amsterdam and Frankfurt in terms of network integration and airport category, but differs with regard to distance to the host city and landside accessibility. The strongest similarity exists between the cases of Frankfurt and Amsterdam, which are both strongly integrated into land and airside traffic systems, and in close spatial linkage to their corresponding cities. The comparison of these two hub airports establishes the international perspective of the current dissertation.

1.6.3 Research hypotheses and questions

The main question in the present dissertation is derived from an impact model (see section 3.6, figure 11) and reads as follows

> What role do knowledge-intensive companies, with their locational requirements and spatial business practices, play in terms of the development and transformation of property markets in and around international airports?

In addition to this central research question, the thesis also aims at answering the following sub-questions:

- What general relationship exists between international airports and knowledge economy companies?

- What role do international airports have within the knowledge creation process, and the business practices and optimization of firm-internal and firm-external value-added chains?

- What role do international airports play within the site selection process of knowledge-intensive companies?

Based on these questions, the following two main hypotheses are put forward:

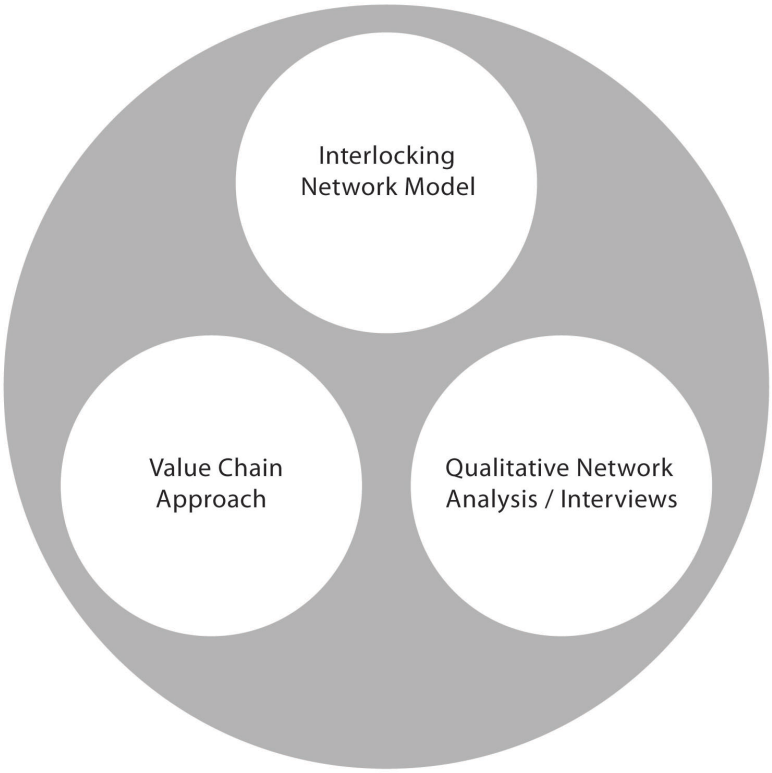
> **Hypothesis 1**: Knowledge-intensive firms locate at and around hub airports in order to benefit from geographical and relational proximity to partners along the value chain and to different sources of knowledge.
>
> **Hypothesis 2**: If knowledge-intensive companies and their highly mobile employees demand accessibility, then the emergence of new real estate and functional space at and around international airports is stimulated.

In order to explore the evolving knowledge-based activities at and around the selected airports, a methodologically mixed approach, consisting of quantitative and qualitative methods is required (see figure 5).

1.7 Research methods

From our point of view, relational thinking in terms of connections of activities, linked through both physical and non-physical flows, is of major importance in understanding the spatial development processes around the airports of Frankfurt, Munich, Düsseldorf and Amsterdam. According to Dicken (Dicken, 2011), the critical point in applying a network approach is that it draws attention to the interconnectedness of economic activities across different spatial scales. An exclusive focus on quantitative approaches would fall short of the mark. Thus, a deeper understanding of the airport-related spatial processes can only be achieved through a combination of quantitative and qualitative approaches.

Figure 5: Triangulation of quantitative and qualitative research methods



Source: Modified figure according to Lüthi, 2014, p.106

In a first research phase, we use the Interlocking Network Model by Peter Taylor (Taylor, 2004) in order to analyze firm-internal relationships. In practice, firm-internal activities are hard to analyze. Approaches such as collection of data concerning business travels or counting of email exchange between IP nodes often fail because of data protection regulations or the company's fear of competitive disadvantage. One approach to bridging these difficulties has been developed by the Globalization and World City Study Group (GAWC) based at Loughborough University. Generally, firm-internal activities operate through office networks across a large number of cities and across different spatial scales. GAWC puts special emphasis on office locations and the network that is formed by these office locations, specified as a "world city network".

In broad terms, the Interlocking Network Model can be understood as a matrix (s_{ij}) consisting of columns representing firms and lines representing cities and office locations respectively (see table 2). The cells of the matrix include the so-called service value, a measure reflecting the size, importance and function of the office location or city within a given company's overall office network.

Table 2: The service activity matrix

	Firm 1	**Firm 2**	**…**	**Firm m**
City 1	0	4	…	2
City 2	4	2	…	1
…	…	…	…	…
City n	5	1	…	3

Author's figure, 2014

Commonly, information on the different office locations and the office network is available on the company's website. By using a scoring system ranging from 0 to 5, the individual locations of each firm are rated with 0, indicating a city with no firm representation, and 5 indicating a company's headquarters. A standard office is scored with 2 while office locations with low importance within the office network are downgraded to the score of 1. Office locations with a large staff or extra-city jurisdiction – for example a regional headquarters – are upgraded to values of 3 or 4. The result of this scoring process is a service activity matrix, which provides the basis for the Interlocking Network Analysis.

The Interlocking Network Model allows estimation of the city's connectivity from the office networks of multi-location, multi-branch enterprises in advanced producer services, and High-Tech sector, as these companies organize their business activities across their offices worldwide (Pain and Hall, 2008). The basic premise of the Interlocking Network Model is that the more important the office, the greater its flows of information will be to other office locations. It provides one specific way to address the question of how inter-city relations can be empirically measured despite the chronic lack of data on inter-city information flows.

In a second research phase, the Interlocking Network Model will be completed by a value chain analysis. This internet-based research activity will combine relational data on the companies' site with the degree and significance of working interrelationships along the respective firm's chain of value. Through the methodological extension of the value chain analysis, both a firm-centric and region-centric perspective is avoided. It provides a valuable analytical instrument for the researching of business organization and networks that cut across different spatial scales. Hence, the strength of this methodical approach is its multi-scalar perspective. Moreover, the value chain analysis helps us to understand where different outsourced knowledge-intensive activities are located.

Finally, in a third research phase, and in addition to quantitative approaches, this dissertation also includes a series of in-depth personalized interviews with business practitioners and site selection specialists. The interview method provides qualitative evidence complementing quantitative data gathered via the empirical research. Thus, we gain deeper insights into the strategic networking of knowledge-intensive companies, the role an airport plays within the site selection process, and the knowledge-creation process. Moreover, qualitative research actions allow us to fully understand the actual grounds on which the location process is based. This research phase will be the empirical backbone of the dissertation.

The combination of quantitative and qualitative approaches produce an extensive and rich spread of data on the actual changes and issues relevant to the study that could not be elicited by alternative means. Further information concerning the different methods and their applications is provided in the respective chapters.

1.8 Outline of the dissertation

In terms of structure, this dissertation is organized into four articles, which represent the main findings. Moreover the structure and content of the different articles reflect the morphogenesis with regard to the knowledge acquisition during the various phases of the research process.

The first article – written in German – is entitled “Urbane Funktionen und Strukturen – Flughäfen als Treiber für Immobiliensstandorte” (in English: “Urban functions and structures – airports as drivers of real estate locations”). This conceptual contribution discusses two contemporary aspects of spatial development: The emergence of the knowledge economy and the role of airports as a key driver of commercial real estate developments. These development processes are discussed using the cases of Amsterdam and Frankfurt. In summary, it can be stated that airports have outgrown their primary function as network and service providers for the aviation industry. Airports have evolved as new centers of urbanized spatial patterns, as multifunctional and multimodal locations functioning as network infrastructures for knowledge-intensive activities.

The second article, entitled “Hub Airports and the Knowledge Economy. A relational perspective“, published by Routledge within the Regions and Cities series, is also a conceptual article, which introduces a combined relational framework of physical and non-physical accessibility, and examines the specific role of hub airports for knowledge intensive firms. This article is triggered by the observation that knowledge has increasingly become a key driver for the competitiveness of companies, cities and regions. For companies, knowledge is an important resource for innovation, which, in turn, is one of the major drivers of economic growth. The process of knowledge creation requires a dynamic interplay between tacit and explicit forms of knowledge, as well as a high level of interaction between people within organizations and between them. Thus, knowledge intensive firms require access to information and the ability to acquire experienced based knowledge via face-to-face contact. Accessibility is considered in both its physical and non-physical dimensions. Physical accessibility enables the movement of people and establishes face-to-face contact; non-physical accessibility facilitates the exchange of information. Physical accessibility can be associated with network economies and agglomeration economies. Whereas rail and road accessibility work on the scale of agglomerations, accessibility by air enables network links to worldwide locations. In general, accessibility is an externality that enables firms to reduce costs and enlarge their market areas and, therefore, to realize economies of scale and economies of scope, which in turn generate economic growth. Although, relations between networks of cities and agglomeration effects are discussed broadly, physical infrastructure – especially the role of hub airports – and spatial connectivity are still not integrated adequately into the concept of externalities within knowledge production.

The third article, with the title “Where globality encounters locality: Emergence of new

knowledge-based spaces around the German airports of Frankfurt, Munich and Düsseldorf", analyzes knowledge-based spatial patterns and presents the empirical results for the three German case studies, namely Frankfurt, Munich and Düsseldorf. In the recent past, all three airports have rapidly become new urban growth generators and centers of knowledge-based activities. The site selection and relocation process of knowledge-intensive companies in close spatial proximity to these airports, document this spatial development impressively. The reasons for locating knowledge-intensive activities in close spatial linkages to international airports, however, still remain unclear. The article puts the location requirements of knowledge-intensive companies into focus and builds on the idea that site selection is the result of the specific location requirements of an economic activity, the existing site conditions, and the required degree of interconnectedness. Thus, one of the most important keys to understanding these processes and alterations are the locational requirements and changing internal and external value chains of knowledge-intensive companies. The empirical findings indicate that the airports of Frankfurt, Munich and Düsseldorf are not primarily perceived as a transportation node but as an advantageous business location that supplies a rare competitive advantage: accessibility. With the changed locational requirements of the knowledge economy, and thus perception and evaluation of airports and their adjacent areas, a new urbanizing space is emerging with the knowledge economy as an important driver. By investigating the need for geographical and relational proximity of knowledge-intensive companies, and the actual role the airport has played within a firm's decision making process about locating activities at and around the three major German airports, the article contributes to the emerging body of airport-driven literature and sharpens our understanding of how to interpret these new spatial articulations on a micro-level spatial scale.

The fourth article – entitled "From hub-airport to hub-office: New focal points of multi-scalar knowledge generation. The case of Amsterdam-Schiphol and Frankfurt Rhine-Main" – continues with the methodology introduced in the second and third article, puts it into international perspective, and looks specifically at airports with a hub function. By using the cases of Amsterdam and Frankfurt – two of Europe's hub airports of international standing – the article takes a closer look at the nature and organization of networks of knowledge-intensive companies at and around hub airports, the airport's role within the daily business of knowledge-intensive companies, and their significance within the site selection process. Not long ago, both airports were considered purely infrastructural facilities. This situation is changing, and successively both airports resemble urban-like entities. Within this transformation the knowledge economy has turned out to be a major driver. The findings show that knowledge-intensive companies – and here globally operating multi-branch firms in particular – make strategic use of the location and the hub competence of the airport by installing a highly accessible "hub office" within their internal office hierarchy. Moreover, the results show that both airports and their adjacent areas are also attracting a significant share of companies that have only a little or no affinity to air transportation networks.

Based on the findings presented in papers 1 to 4, the dissertation concludes with a general discussion of the main findings in chapter 6.

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2 Urbane Funktionen und Strukturen. Flughäfen als Treiber für Immobilienstandorte.

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The chapter has been slightly edited to fit the format of this dissertation.

Zusammenfassung

Das Verhältnis von Raum und Mobilität ist wechselartig. Seit jeher sind Kreuzungspunkte Ausgangspunkte der Raumentwicklung, des Handels und des Wissensaustausches.

Die Immobilie Flughafen regelt als raumgebundene Infrastruktur in erster Linie den reibungslosen Ablauf des Luftverkehrs. Diese verkehrstechnisch zwar zutreffende Kurzbeschreibung von Flughäfen greift jedoch im Hinblick auf die gegenwärtigen Entwicklungen an internationalen Flughäfen zu kurz, da sie insbesondere solche Funktionen vernachlässigt, welche den Flughafen als ein für Passagiere, Nicht-Reisende und Frachtgüter vielschichtiges System mit diversen und flexiblen Anschlüssen an lokale, regionale, nationale und internationale Märkte erscheinen lässt. Das traditionelle Verständnis vom Flughafen als Ort von ankommenden und abfliegenden Flugzeugen hat sich stark gewandelt. Flughäfen sind heute Interaktionsräume und Verkehrsknotenpunkte zugleich, die aufgrund ihrer absehbaren Entwicklungspfade zunehmend als Informations-, Geschäfts- und Wissensdrehscheiben fungieren. Heute haben sich viele Flughäfen zu multifunktionalen und multimodalen Immobilienstandorten, zu Knotenpunkten des Informationsaustausches und des globalen Warenhandels verdichtet. Die Überlagerung von unterschiedlichen leistungsfähigen Transportmodi aus Luft, Schiene und Straße hat eine neuartige Standortqualität auf der Schnittstelle von globalen, nationalen, regionalen und lokalen Verkehrsströmen hervorgebracht. Damit sind Flughäfen nicht mehr nur als einfache Punktgrößen zu begreifen, sondern als Netzwerkinfrastrukturen, die einen entscheidenden Beitrag für die Wertschöpfung wissensintensiver Unternehmen leisten.

Das Zusammenspiel von Service- und Netzwerkinfrastruktur hat Flughäfen und ihre direkten Umfelder zu hochattraktiven Standorten für Unternehmen der Wissensökonomie gemacht. Dies gilt vor allem für wissensintensive Firmen, für die sowohl relationale als auch geographische Nähe entscheidend ist. Eine verstärkte Büroimmobilienentwicklung direkt am und im direkten Umfeld der Flughafenterminals dokumentiert diesen Entwicklungsprozess. In den neuartigen bürostandörtlichen Mustern um die immobile Infrastruktur Flughafen lässt sich das komplexe Wechselspiel vom Immobilität und Mobilität ablesen. Ein Schlüssel zum

Verständnis dieser raumstrukturellen Prozesse sind die veränderten Standortanforderungen wissensintensiver Unternehmen. Wissensintensive Unternehmen wählen optimale marktorientierte Standorte in Abhängigkeit ihrer individuellen Wertschöpfungsketten sowie des Vernetzungsgrades der an der Herstellung der Dienstleistung, Produktlösung und Endprodukte involvierten Unternehmen.

Die Ergebnisse zeigen, dass Flughäfen nicht mehr primär als Infrastruktureinrichtung wahrgenommen werden, sondern als vorteilhafter Immobilien- und Geschäftsstandort. Multimodalität in Verbindung mit einer hochwertigen Dienstleistungsinfrastruktur wird zunehmend als entscheidender Wettbewerbs- und Entwicklungsvorteil im Rahmen der internen und externen Leistungserstellung erachtet.

Individuelle Leistungsbeiträge des Kandidaten:

- Literatur- und Datenanalyse
- Erarbeitung der inhaltlichen Konzeption
- Schriftliche Abfassung der Forschungsergebnisse

2.1 Einleitung

Flughäfen liegen in der europäischen Wahrnehmung meist „da draußen“. Wir denken noch immer monozentrisch von der Kernstadt nach Außen in die Peripherie. Doch die funktionalen Realitäten haben sich verändert. Logistikunternehmen haben sich Flughäfen zu ihrem Zuhause gemacht und immer mehr Unternehmen der Wissensökonomie folgen. Drehscheibenflughäfen lagern immer unterschiedlichere urbane Funktionen an und erwecken den Anschein der Herausbildung von stadtähnlichen, urbanen Strukturen. Der folgende Beitrag wirft erst einen kurzen Blick auf die veränderte Rolle von Flughäfen. Danach erläutern wir das Wechselspiel von Verkehrsknotenpunkten und Raumentwicklung und zeigen danach, wie Flughäfen als Entwicklungstreiber eines neuen urbanen Ordnungsmusters zu begreifen sind. Darin spielt unseres Erachtens die Wissensökonomie mit ihren Standortanforderungen an Komplementarität von räumlicher Nähe und relationaler Nähe eine entscheidende Rolle für die Herausbildung von urbanen Strukturen am und um die Drehscheibenflughäfen. Flugverkehr, Straße, Schiene und Langsamverkehr verbinden sich zu multi-modalen Erreichbarkeitsknoten, die enorme Interaktionspotentiale ausbilden. Daraus entwickeln sich wiederum neue Segmente des Immobilienmarktes.

2.1.1 Vergangenheit als Prolog

Am Anfang stand der Traum des Menschen, fliegen zu können. Dieser Traum wurde Ende des 19. Jahrhunderts durch wagemutige Pioniere wie Louis Blériot oder Otto Lilienthal Realität. Der technische Fortschritt hat seitdem die Luftfahrt weiter perfektioniert. In den Anfangsjahren reichten noch einfache Kuhweiden als Flugplatz, so genannte Aerodrome, wie die Huffman Prairie im Falle der Gebrüder Wright. Mit der zunehmenden Nachfrage nach Flugverkehrsdienstleistungen sowie der Größe der Flugzeuge stiegen auch die Ansprüche an den reibungslosen Ablauf.

Anfang des 20. Jahrhunderts wurde das Konzept des Flughafens erstmals durch den brasilianischen Flugpionier Alberto Santos Dumont eingeführt (Schulz et al. 2010: 2). Seitdem haben sich Flughäfen sowohl in ihrer Textur, ihrer Komplexität als auch in ihrer Funktion ständig gewandelt. Beispielhaft für diesen Wandel waren und sind Fortschritte im Bereich der Flugzeugtechnik ab den 1960er Jahren, stark gestiegene Fracht- und Passagierzahlen oder das sich über die Jahre gewandelte Marktumfeld der Flughafenbetreiber.

Eines hat sich jedoch nicht geändert. Von Beginn an stellten Flughäfen „Visitenkarten“ oder Foyers von Städten dar. Sie vermitteln den ersten oder letzten Eindruck einer Stadt entweder auf der Fahrt vom Flughafen in die Stadt oder umgekehrt. Sie übernehmen damit jene Gateway-Funktion, welche zuvor Stadttoren, Häfen oder Bahnhöfen jahrhundertelang oblag.

2.2 Das Wechselspiel von Verkehrsknotenpunkten und Raumentwicklung

Seit der sogenannten „Neolithischen Revolution“ (Childe 1950), dem Übergang einer nomadischen Lebensweise hin zur Sesshaftigkeit mit produzierender Wirtschaftsweise, stehen technische Erneuerungen im Bereich des Transport- und Verkehrswesens und

Raumentwicklung in einer engen Wechselbeziehung. Die Mobilität von Produktionsfaktoren wie Arbeit, Kapital oder Wissen ist eine Grundvoraussetzung für eine arbeitsteilige Wirtschaft (Merki 2008: 8), wie sie sich innerhalb fester Siedlungsplätze und Städte entwickelte. Ausgangspunkt einer solchen arbeitsteiligen Spezialisierung ist die Existenz von festen Infrastruktursystemen. Standorte, an denen die aus Netzen bestehenden Verkehrssysteme den Verkehr bündeln, werden als Knotenpunkte bezeichnet (Merki 2008: 26). Diese Kreuzungspunkte des Güter- und Personenverkehrs waren seit jeher Ausgangspunkt für städtische Entwicklungen. Erfindungen wie das Schiff, die Eisenbahn, das Automobil, die Straßen- und S-Bahnen oder das Flugzeug haben allesamt dazu beigetragen, dass sich die Verkehrszentralität von Städten und Standorten neu definierte.

So hat die verbesserte Erreichbarkeit ehemals abseits gelegener Städte, etwa durch die Anbindung an ein Schienennetz, oftmals zu deren Wachstum beigetragen, Grundlagen neuer wirtschaftlicher Prosperität geschaffen und die Position der Stadt innerhalb der urbanen Hierarchie verbessert. Gleiches lässt sich für die verbesserte Integration von Städten in die Flugverkehrsnetze und die daraus resultierenden Auswirkungen auf die Raumentwicklung der betreffenden Städte konstatieren. Die wirtschaftliche Entwicklung von Städten wie Singapur oder Dubai und deren verbesserte Position innerhalb der globalen Städtehierarchie im Verlauf der letzten Dekade ist weitestgehend verknüpft mit der Geschichte ihrer Verkehrsgunst.

Die Auswirkungen einer verbesserten verkehrstechnischen Erschließungsqualität auf die gebaute Umwelt lassen sich vor allem auf der Ebene der Mikroumfelder um die Infrastruktureinrichtungen herum ablesen. Betrachtet man alleine die technischen Neuerungen des mechanisierten Transports der letzten zwei- bis dreihundert Jahre sowie deren Auswirkungen auf den Raum, so wird verdeutlich, dass jeder Transportmodus zu einem ihm spezifischen standörtlichen Raummuster geführt hat (Kramar und Suitner 2008: 87; Conway 1993: 1). Häfen, Bahnhöfe oder Flughäfen wurden zumeist am Stadtrand geplant. Innerhalb kürzester Zeit entwickelten sie sich zu Impulsgebern der Standort- und Immobilienentwicklung. Prominente Beispiele sind Frankfurt Hauptbahnhof oder New York Grand Central (vgl. Schlichting 2001).

Bezogen auf Flughäfen als raumgebundene Infrastruktur an der Schnittstelle zwischen Luftverkehr und terrestrischem Verkehr konstatiert Edward J. Taaffe bereits 1956: “Canals, railroads and highways, channeling the flow of traffic, have created new urban alignments, hinterlands and nodal points. Now air transportation promises to become a vital factor“ (Taaffe 1956: 219).

2.3 Flughäfen als neues vielschichtiges System

Nach lexikalischem Verständnis sind Flughäfen großflächige Anlagen der Luftfahrt, die primär dem Starten und Landen von Flugzeugen sowie durch entsprechende technische Anlagen und Serviceeinrichtungen der Personen- und Güterabfertigung dienen (Leser 2005: 238). Folgende fünf Kernbestandteile charakterisieren in der Regel einen jeden Flughafen: Start- und Landebahn, Kontrollturm, Wartungshalle, Flughafengebäude sowie Park- und Cargo-Bereiche (Edwards 2005: 6).

Diese verkehrstechnisch zwar zutreffende Definition von Flughäfen greift jedoch im Hinblick auf die gegenwärtige Entwicklung an internationalen Flughäfen zu kurz. Diese enge Definition vernachlässigt insbesondere solche Funktionen, welche den Flughafen als ein für Passagiere, Nicht-Reisende und Frachtgüter vielschichtiges System mit diversen und flexiblen Anschlüssen an lokale, regionale, nationale und internationale Märkte erscheinen lässt. Die unterschiedlichen Funktionen und das veränderte Verständnis von Flughäfen lassen sich sprachlich am besten mit dem Bild eines Marktplatzes fassen (Gottdiener 2001; Edwards 2005), der neben den Bedürfnissen der rein verkehrlichen Marktteilnehmer auch jenen Zwecken anderer Akteursgruppen, etwa aus der Handels- und Dienstleistungsbranche, Rechnung trägt.

Flughäfen sind damit nicht mehr nur als einfache Infrastruktureinrichtungen oder als Solitäre an der Peripherie der Städte zu begreifen. Flughäfen sind heute mehr (Güller et al. 2003). Sie sind Netzwerkinfrastrukturen, Wissensdrehscheiben und Impulsgeber für die Entwicklung von Immobilienstandorten. Flughäfen entfalten zunehmend stadtbildende Kräfte und ihre Auswirkungen auf den übergeordneten Prozess der Re-Konfiguration des metropolitanen Raumes sind weitreichend.

2.4 Flughäfen als Entwicklungstreiber eines neuen urbane Ordnungsmusters

In den vergangenen Dekaden ist es sukzessive zu einer funktional-ökonomischen Anreicherung der Stadtperipherie mit einer Vielzahl von vormals in den Innenstädten lokalisierten Nutzungen gekommen. Dies führte zu einer Abnahme des Kern-Rand-Gradienten sowie zu einer Erosion der Relation zwischen den traditionellen Polen von Stadt und Peripherie. Während sich das monozentrische Beziehungsgefüge im Zuge dieser Suburbanisierungsprozesse verstärkt auflöst, kommt es zeitgleich zur Herausbildung eines komplexen polyzentrischen Systems, gekennzeichnet durch eine Vielzahl ausgelagerter und gegenüber der Kernstadt emanzipierter Subzentren, die in ihrer Struktur sowohl monofunktional als auch multifunktional gestaltet sein können (Fassmann 2004: 115). Für diesen nur noch bedingt mit den herkömmlichen Vorstellungen von Stadt zu greifenden räumlichen Rekonfigurationsprozess hat die Fachdiskussion eine Vielzahl von Neologismen hervorgebracht (vgl. Lang 2000: 31). Der auffälligste und wohl in der Fachliteratur am meisten gewürdigte Ausdruck stellt hierbei Garreaus Begriff der „Edge City“ dar (Garreau 1991). Flughäfen und deren Umfelder sind ein Beispiel solcher neuartigen Subzentren und oftmals Start- oder Endpunkt einer Entwicklungsachse – dem so genannten

Flughafenkorridor (Schaafsma et al. 2008) – zwischen dem Flughafen und den jeweiligen Kernstädten.

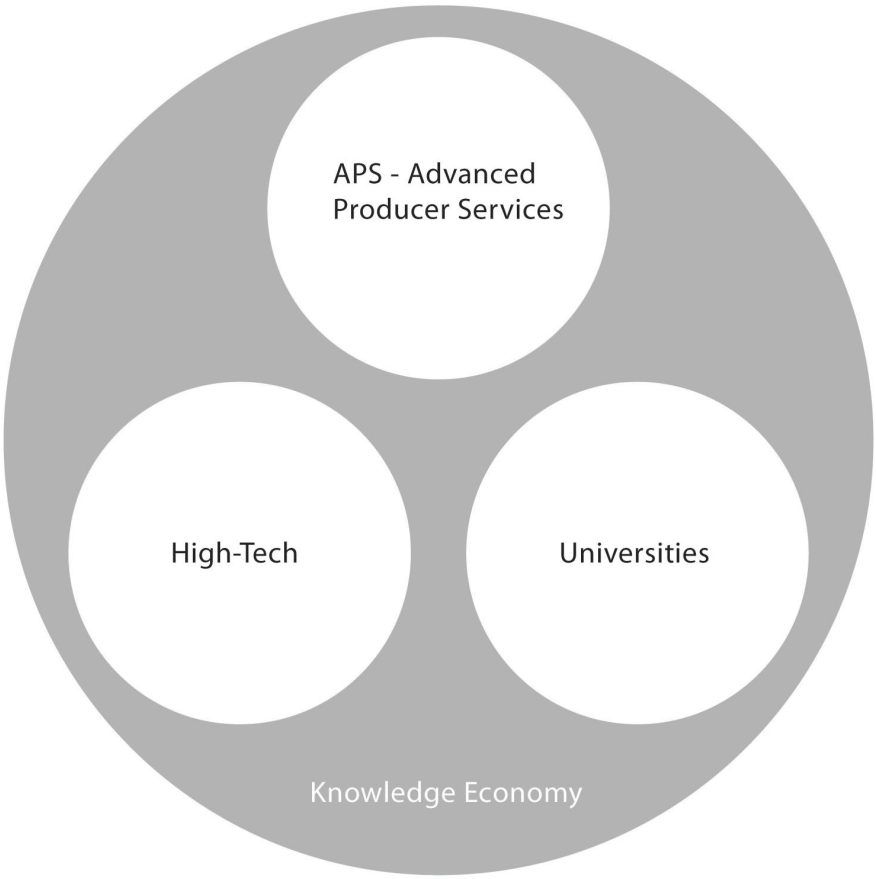
Ausgehend von einer explizit flughafenorientierten Raumentwicklung bereicherte Kasarda die Diskussion um den Begriff der Aerotropolis, einer speziellen Ausprägung der Edge City (Properi 2007). Nach Kasarda bezeichnet die Aerotropolis eine bis zu 15 Meilen vom Flughafen entlang der Hauptverkehrsachsen abstrahlende neue urbane Form luftfahrtorientierter Business-Clusters (Kasarda 2004: 92).

In den letzten Jahren haben sich Flughafenstandorte jedoch nicht nur auf zeitsensitive Wirtschaftszweige des produzierenden Gewerbes und Logistiker anziehend ausgewirkt, sondern ebenfalls auf wissensbasierte Unternehmungen der Dienstleistungs- und High-Tech Branchen. Dies drückt sich räumlich in einer verstärkten Ansiedlung von Hauptquartieren und regionalen Niederlassungen entweder direkt am oder in unmittelbarer Nähe zum Flughafen aus. Geschah diese Entwicklung in den Anfangsjahren noch unmerklich und im Verborgenen, so tritt die veränderte Raumstruktur nun zunehmend zu Tage. Eine neue räumliche Hierarchie von Wertschöpfungssystemen entsteht – und damit eine Re-Konzentration auf „dichte Kompetenzzentren“.

2.5 Die Bedeutung räumlicher Nähe und relationaler Nähe für die Wissensökonomie

Flughäfen stehen im Standortwettbewerb einer sich ausbreitenden Wissensökonomie. Wissen gilt als unentbehrliche Grundlage von Innovationen (Kloosterman 2008) und damit als Basis der Wissensökonomie. Unter Wissensökonomie werden hier wirtschaftliche Aktivitäten verstanden, die von Wissen als Inputfaktor besonders abhängig sind und auf der Outputseite entweder neues Wissen – zum Beispiel in Form von Patenten, Verfahrenskenntnissen etc. – oder innovative Hightech-Produkte und Verfahren bereitstellen (Kujath und Schmidt 2007). Wissensintensive Dienstleister und High-Tech Unternehmen bilden den Kern der Wissensökonomie (Kujath und Schmidt 2007; Thierstein 2006 et al.), siehe Abbildung 6.

Abbildung 6: Die Standbeine der Wissensökonomie



Quelle: Modifizierte Darstellung nach Thierstein et al, 2006, S. 35

APS-Unternehmen bieten anderen Dienstleistungsunternehmen fachkundige, wissensbasierte Dienstleistungen an und arbeiten für diese spezialisierte Informationen auf. Als Beispiele lassen sich Finanzdienstleister wie JP Morgan Chase und Goldman Sachs, Beratungsunternehmen wie The Boston Consulting Group oder Roland Berger, Engineering-Firmen wie Arup, Architektenbüros wie Foster & Partners oder Logistikanbieter wie DHL und United Parcel Service nennen. Weil alle diese Dienstleister Informationen generieren, analysieren, austauschen und kommerziell nutzen, sind sie wichtige Intermediäre in der Wissensökonomie. Die von ihnen erbrachten Dienstleistungen werden durch interne Verbindungen zwischen APS-Niederlassungen auf der ganzen Welt sowie aus vielgestaltigen Verbindungen mit branchennahen Unternehmen und Kunden entlang der jeweiligen Wertschöpfungskette ermöglicht. Weil APS-Firmen zudem expandieren, spielen die Informationsflüsse innerhalb und zwischen den Firmen eine entscheidende Rolle für die Anbindung von Städten an die Weltwirtschaft.

Der High-Tech Sektor ist geprägt von hoch qualifizierten Arbeitskräften – darunter viele Wissenschaftler, Ingenieure usw. –, hohen Wachstumsraten, im Verhältnis zu den Umsätzen hohen Forschungs- und Entwicklungsaufwendungen und einem weltweiten Markt für seine Produkte.

Die Organisationsstrukturen transnationaler Unternehmen lassen einen gemeinsamen Kern erkennen: Immer stärker spezialisierte Einheiten werden weltweit in ein Netzwerk von Aktivitäten integriert, welche die Effizienz, Reaktionsfähigkeit und Kreativität fördern. Städte beherbergen solche Aktivitäten und urbane Drehscheiben – wie zum Beispiel ein Flughafen – spielen als firmeninterne oder externe Knoten in den globalen Wissensnetzwerken eine entscheidende Rolle. Wissen kann dabei unterschiedlicher Art sein und auf unterschiedliche Weise entwickelt werden:

(1) Wissen wird in standardisiertes Wissen und kontextabhängiges Wissen unterschieden (Läpple 2004). Standardisiertes oder kodifiziertes Wissen liegt in gedruckter oder digitaler Form vor und kann leicht z.B. per Email oder Telefon ausgetauscht werden. Von kontextabhängigem, implizitem Wissen oder „tacit knowledge“ spricht man dann, wenn es sich um Fähigkeiten oder Können von Personen handelt, die nicht ohne weiteres mittels Schrift oder durch Telekommunikation eindeutig vermittelt werden können. Meric S. Gertler zitiert daher Karl Paul Polanyi mit den Worten: „We know more than we can tell“ (Gertler 2003: 77).

(2) Um die unterschiedlichen Wege der Wissensgenerierung zu erläutern, wird zwischen analytischem, synthetischem und symbolischem Wissen unterschieden (Asheim und Coenen 2005). Analytisches Wissen bezieht sich auf Vorgänge, in denen formale Modelle und kodifiziertes Wissen eine Rolle spielen. Die Schaffung analytischen Wissens bedingt die Zusammenarbeit innerhalb einer Arbeitsgruppe oder zwischen Arbeitsgruppen. Synthetisches Wissen entsteht durch die neue Kombination vorhandenen Wissens, z.B. im Maschinenbau. Das Wissen wird in einem Austauschprozess mit Kunden, Zulieferern oder Forschungseinrichtungen entwickelt (Asheim und Gertler 2005; Thierstein et al. 2008). Symbolisches Wissen hingegen meint die ästhetischen Attribute eines Produkts. Dazu zählt die Produktion von Design und Bildern. Befördert wird die Schaffung symbolischen Wissens durch den Austausch mit anderen Kreativen sowie durch ein urbanes Umfeld (Asheim und Gertler 2005).

2.5.1 Bedeutung von Face-to-Face-Kontakten für die Wissensökonomie

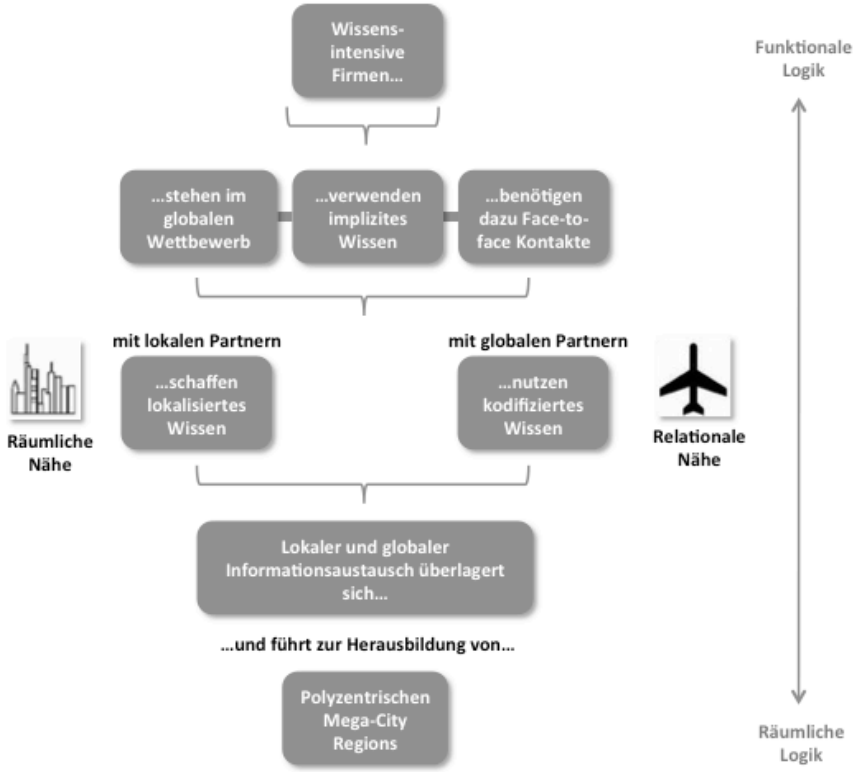
Kommunikationsmittel ermöglichen die Übertragung von Informationen. Aus diesen wird durch kognitive Leistungen neues Wissen generiert. Dieser schöpferische Prozess ist via Email oder Telefon nicht ohne weiteres möglich. Erforderlich sind ein gemeinsamer kognitiver, kultureller und sozialer Kontext sowie ein direkter Kontakt, häufig als Face-to-Face-Kontakt bezeichnet. Von Vorteil für direkte Kontakte sind kurze Wege und eine hohe Dichte an Möglichkeiten des Informationsaustausches, d.h. eine räumliche Dichte, die nur in bestimmten urbanen Quartieren erreicht wird (Läpple 2004; Thierstein et al. 2008). Dort sind Möglichkeiten zum informellen Austausch geboten, beispielsweise in der Mittagspause oder nach Arbeitsende in umliegenden Cafés, Bars und Restaurants (Rogers und Larsen 1984). Face-to-Face-Funktionen breiten sich heute über die Region aus. Sie konzentrieren sich an

bestimmten Orten, wie neuen städtischen Zentren, Edge Cities auf der Achse zum Flughafen oder an Stationen des Hochgeschwindigkeitsnetzes der Bahn (Hall und Pain 2006). Die Schaffung neuen Wissens ist auf interaktionsaffine Orte angewiesen, die durch hohe Erreichbarkeit gekennzeichnet sind und sich nicht mehr ausschließlich in Innenstädten finden.

2.5.2 Bedeutung von Hubflughäfen für die Wissensökonomie

Unternehmen der Wissensökonomie stehen heute in einem weltweiten Wettbewerb. Sie generieren neues Wissen durch physische Interaktionen vor Ort und sind gleichzeitig weltweit mit hoch erreichbaren Partnerstandorten vernetzt, die effizient erreichbar sind. Räumliche Nähe und relationale Nähe sind daher Zwillinge der Wissensökonomie (Faulconbridge 2007). Wissensintensive Unternehmen stehen vor der Anforderung, die Schaffung von neuem Wissen über Face-to-Face-Kontakte am Unternehmensstandort selbst oder in seiner Nachbarschaft hinaus in einem größeren räumlichen Maßstab zu organisieren. Die Nutzung von Informationstechnologien aller Art, gepaart mit wachsenden Möglichkeiten der Koordination über weite Entfernungen hinweg, verbessert die Austauschmöglichkeiten sowie die Schaffung von neuem Wissen zwischen weit auseinander liegenden Orten (Torre und Rallet 2005). Flugreisen bieten die Möglichkeit, weltweit Face-to-Face-Kontakte zu arrangieren. So tritt zur Rolle von geographischer Nähe die relationale Nähe hinzu (Gertler 2003; Kramar und Suiter 2008). Polyzentrische Mega-City Regions (Hall und Pain, 2006) ermöglichen sowohl geographische als auch relationale Nähe. Sie bieten einerseits dichte, vielfältige urbane Orte mit einer hohen Wahrscheinlichkeit der Interaktion zwischen Menschen. Anderseits generieren Drehscheibenflughäfen mit einer großen Anzahl von Direktflügen zu internationalen Destinationen hochgeschätzte Erreichbarkeitsvorteile (Simmie 2003; Convery et al. 2006).

Abbildung 7: Räumliche und relationale Nähe



Quelle: Dross, Thierstein, 2011, S. 29

2.6 Flughäfen als neuartige funktionale Räume

Mittlerweile ist anerkannt, welchen Beitrag Hubflughäfen als Netzwerkinfrastruktur für die Wertschöpfung wissensintensiver Unternehmen leisten. Auf der anderen Seite beginnt man erst allmählich zu ahnen, aufgrund welcher Prozesse sich urbane Strukturen in europäischen Flughafenregionen herausbilden.

Heute sind Flughäfen mehr als nur einfache, von verkehrstechnischen Überlegungen getriebene mono-modale Solitäre in der Peripherie der Städte. Bedingt durch die Ansiedlung zusätzlicher Nutzungen und Funktionen haben sich Flughäfen graduell zu multifunktionalen Immobilienstandorten gewandelt. Sie sind gekennzeichnet durch eine breite Mischung unterschiedlichster Immobilientypen wie Büro, Logistik, Hotels, Einrichtungen der Erholung und Gesundheit, von Wellness oder Wohnbebauung. Für letzteres stellt Helsinki-Vantaa ein gutes Beispiel dar, wo im direkten Umfeld zum Flughafen auch hochwertige Wohnbebauung vorzufinden ist.

Ursächlich für diese Entwicklung sind neben den veränderten Anforderungen der betrieblichen Standortwahl wissensintensiver Unternehmungen auch die zunehmend unsichereren Marktbedingungen für Betreibergesellschaften von Flughäfen und

Fluggesellschaften. Um unter diesen neuen Marktgegebenheiten zu bestehen, haben viele Flughafenbetreiber im Zuge der Entwicklung neuer Geschäftsfelder den Ausbau von sogenannten ‚Non-Aviation'-Nutzungen forciert. Darunter werden alle Dienstleistungsfunktionen subsumiert, die „lediglich mittelbar das Funktionieren des Flughafenbetriebs unterstützen, indem sie z.B. mit ihren finanziellen Erträgen zur Erhöhung der Wirtschaftlichkeit des Unternehmens beitragen" (Dehn; Hacker & Vesely 1998: 63). Beispielhaft sind die Sektoren Einzelhandel, Gastronomie oder sonstige Immobiliennutzungen zu nennen (Warschun 2007). Der Ausbau des Non-Aviation-Bereichs trägt somit entscheidend zur Entstehung multifunktionaler Nutzungsagglomerationen auf dem Flughafengelände sowie dessen unmittelbarer Umgebung bei. Internationale Flughäfen werden durch diese zusätzlichen Angebote, beispielsweise an Büros und Einzelhandelsflächen, immer mehr zu Konsum- und Erlebniswelten (Haas und Wallisch 2008). Die ökonomische Robustheit des Standorts gegenüber der Volatilität in der Luftverkehrsnachfrage erhöht sich.

Diese Entwicklung wird vielfach mit dem Begriff „Airport City" umschrieben. Der Begriff „Airport City" erfährt im Zusammenhang mit der flughafenbezogenen Immobilienentwicklung in der wissenschaftlichen Literatur, Presse und seitens der Flughafenbetreiber am meisten Würdigung, ohne jedoch einheitlich definiert zu sein. Die einzelnen definitorischen Ansätze lassen Differenzen sowohl im Hinblick auf die Merkmale als auch auf die räumliche Abgrenzung erkennen. Oft setzen „Airport City"-Definitionen an der hohen baulichen Dichte sowie der Breite der Angebote und Kundengruppe an (Conway 1978: 48; Schaafsma 2003: 34ff.). In Anlehnung an das Begriffsverständnis von Güller und Güller (2003) versteht man unter "Airport City" „the more or less dense cluster of operational, airport related activities, plus other commercial and business corners, on and around the airport platform" (Güller et al. 2003: 70).

Im Zusammenhang mit dem Begriff „Airport City" muss jedoch angemerkt werden, dass die begriffliche Verbindung von Flughafen mit dem Stadtbegriff nicht unproblematisch ist und daher mit besonderer Vorsicht gebraucht werden sollte. Auch wenn Flughäfen verstärkte urbane Funktionen auf sich vereinigen können, sind sie keine Städte im engeren Sinn (Schubert und Conventz 2011: 20). Sie verfügen bislang weder über die für Städte konstitutive permanente Einwohnerschaft noch über eine Gemeindeverwaltung bzw. -verfassung. Vielmehr verbirgt sich hinter dem Begriff vorrangig eine Geschäfts- bzw. planerische Entwicklungsstrategie, die sich nicht zuletzt aus den für die Flughafenbetreiber veränderten Rahmenbedingungen ergibt.

Dennoch spielt sich strukturell weit mehr ab als äußerlich erkennbar wird. Jenseits der geographisch-funktionalen Sicht kann man die Charakteristika der baulichen Umgebung der Airport City als eine Situation identifizieren, welche als wichtiges Argument für die Definition als Stadt gilt: Durch die sich gegenseitig bedingende Interaktion der Akteure wird „Stadt" durch „städtisches Leben" respektive das „Städtische" ersetzt. Interaktion, nicht der Raum, ist die Essenz der Stadt und von städtischem Leben. Mit „Stadt" werden der physisch-räumliche Gegenstand, seine Typologie und seine Eigenschaften bezeichnet; mit „urbanen Strukturen" die „städtischen" Organisations-, Funktions- und Gebrauchsmuster. Für die Beschreibung von Siedlungsphänomenen, welche städtischer Organisationslogik, nicht aber deren typischer baulicher Ausprägung folgen, wird deswegen auf den Begriff „urbane Strukturen" ausgewichen.

2.6.1 Flughäfen als multimodale Netzwerkinfrastruktur

Ein weiterer Faktor, welcher die Genese und das Wachstum von urbanen Strukturen und Immobilienentwicklungen unterstützt, ist die Anbindung des Flughafens an die Kernstadt sowie die Integration des Flughafens in weitere regionale, nationale und internationale Verkehrsnetze. Viele Flughafenstandorte in Europa vereinen heute zwei Qualitäten: Zum einen die weltweite Erreichbarkeit per Flugzeug, zum anderen die lokale, regionale und nationale Erreichbarkeit per Fern- und Schnellstraße beziehungsweise Stadt-, Regional- und Fernbahn (Speer 1997: 16).

Vor allem dem Flughafenbahnhof kommt diesbezüglich eine entscheidende Bedeutung zu. Gewährleistete dieser in der Vergangenheit als Satellit des Hauptbahnhofs oder als Einzelhaltestelle einer Regionalbahn- oder U-Bahnlinie vornehmlich die An- und Abreise von Fluggästen, so kommt dem Flughafenbahnhof als Verkehrsknoten unterschiedlicher Transportmedien heute eine neue Bedeutung zu. Dieses neue Verständnis von Flughäfen und deren Bahnhöfen wird von Güller et al. wie folgt beschrieben:

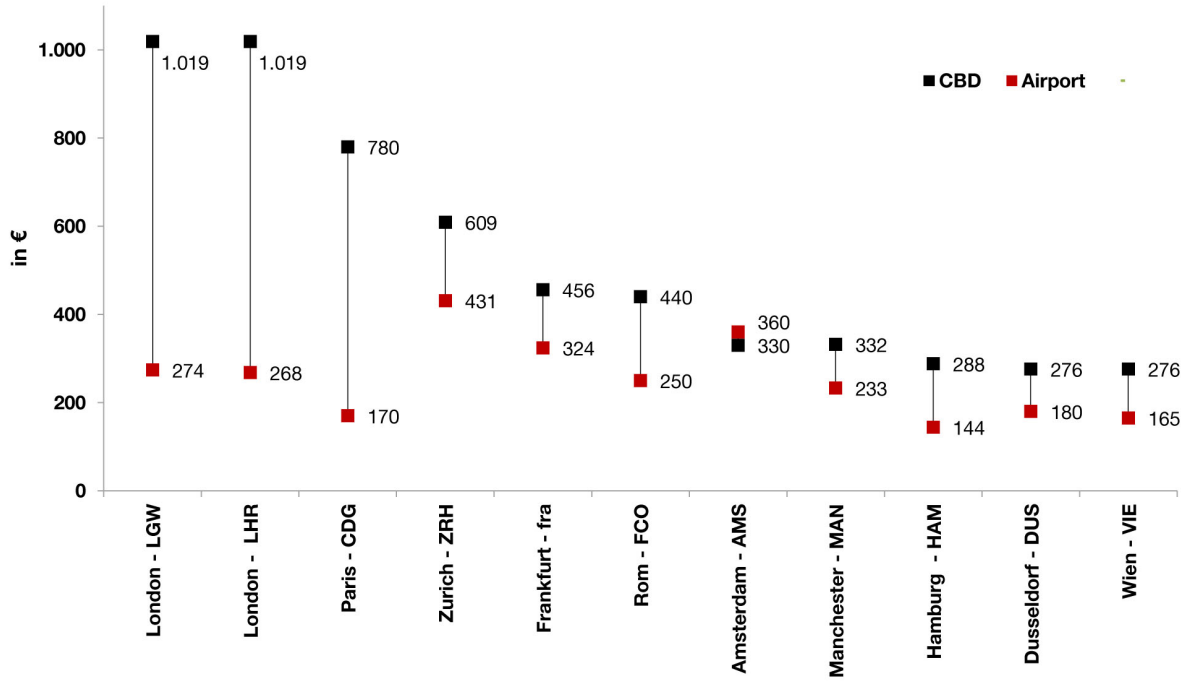
„Airport interchange is the airport railway station's function as a node in landside traffic networks: it not only serves air traffic passengers and airport employees, but is also used to interchange between regional and national public transport networks (rail-rail, rail-subway, rail-bus, bus-bus, etc.). [...] Airport interchange requires the convenient interconnection of all modes of transport" (Güller et al. 2003: 131).

Flughäfen sind damit nicht mehr als einfache Punktgrößen zu verstehen, sondern als Netzwerkinfrastruktur, welche die luftseitigen Verkehrsströme mit den landseitigen Verkehrsströmen in unmittelbarer und einzigartiger Weise zusammenführt.

2.6.2 Der Flughafen als neues Wissensquartier

Aufgrund ihrer zunehmend ausgereifteren Infrastruktur sowie der Genese von urbanen Strukturen konnten Flughäfen sich in den letzten Jahren verstärkt als Bürostandorte vor allem von Unternehmungen der Wissensökonomie etablieren. Dies drückt sich räumlich in einer verstärkten Ansiedlung von Hauptsitzen von Unternehmen und regionalen Niederlassungen direkt am Flughafen aus. Zwischenzeitlich beschränken sich die Entwicklungen nicht mehr nur auf das Flughafengelände, sondern umfassen auch umliegende Gebiete. Hierdurch konnte in den letzten Jahren vielfach eine kritische Masse an Büroflächen erreicht werden, die letztlich zur Herausbildung neuer Teilmärkte innerhalb des Gesamtmarktes beigetragen haben. Aufgrund der oftmals einzigartigen verkehrstechnischen Erschließungsqualität der Teilmärkte liegen die hier realisierten Mieten weit über dem marktüblichen Durchschnitt. Oftmals reichen sie sogar an die Spitzenmieten im Gesamtmarkt heran. Im Fall von Amsterdam hat sich das Mietpreisgefüge sogar umgedreht. Hier ist nicht der Innenstadtbereich oder Central Business District der teuerste Bürostandort, sondern der Flughafen Amsterdam Schiphol, siehe Abbildung 8.

Abbildung 8: Ausgesuchte Spitzenmieten im Vergleich (2009)



Quelle: Eigene Darstellung, modifiziert nach CB Richard Ellis, 2009

Auch die Nutzergruppen, welche Büroflächen an Flughäfen nachfragen, haben sich verändert. In den letzten Jahren haben sich Flughäfen als Standort nicht nur auf zeitsensitive Wirtschaftszweige des produzierenden Gewerbes und Logistiker anziehend ausgewirkt, sondern ebenfalls auf reise- und wissensintensive Unternehmungen der Dienstleistungsbranche. Diese neuen potentiellen Nutzergruppen zeichnen sich vor allem durch ihren sehr hohen Mobilitätsbedarf aus, häufig gekennzeichnet durch eine hohe internationale Vernetzung und eine hohe Kontakthäufigkeit zwischen Kunden und Angestellten. Flughäfen als Bürostandort sind damit insbesondere für jene mobilitäts- und wissensintensiven Unternehmen interessant, welche auf der Schnittstelle von physischen Plätzen und virtuellen Netzwerken arbeiten und für die sich eine physische Zusammenkunft mit anderen Geschäftspartnern nur dann als sinnvoll erweist, wenn aus der Face-to-Face Interaktion ein Mehrwert für ihre Arbeit resultiert. Nachfrage nach Büroflächen an Flughäfen wurde in den letzten Jahren vor allem von Unternehmen aus folgenden Branchen generiert: Beratung, Information und Kommunikation, Einzelhandel, Verwaltung, Industrie und Bauunternehmen, Personalberatung, Gesundheitswesen, Transport und Verkehr sowie dem Bereich Finanzdienstleistung. Neben den genannten Branchen lässt sich in der letzten Zeit auch eine zunehmende Nachfrage von Universitäts- und Forschungseinrichtungen verzeichnen. Ein Beispiel ist das House of Logistics in Frankfurt, ein Zusammenschluss aus unterschiedlichen Wissenschafts- und Forschungseinrichtungen.

2.7 Fazit

Flughäfen waren in der Vergangenheit funktionale, von verkehrstechnischen Überlegungen getriebene mono-modale Solitäre in der Peripherie der Städte. Diese Beschreibung trifft heute auf eine Vielzahl von Flughäfen nicht mehr zu. Heute haben sich viele Flughäfen zu multifunktionalen und multi-modalen Immobilienstandorten, zu Knotenpunkten des Informationsaustausches und des globalen Warenhandels verdichtet. Die Überlagerung von unterschiedlichen leistungsfähigen Transportmodi aus Luft, Schiene und Straße hat eine einzigartige Standortqualität auf der Schnittstelle von globalen, nationalen, regionalen und lokalen Verkehrsströmen hervorgebracht. Damit sind Flughäfen nicht mehr nur als einfache Punktgrößen zu begreifen, sondern als Netzwerkinfrastrukturen, die einen entscheidenden Beitrag für die Wertschöpfung wissensintensiver Unternehmen leisten. Flughafenstandorte haben sich im selben Zeitraum weiter aufgewertet, weil Flughafenbetreiber die Non-Aviation-Aktivitäten stark ausgebaut haben, was wiederum neuartige urbane Strukturen hervorbringt. Das Zusammenspiel von Service- und Netzwerkinfrastruktur hat Flughäfen und ihre direkten Umfelder zu hochattraktiven Standorten für eine Vielzahl wissensintensiver Firmen werden lassen, für welche sowohl relationale als auch geographische Nähe entscheidend sind. Dabei kommt die Nachfrage heute nicht mehr nur von Unternehmen mit direktem Bezug zum Fluggeschäft, wie zum Beispiel Logistik, sondern verstärkt auch von wissensintensiven Unternehmen, etwa aus dem Einzelhandel, der Informationstechnik, der Rechtsberatung, der Finanzdienstleistung und dem Gesundheits- oder Versicherungswesen.

Flughäfen werden in Zukunft dank ihrer Drehscheibenfunktion weitere hochwertige Dienstleistungsangebote anziehen, die man heute eher in Kernstädten vorfindet. Die Herausforderung besteht darin, funktionale Erfordernisse an das Raumprogramm mit räumlich-architektonischer sowie städtebaulicher Qualität zu verbinden. Dazu gesellt sich hochwertige Freiraumplanung, denn es ist davon auszugehen, dass diese neuen urbanen Strukturen auch dank kurzer Wege und hoher Aufenthaltsqualität eine starke Konkurrenz zu traditionellen Kernstädten werden können.

Das traditionelle Verständnis vom Flughafen als Ort von ankommenden und abfliegenden Flugzeugen hat sich stark gewandelt. Flughäfen sind heute über ihre Konzessionsgrenze hinaus zugleich funktionale Interaktionsräume und Verkehrsknotenpunkte, die aufgrund ihrer absehbaren Entwicklungspfade zunehmend als Informations-, Geschäfts- und Wissensdrehscheiben fungieren und daher entsprechend qualitätsvoller Gestaltung bedürfen.

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3 Airports and the knowledge economy. A relational perspective.

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The chapter has been slightly edited to fit the format of this dissertation.

Abstract

The second article, entitled “Hub Airports and the knowledge economy. A relational perspective“, published by Routledge within the Regions and Cities series, is also a conceptual article, which introduces a combined relational framework of physical and non-physical accessibility, and examines the specific role of hub airports for knowledge intensive firms. This article is triggered by the observation that knowledge has increasingly become a key driver for the competitiveness of companies, cities and regions. For companies, knowledge is an important resource for innovation, which, in turn, is one of the major drivers of economic growth. The process of knowledge creation requires a dynamic interplay between tacit and explicit forms of knowledge, as well as a high level of interaction between people within organizations and between them. Thus, knowledge intensive firms require access to information and the ability to acquire experienced based knowledge via face-to-face contact. Accessibility is considered in both its physical and non-physical dimensions. Physical accessibility enables the movement of people and establishes face-to-face contact; non-physical accessibility facilitates the exchange of information. Physical accessibility can be associated with network economies and agglomeration economies. Whereas rail and road accessibility work on the scale of agglomerations, accessibility by air enables network links to worldwide locations. In general, accessibility is an externality that enables firms to reduce costs and enlarge their market areas and, therefore, to realize economies of scale and economies of scope, which in turn generate economic growth. Although, relations between networks of cities and agglomeration effects are discussed broadly, physical infrastructure – especially the role of hub airports – and spatial connectivity are still not integrated adequately into the concept of externalities within knowledge production.

Contribution of the PhD candidate:

- Literature review
- Discussion of the significance and changed role of airports within the field of economic geography and in the knowledge economy context
- Integration of the analysis concept into the field of economic geography
- Elaboration of the research questions and hypotheses
- Elaboration of an approach to understand the hidden structures of knowledge-based spatial patterns at and around international airports

3.1 Introduction

In recent decades global integration and internationalization of economic processes have entailed a reconfiguration process of spatial development on all spatial scales. One consequence of this transformation is the emergence of a new spatial logic in which the architecture of societies, economies and national states is impacted by all kinds of flows. Increasingly, a new spatial pattern of hierarchical, organized, and globally-networked cities can be observed (Friedmann, 1986; Sassen; 2001; Hales and Pena, 2012). Related to the global trends in spatial development, a controversial debate on the correct interpretation has emerged and is dominated by two competing positions: flatness versus spikiness. In 2005, for the first time Friedman argues that the world has become flat (Friedman, 2005). Following Friedman's line of thinking, the world's flattening is the spatial consequence of new information and communication technologies, which have enabled a workforce of millions of well-qualified employees to enter into global competition.

In the same year, Ikenberry, one reviewer of Friedman's book entitled "The world is flat," ironically resumes that the world is not becoming flat, but rather that such an image just appears "from a seat in business class" (Ikenberry, 2005). This estimation is shared by Florida (Florida, 2005), who argues that the world and "global playing field" have not been leveled as proclaimed by Friedman's hypothesis. Instead, the world has become increasingly spiky (Florida, 2005). Florida reasons that a diminishing number of cities must compete for talent, creative people, and global business elites that drive the global economy (Florida, 2005). Indeed, spikiness appears to have stirred the controversial debate: developments in information technology may have shrunk the world, but there appears little evidence of the 'end of geography' (O´Brien, 1992) or the 'death of distance' (Cairncross, 1997).

In order to understand the competitive nature of cities, especially those exposed to global competition, it is essential to understand the character of their networks. Following Castells (Castells, 1996) seminal work on space of flows, societies are centered around all kinds of flows: "flows of capital, flows of information, flows of technology, flows of organizational interactions, flows of images, sounds, and symbols" (Castells, 1996). In his conceptualization Castells claims that the "space of flows" has become the underlying driver of spatial forms and processes rather than the "space of place": "The global city is not a place, but a process" (Castells, 1999). The accuracy of Castell's assumption becomes obvious with the growing relevance of the knowledge economy and its spatial tendencies and practices towards both its concentration around hubs and nodes of high accessibility and its global, functional dispersal of value chains and knowledge networks. The organizational architectures of transnational corporations are converging towards a common configuration in which increasingly specialized units worldwide are integrated into a network of operations that promote efficiency, responsiveness, and creativity. Cities are home to these operations, and "hub cities" (Conventz et al., 2014) play a key role as nodes in global knowledge networks, whether as intra-firm or extra-firm links.

Various research findings, such as those by the Globalization and World Cities (GaWC) Research Network, on world city networks confirm this trend (Taylor et al., 2011). According to the GaWC Research Network, cities are organized in a global urban hierarchy led by a small group of cities, namely London, New York, Hong Kong, Tokyo and Paris, which are all well-connected to each other (Derudder et al., 2010).

The rise of the networked economy, the space of flows, and the growing spikiness of the global urban hierarchies are fueled by advances in transport and telecommunication technologies as well as a growing mobility of global business elites and highly talented people. In light of these trends, airports have gained center stage. Through their capability of concentrating different kind of flows, from local to global spatial scale, airports have advanced to key nodes within the networked economy. Airports as fixed, terrestrial infrastructure systems of the aviation industry are a basic prerequisite within the wealth-creation process of national economies and a catalyst for the "networked world economy." Globalization and the dimensions it has achieved today would be hardly conceivable without the network capability of airports and air transportation. In a growing knowledge economy, which is mostly a "relational phenomenon," air traffic services allow a fast organization of spatially separated knowledge carriers and thus, the strategic combination of highly specialized knowledge and skills from different parts of the value chain.

In order to benefit from the unique networking potentiality of airports, competence-based companies have started to settle their regional, national, and sometimes supranational branches, near airports, as many European examples plainly show. In Switzerland, for instance, the Glatt Valley is one of the top five performing business locations countrywide, benefiting from the good location factors, among which is the international airport of Zurich (Lang, 2012). A myriad of corporate headquarters have favored the Glatt Valley as their preferred office site, and a demand is attracted from the IT-sector (Lang, 2012). A similar picture emerges in Munich, where the city's neighboring municipalities have shown above average benefits from the continuous settlement and expansion of companies in the past few years since the airport's inauguration in 1992 (Droß and Thierstein, 2011; Ernst Basler + Partner AG, 2010). From an economic point of view, the axis between the airport and the city of Munich is considered the most powerful airport-city corridor across Europe, and it is home to a variety of multinational corporations, such as SAP, Microsoft, Baxter, Cassidian, EADS, BMW, GE Electric, Swiss RE, et cetera (Müller, 2012).

How can one interpret these new spatial articulations on a micro-level spatial scale? From our point of view, one of the most important keys to understanding these processes and dynamics are the locational requirements and changing internal and external value-added chains of knowledge-intensive companies. By combining the concept of accessibility with the theoretical approaches of network economies and agglomerations economies, this chapter introduces a new approach in order to understand the spatial alterations around airports.

The following chapter presents a theoretical conceptual framework to better understanding of the new knowledge-based patterns around international airports. This chapter constitutes the conceptual background for an empirical investigation. The results of this empirical investigation are presented in chapter 4. The latter course of this chapter is structured as follows: The second section presents general remarks on different types of airports and airport systems, paying particular attention to hub airports. The third part reflects upon the emerging concept of the knowledge economy, the way in which knowledge is created, and the way in which knowledge-based activities are shaping and transforming spatial textures. In section four to six, we present our research frame. The chapter closes with concluding remarks and a future outlook in research.

3.2 Airports and changing air traffic patterns

Airports are complex and multilayered systems with an array of different types, characteristics, and physical appearances. As places where aircrafts can take off and land, airports form the “achilles heel” (von Gerkan, 1997) within the global air transport system (Knippenberger, 2012). In their simplest embodiment, airports are characterized by five core elements: runways and taxiing areas, air traffic control buildings, aircraft maintenance buildings, passenger terminals and car parks, and freight warehouses (Edwards, 2005). Currently there is no uniform classification of the different types of airports (cf. Federal Aviation Administration, 2013; The Boston Consulting Group, 2004). However, one classification is provided by The Boston Consulting Group (BCG), which differentiates between four types of airports: primary international hubs, secondary hubs, international “origin and destination” (O&D) airports, and finally regional airports (The Boston Consulting Group, 2004). Hub airports, or simply hubs, are the biggest type of airports and serve as transfer points for airlines and their alliance partners to bring passengers to their intended destination. Usually hubs are home of a flagship carrier, integrated in a strategic alliance such as Star Alliance, Sky Team, Oneworld etc., and are characterized by a high share of transfer passengers and a large catchment area (The Boston Consulting Group, 2004). Major global examples of airports of this category are Miami, Atlanta, Hong Kong, Singapore etc. In Europe, the biggest and most important hub airports are located in Frankfurt, London, Paris, Amsterdam, and Madrid.

In contrast to primary hub airports, international “origin and destination” airports are marked by a lower proportion of transfer passengers and a catchment area that is about half as big as those of primary hub airports. These airports, such as Sydney, serve airlines as main hubs for long-haul flights or as a secondary hub of a major airline (The Boston Consulting Group, 2004). Secondary airports again show a low share of transfer traffic and a small catchment area. Secondary hubs like Vienna function as the main hub of a regional airline or a secondary hub of a major airline (e.g. Lufthansa and the Star Alliance) (The Boston Consulting Group, 2004). The smallest type of airports within the BCG categorization are regional airports. Those airports have no transfer competences and only serve a very small catchment area. Generally, regional airports are integrated into the networks of regional and low cost carriers.

3.2.1 Hub-and-spoke versus point-to-point

However, since the inauguration of the world's first airports, airports have changed their structure and functions the same way as air traffic has changed its patterns and airlines their business models. With regard to airline business models, the debate is dominated by two fundamentally competing positions: hub-and-spoke strategy versus point-to-point traffic (Buchanan and Siraut, 2009; Heymann, 2006).

"Point-to-point connections between the world's largest cities dominated networks in the early post-war period. Only a few routes had sufficient demand to serve air traffic. With growth in demand came development of a large number of small and mid-sized regional hubs and international origin and destinations, a second stage of the life cycle. Most recently, increasing cost pressures as well as airline and alliance consolidation is leading to a concentrating of long-haul traffic into a few mega-hubs, with an accompanying rise in continental point-point traffic" (The Boston Consulting Group, 2004).

The underlying idea of the hub-and-spoke business model refers to the image of a chariot wheel with the hub airport as central element around which the different subcomponents, the spokes, are anchored (Derudder et al., 2007). Scheduled airlines which have implemented the hub-and-spoke model bundle their passenger streams at one or more hubs from where they are transferred to their final destination. Contrary to this, airlines flying point-to-point feature only direct flights between airports. The onward connection with the same airline is more the exception than the rule (Heymann, 2006). Although the hub-and-spoke model encompasses an array of disadvantages, like the inconvenience of changing airplanes and the acquiescence of longer travel times, the advantages outweigh the disadvantages. Airlines benefit from a higher efficiency "due to the presence of economies of traffic density and economies of scope" (Nero, 1999). "Pooling passengers from many different points of departure makes it possible for airlines to offer flights to places that would otherwise be uneconomic" (The Economist, 2013). Airport operators favor hubs because they offer a higher frequency compared to other airports, and business travelers and knowledge workers appreciate the access to the airlines' destination networks allowing them to reach virtually every city, market area, or network partner on the globe. Especially in the growing context of the knowledge economy airports, hub airports have gained centre stage and evolved into a new, powerful core of economy activity within the urban-regional systems. Studies by Dross and Thierstein (2011) and by Thierstein, Goebel and Lüthi (Thierstein et al., 2007) show that airport access has an impact on economic performance. Airport locations are increasingly attracting knowledge-based activities, which in turn boost spatial development (Button and Taylor, 2000; Droß and Thierstein, 2011; Goebel et al., 2007; Haas and Wallisch, 2008; Kramar and Suitner, 2008; Schaafsma et al., 2008; Schubert and Conventz, 2011; Conventz, 2010).

3.3 The emergence of the knowledge economy

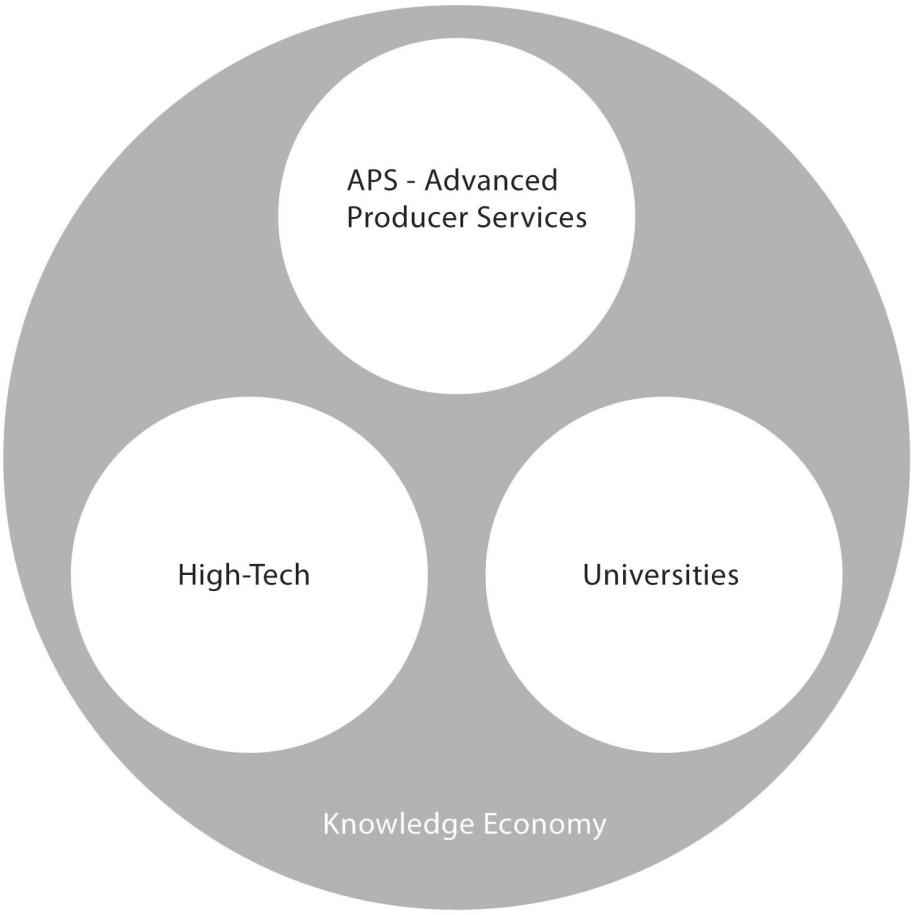
In recent years the global economy has found itself in a fundamental transitional phase (Dicken, 2011). Increasingly, the western hemisphere is experiencing a shift from a natural-based to a knowledge-based economy. In this context, the importance of traditional production factors like land, labour, and capital are losing in weight while the role of knowledge as a resource is steadily gaining importance (Rollwagen and Voigt, 2012; van den Berg et al., 2005). Today, knowledge, as it is applied in innovation, research and development, product design etc., is considered as a key driver for innovation, economic growth, and spatial development (Thierstein et al., 2006). At the same time, knowledge has become an integral part to not only those companies engaged in producer services and advanced manufacturing, but also to "firms in traditional industries in order to stay ahead of international competitors, occupy markets niches, and maintain a competitive advantage" (Bathelt and Glückler, 2011). Although the growing importance of knowledge as a resource has already been identified in the 1960s, as demonstrated in the works of Machlup (1962) or Drucker (1969), no commonly accepted definition of the knowledge economy has been elaborated at present. One reason for this absence might stem from the complexity of the term 'knowledge,' which allows different definitions and approaches (Lüthi, 2011). Following Lüthi (2011) the knowledge economy can be defined as follows:

''the knowledge economy is that part of the economy in which highly specialized knowledge and skills are strategically combined from different parts of the value chain in order to create innovations and to sustain competitive advantage'' (Lüthi, 2011).

By contrast to other definitions, this particular definition underlines the relational character of the knowledge economy. Since highly specialized knowledge and skills are based on a combination of scientific knowledge and practical experience, "the knowledge economy establishes strategic links between firms and other organizations as a way to acquire specialized knowledge from different parts of the value chain" (Lüthi, 2011).

According to Thierstein et al. (2006), the concept "knowledge economy" is based on three interdependent pillars, namely advanced producer service (APS), High-Tech industries, and knowledge-creating institutions such as universities and research establishments (Thierstein et al., 2006).

Figure 9: The three pillars of the knowledge economy



Source: Modified figure according to Thierstein et al., 2006, p.35

APS provides expertise, knowledge-based services, and process-specialized information for other service sectors and advanced manufacturers. Examples include financial service firms such as Ernst & Young, management consultancies such as Roland Berger Strategy Consultants, engineering firms like Bouygues, architectural outfits such as UNStudio or Renzo Piano Building Workshop, and logistics firms like TNT Express or DHL. By contrast, the High-Tech sector (including manufacturing) is defined by highly skilled employees, of which many are scientists and engineers, in addition to 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.

Early definitions on knowledge often made a distinction between codified or explicit knowledge on the one hand, and tacit knowledge on the other hand (Polanyi, 1966). As opposed to tacit knowledge, which is highly contextualized and not effectively transferable between individuals via certain media, explicit knowledge is codifiable, articulable, and storable, whether verbally, visually, or symbolically. New information and communication technologies offer the opportunity of increasingly codifying and commodifying knowledge, and then make it tradable across time and long distances. Thus, 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. With his well-known phrase “we know more than we can tell” (Polanyi, 1966), Polanyi illustrates the fundamental idea of the distinction between explicit and tacit knowledge (Gertler, 2003).

In the recent past, however, the “tacit-codified dichotomy” or “knowledge-as-objective perspective” (Vissers and Dankbaar, 2013) has been confronted with growing doubt and criticism (Vissers and Dankbaar, 2013). In contrast to older definitions, which understand knowledge as an object or a commodity, most recent approaches put the carrier of knowledge and the way knowledge is generated into the center of consideration and argue that knowledge must be seen as activity and process. Supporters of the “knowledge-as-activity perspective” (Vissers and Dankbaar, 2013) underline the procedural character of knowledge generation, the idea of a continuum, and point out that pure reduction to a dichotome thinking falls short in order to “capture all the varieties of “un-utterableness” present in organizational knowing and learning” (Vissers and Dankbaar, 2013).

3.4 Knowledge generation between global networking and regional complementarities.

In order to stay competitive, knowledge-intensive companies are forced to constantly create new knowledge, which implies a strategic combination of implicit and explicit knowledge. In many cases, knowledge generation happens through a complex interplay of global networking and regional complementarities. Business activities and reorganized knowledge flows are intensified by the decline of transportation and communication costs and thus the easier transmission of information and knowledge as well as the existence and improvement of supportive physical infrastructure. According to Camagni (Camagni, 1993) these knowledge flows are organized in a hierarchical architecture. This “nested hierarchy” is characterized by three levels of cities with “world cities” on the top, “national cities” in the middle and “regional cities” at the bottom (Camagni, 1993). In the recent past, however, Camagni’s theoretical argument has been confronted with critique (Taylor, 2004). Taylor, for example, argues that knowledge flows no longer squeeze through a single gateway. Instead, “knowledge flows can criss-cross through economic space along all manner of routes” (Taylor, 2011). With reference to Amin and Cohendet (Amin and Cohendet, 2004), Lüthi stresses the overlapping and trans-scalar character of knowledge practices, which are distinguished by manifold connections varying in intensity and spatial reach (Lüthi, 2011). On the one hand, knowledge-intensive companies generate, exchange or trade knowledge locally through physical human interaction. On the other hand, they are simultaneously interconnected with partner sites around the world, which are then efficiently accessible. Local and tacit knowledge is generated by local partners within close spatial proximity. The greater the distance, the less likely the chances that such exchange processes will occur (Boschma, 2005).

Contrastingly, codified knowledge is used by global partners in relational proximity. Relational proximity is typified by people in far-flung locations collaborating on a shared project. It is supported by rich and diversified network infrastructures of global travel and communication, including rapid and frequent trains and flights and sophisticated logistic

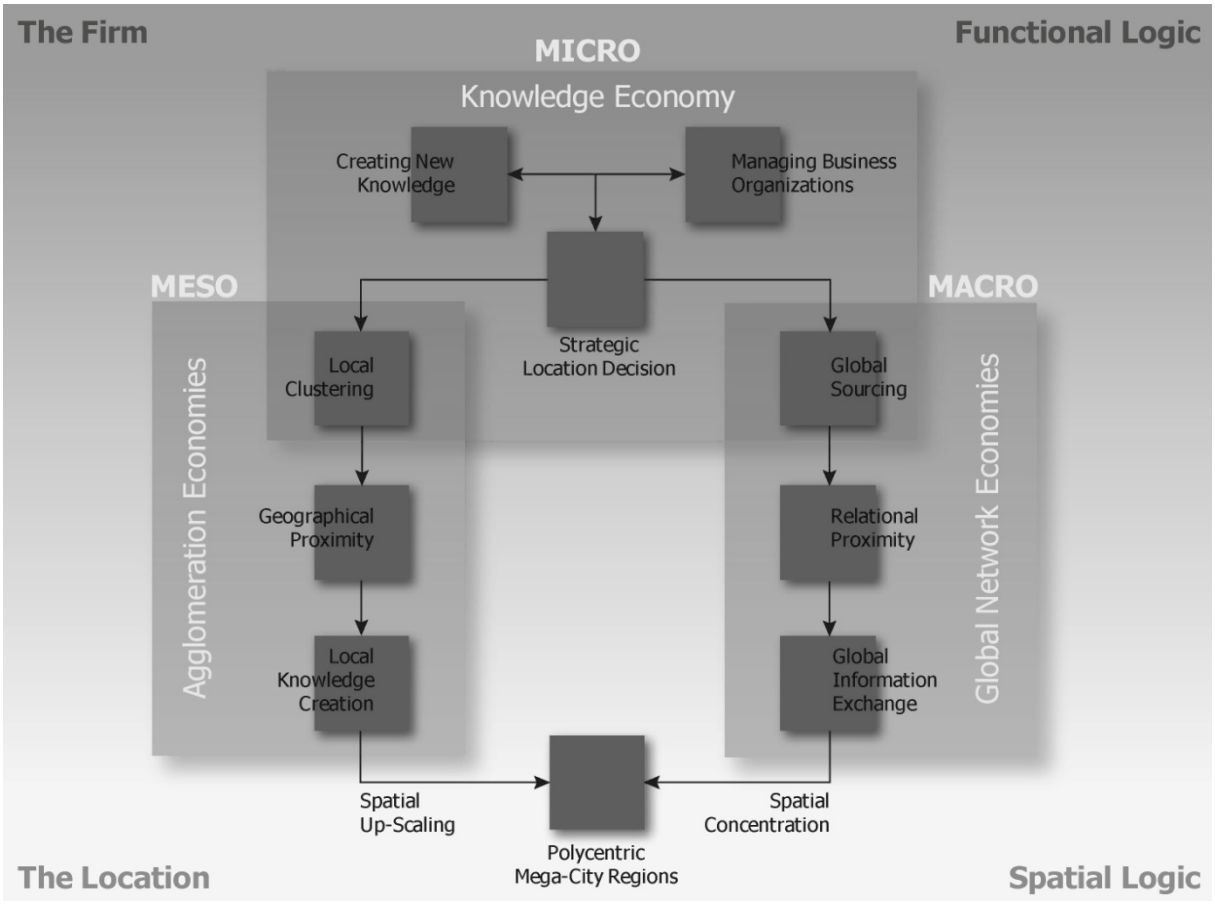
networks. Nowadays continental high-speed trains and intercontinental hubs airports fall under this category, in order to keep freight and people on the move and provide easy access to a variety of facilities for real-time and interactive communication. Various kinds of communication and information technologies in conjunction with the existence of physical network infrastructures enhance the possibilities to exchange and create knowledge between geographically separated locations (Sassen, 2001; Torre and Rallet, 2005). Accordingly, as the economic significance of global accessibility has increased, the areas of highest accessibility have turned out to be among the most profitable in this development in recent years. Compared to terrestrial modes of transport, which must often bow to topographical restrictions, air traffic allows a type of movement almost free from natural resistance and the possibility to arrange face-to-face interaction with people from around the globe. Consequently, geographical proximity and relational proximity are complementary components within the complex process of knowledge generation (Gertler, 2003; Faulconbridge, 2007; Kramar and Suitner, 2008).

Thus, personalized interactions and geographical proximity have not lost their significance despite the possibility of substituting direct human interaction through modern means of communication. Instead, physical human interaction has become more important than ever, especially in the knowledge economy context (Storper and Venables, 2004). As the growing volume of business-related traffic shows, the more we are able to substitute those meetings, the greater the need for face-to-face activities seems to be (cf. Kujath, 2010). Cities and other forms of large-scale urban systems like for example polycentric Mega-City Regions (Hall and Pain, 2006), facilitate knowledge creation at the intersection of geographical and relational proximity. Hall and Pain (2006) define “Mega City Regions” as “a series of anything between ten to 50 cities and towns, physically separated but functionally networked, clustered around one or more larger central cities, and drawing enormous economic strength from a new functional division of labour. These places exist both as a separate entities, in which most residents work locally and most workers are local residents, and as parts 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). The process of knowledge creation benefits in different ways from these large-scale urban systems. While these locations provide diverse, high-density and interaction-affine urban spaces, airports, especially those with hub function, offer a large number of direct flights to international destinations and, therefore, a rare competitive advantage: accessibility.

3.5 The two interwoven processes of Mega-City Region development: Agglomeration and network economies

Based on this, we argue that polycentric Mega-City regions are the outcome of a spatial up-scaling of agglomeration economies and a spatial re-concentration process of network economies. Figure 10 schematically depicts the inter-relation between the functional and the spatial logic of the knowledge economy.

Figure 10: Agglomeration and network economies in the context of Mega-City Region development



Source: Lüthi et al., 2013, p.279

Agglomeration economies result from the clustering of knowledge-intensive firms in certain areas, enabling them to benefit from spatial proximity and local knowledge spillovers. 'Agglomeration economies' is a general concept, referring to a variety of different theories that have been elaborated over the course of time, which include traditional agglomeration models (Marshall, 1920), new industrial geographies (Becattini, 1991), and innovation systems (Cooke, 1992). All of these approaches underline spatial proximity as a key driver of innovation within knowledge-based activities and realizing competitive advantages (Porter, 2000; Bentlage et al., 2013), both of which are further enhanced by short geographical

distances. Through geographical proximity personalized interactions are supported, which in turn enhance the exchange of tacit and experienced-based knowledge.

According to Howells, this leads to the tendency for localized knowledge pools to develop around specific activities which influence the communication, scanning, and learning patterns, as well as the sharing of localized knowledge and the innovation capabilities of knowledge-intensive firms (Howells, 2000). 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 a consequence, polycentric Mega-city Regions are increasingly enabled to achieve agglomeration economies of comparable magnitude to those of large mono-centric cities (cf. Conventz and Thierstein 2014).

The functional logic of the knowledge economy does not only affect agglomerations economies. The spatial re-concentration of network economies results from global sourcing strategies of knowledge-intensive firms and is largely determinate by the location behavior of knowledge-intensive companies. In order to stay competitive, support better market access, and source knowledge inputs, knowledge-intensive companies tend to organize their networks globally. Global sourcing strategies, again, lead to relational proximity between diverse involved economic actors and economic entities. In this regard, organizational and temporary proximity have turned out to be of major importance (Bentlage et al., 2013). According to Boschma (2005), organizational proximity can be defined as “the extent to which relations are shared in an organizational arrangement, either within or between organizations” (Boschma, 2005). However, organizational proximity as a prerequisite is created in order to control uncertainty and opportunism within the process of knowledge creation (Boschma, 2005). Moreover, organizational proximity offers a “powerful mechanism of long-distance coordination” (Torre and Rallet, 2005). As opposed to organizational proximity, temporary proximity is made possible by supportive physical and technical infrastructures. These include international gateway infrastructures, like airports and high-speed train nodes, or interactive communication infrastructures. This global information exchange brings an enormous number of potential suppliers and customers within reach of knowledge-intensive firms without demanding enduring co-location and local embedding (Amin and Cohendet, 2004).

3.6 Framing the analysis: An approach to understand the hidden structure of knowledge-based spatial patterns at and around international airports.

Based on the previous attempts, we now present our main research hypotheses and research questions aiming to reveal the specific role of international airports for knowledge intensive firms and the spatial consequences that result from the spatial practice of the knowledge economy. The contribution aims to depict a new understanding of the complex and multilayered interplay between an accessible infrastructure, such as an international airport, and the knowledge-based spatial patterns that have popped up around international airports.

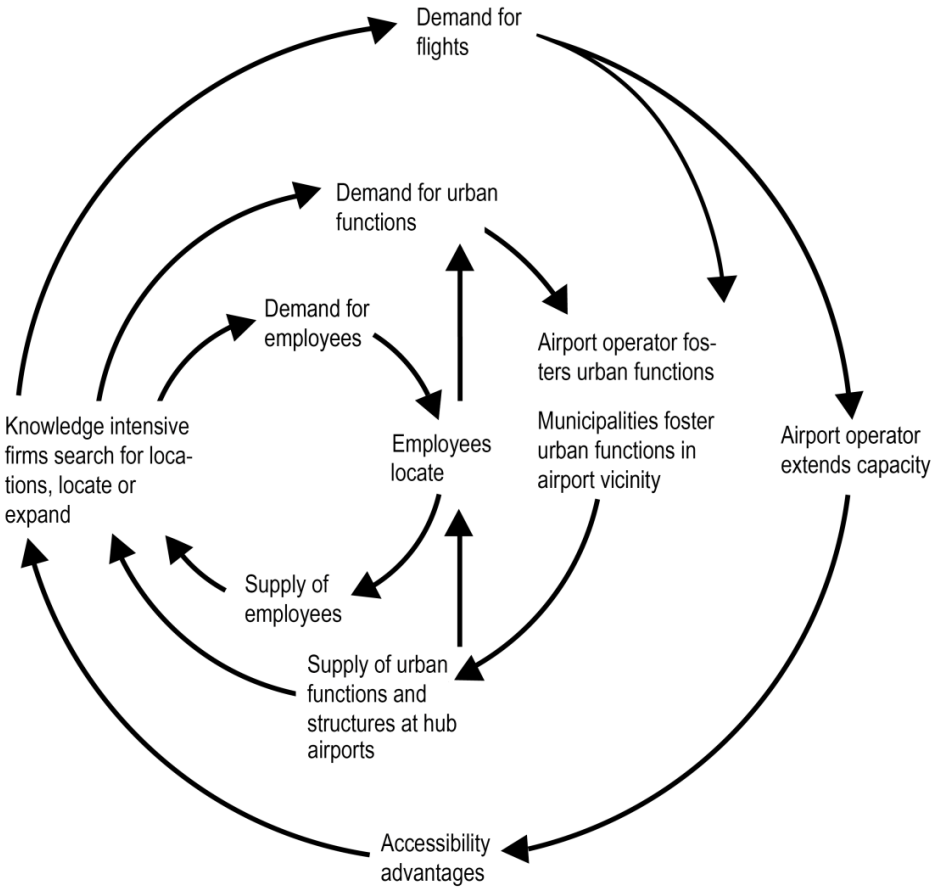
Similar to the interaction between a traffic junction and the spatial development of its surroundings, the linkage cannot be reduced to only one causal chain, but rather a more

complex approach is required. One reference point for identifying the different causal chains and how they interweave among themselves is a conceptual-analytical approach through the use of an impact model, as shown in figure 11. This approach allows the identification of the complex causal chains and their single elements.

The starting point of our stylized impact model is the location behavior and site selection process of knowledge-intensive firms. The model describes three interdependent cycles, and where they have the greatest similarity is where we can begin to understand it. The outermost circular flow relates to the international accessibility: knowledge-intensive companies have a demand for air traffic services so airport operators react by adjusting their capacity according to the demand. Finally, knowledge-based companies benefit from a higher degree of accessibility. The intermediate cycle illustrates the evolving urban structures and developments. As a result of the increased demand, airport operators and municipalities facilitate the centralization of urban functions in and around the airport. The inner cycle relates to the knowledge workers. Knowledge-intensive firms search for employees, who then, after being hired, settle in close spatial proximity to their workplace. As a result of all three causal chains, a spatial entity is created and characterized by a new spatial quality and accessibility profile. The maturing process of this development heightens the attractiveness of the airport location to such an extent that the settlement process of additional knowledge-based companies continues and existing company start to expand.

The increased demand for air traffic services drives a second business activity of airport operators: the non aviation sector, in which real estate services play a key factor for future growth. Such non-aviation activities can be comprised of retail developments, as well as the implementation of new and existing retail concepts like shopping arcades and malls, Michelin Star Award-winning restaurants, offices, hotels, conference spaces, exhibition and convention centres, hospitals and beauty facilities, leisure places, recreational facilities, museums, and fitness facilities. All these developments and services can be used by the knowledge-intensive firms, their employees, and local residents. With the changed locational requirements of the knowledge economy, the altered use of airports by different customer groups, and the shifting perception of airports, a new urbanizing space is emerging. The longer the process takes, the more companies from the knowledge economy are attracted and more new urban structures are realized.

Figure 11: Stylized Impact Model[1]



From the theoretical and conceptual considerations discussed above, we deduct the following main research question:

> What role do knowledge-intensive companies, with their locational requirements and spatial business practices, play in terms of the development and transformation of property markets in and around international airports?

Moreover, we are interested in answering the following sub-questions:

- What general relationship exists between international airports and knowledge economy companies?
- What role do international airports have within the knowledge creation process, and the business practices and optimization of firms-internal and firms-external value-added chains?
- What role do airports play within the site selection process of knowledge-intensive companies?

Based on these questions, we propose the following two main hypotheses:

[1] The stylized impact model by Dross (TUM), Michaeli (formerly ETH, today TUM), Thierstein (TUM) and Salewski (ETH) was elaborated in an international cooperation between the Chair of Urban Development at Technische Universität München (TUM) and the Chair of Architecture and Urban Design of the Swiss Federal Institute of Technology (ETH), Zurich.

- **Hypothesis 1**: Knowledge-intensive firms locate at and around hub airports in order to benefit from geographical and relational proximity to partners along the value chain and to different sources of knowledge.

- **Hypothesis 2**: If knowledge-intensive companies and their highly mobile employees demand accessibility, then the emergence of new real estate and functional space at and around international airports is stimulated.

In order to get a more profound understanding of the knowledge-based articulations centered around international airports, a network approach consisting of quantitative and qualitative network analysis is required (for a detail discussion the chapter 4). From our point of view relational thinking in terms of connections of activities, linked through both physical and non-physical flows, is central and one key to understanding spatial reshaping processes at and around international airports. A pure reduction to a quantitative approach alone would fall short in this context. The challenge of understanding airport-related spatial processes can only be met through a mixed approach of quantitative and qualitative methods working in tandem.

3.7 Conclusion

Following Castells' seminal concept on "space of flows", societies are centered around various flows (Castells, 1996). Through their ability of concentrate different kinds of these flows, international airports have advanced to become key nodes within the networked economy. Unlike other infrastructure facilities, many European airport locations integrate two core contemporary spatial qualities: worldwide connectivity by air and multimodal landside accessibility on different scales. The accessibility characteristics of international airports increasingly induce a multitude of economic and regional catalytic effects, such as settlements of companies, employment development, and stimulation of innovation, et cetera (Bayerisches Staatsministerium für Wirtschaft, 2002; European Center for Aviation Development – ECAD GmbH, 2008; Ernst Basler + Partner AG, 2010).

Within the growing knowledge economy, which is mostly a "relational phenomenon", airports are increasingly taking center stage. The interactive way in which knowledge is created in a networked and globalized business world requires highly accessible locations which support the exchange process of knowledge and the organization of value-added chains. In this context, international airport and their adjacent areas function more and more as hubs of permanent and temporal knowledge exchange, and as centers of competence. This transformation becomes physically visible with the growing number of office real estate developments and the centralization of urban functions.

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 are not fully clear (Appold and Kasarda, 2012). From our point of view, there is a need for a deeper understanding of the complex interplay between a high-quality infrastructure node and the knowledge-based spatial patterns that begin to emerge around airports. Our analytical concept, presented in this chapter, combines existing theoretical

backgrounds of economic geography and understands airport locations as a relational space driven by dynamic, socio-economic processes. Moreover the concept combines the location behavior of airport-based knowledge-intensive companies with a value chain approach. More than the pure locational perspective, this relational approach makes it possible to understand the networks in which airport-based knowledge-intensive firms interact.

Future research must place a special focus on the spatial organization of intra-firm and extra-firm linkages of APS and High-Tech firms. Understanding the intra- and extra-firm linkages of knowledge-based activities we are able to estimate how well connected airport locations are on a local, regional, national, European and global spatial scale. Moreover, we are able to identify the partners with whom these firms have working relationships and where these partners are spatially located. Based on these findings, an additional qualitative investigation, for example by means of qualitative network analysis, needs to be carried out. Through a qualitative network analysis we will be able to recapitulate:

- the locational strategies of knowledge-intensive companies and the required location and property qualities,
- the network setting in which companies interact and their demand for air traffic services, and
- the significance of spatial and relational proximity to firm-internal and firm-external partners.

Against the backdrop of the growing complexity and connectivity of the world economy, it can be assumed that accessibility aspects will become of overriding importance within the international location competition. On an international scale the demand for air traffic service and a better service quality will increase (Boeing, 2013). The integration of airport locations and their corresponding metropolitan regions into the high-speed railway systems will foster landside accessibility on an European spatial level. Investments into improvement and maintenance of powerful regional and local airport access will be another important prerequisite for the future success of airport locations. The full realization of airport locations' potential as network and service infrastructures and blossoming new spatial entities can only come about through a synergistic interaction between landside and airside means of transport.

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4 Where globality encounters locality: Emergence of new knowledge-based spaces around the German airports of Frankfurt, Munich and Düsseldorf

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The chapter has been slightly edited to fit the format of this dissertation.

Abstract
The third article analyzes knowledge-based spatial patterns and presents the empirical results for the three German case studies, namely Frankfurt, Munich and Düsseldorf. In the recent past, all three airports have rapidly become new urban growth generators and centers of knowledge-based activities. The site selection and relocation process of knowledge-intensive companies in close spatial proximity to these airports, document this spatial development impressively. The reasons for locating knowledge-intensive activities in close spatial linkages to international airports, however, still remain unclear. The article puts the location requirements of knowledge-intensive companies into focus and builds on the idea that site selection is the result of the specific location requirements of an economic activity, the existing site conditions, and the required degree of interconnectedness. Thus, one of the most important keys to understanding these processes and alterations are the locational requirements and changing internal and external value chains of knowledge-intensive companies. The empirical findings indicate that the airports of Frankfurt, Munich and Düsseldorf are not primarily perceived as a transportation node but as an advantageous business location that supplies a rare competitive advantage: accessibility. With the changed locational requirements of the knowledge economy, and thus perception and evaluation of airports and their adjacent areas, a new urbanizing space is emerging with the knowledge economy as an important driver. By investigating the need for geographical and relational proximity of knowledge-intensive companies, and the actual role the airport has played within a firm's decision making process about locating activities at and around the three major German airports, the article contributes to the emerging body of airport-driven literature and sharpens our understanding of how to interpret these new spatial articulations on a micro-level spatial scale.

Contribution of the PhD candidate:

- Accomplishment of the desk and field research for the cases of Frankfurt, Munich and Düsseldorf
- Visualization of the research findings
- Interpretation and discussion of the results
- Identification of future avenues of research

4.1 Introduction

Throughout history, urban competitiveness, growth, and economic prosperity have been highly determined by their connectivity and their positions within networks (Sassen, 2001, Neal, 2011). In this context, air transport, and its spatially fixed infrastructure, the airport, have gained a key position due to their ability to move people and commodities independently of geographical barriers. Not long ago, airports were considered purely peripheral, functional solitaires with little integration into the urban or regional context. In the recent past, however, this situation has changed and airports have re-positioned themselves as an integral part of the knowledge-driven, globally networked economy with far reaching impacts on the spatial structure. Under the general framework of global, time-based competition, the shift from a natural-resource-based to knowledge-based production and the implementation of new business practices, the potentiality and the locational advantages of airports as network-infrastructure have become more integral than ever to urban competitiveness, business models, and the location decision of firms. Like no other infrastructure facility, airports integrate two locational qualities: intercontinental connectivity by air and multimodal landside accessibility on a global, national, regional, and local scale.

Although the profound impacts of airports on the spatial structure have been known since the 1950s (Taaffe, 1956), for a long time thereafter, research on airport-linked spatial development has not attracted much attention within space-related disciplines, such as geography, urban planning, and urban and real estate economics. This lapse of interest has been changing rapidly from the year 2000 on as a continually growing body of airport-related literature plainly shows (Einig and Schubert, 2008; Kasarda, 2000; Yigitcanlar et al., 2008; Hesse, 2013; Conventz et al., 2014; Freestone and Baker, 2011). Increasingly, the changed characteristics beyond the role as a mere infrastructure and service provider for the aviation industry is being recognized (Jarach, 2001). Indeed, airports have not only altered their architectural appearance from mostly modernist buildings “designed in Machine Age architecture” (Schaafsma, 2003) to sophisticated architectural landmarks serving as national “windows to the world” (Foster and Abel, 2010), but they have also taken on new functions and roles as drivers of real estate development (Conventz, 2010; Schubert and Conventz, 2011) and as catalysts of the knowledge economy (Schaafsma et al., 2008; Droß and Thierstein, 2011). Today airports are recognized as powerful engines of economic growth (Florida et al., 2012) and “gateways of metropolitan economies” (Roost and Volgmann, 2013).

Within the context of a constantly growing knowledge economy (see chapter 3) airports and their adjacent areas are more and more experiencing a considerable change in how they are perceived. The site selection and relocation process of knowledge-intensive companies in close spatial proximity to major international airports documents this spatial development in an impressive way. Especially for knowledge-intensive advanced producer service firms and High-Tech companies, airports and their vicinities have become advantageous business locations that supply a rare competitive advantage: accessibility. The importance of locating a company office at and around the terminal building is a topic upon which current literature is deficient. As of today the drivers for locating remain unclear (cf. Appold and Kasarda, 2012).
This chapter sheds light on the redefined role of international airports within the knowledge economy context and presents the final results of an empirical investigation around the three

German airports with the highest passenger volume, namely Frankfurt, Munich, and Düsseldorf. The chapter is organized as follows: firstly, we provide general remarks on the changing role of airports and the impacts on the spatial structure. Afterwards we introduce the research question, main hypotheses, and the methodological approach. Than we present the results from the empirical investigation. Finally we summarize and discuss the main findings. The chapter closes with a conclusion and a future outlook.

4.2 Airport locations, accessibility and new knowledge-based spaces

The term “location is a complex and changing attribute” (Archer and Ling, 1997). In general “location” is the “access to whatever may be import for a particular economic activity, and the demand for urban space derives from the demand for access. […] Each possible use has important access needs, often called linkages – that determines the desirability of a site for that use” (Archer and Ling, 1997). “Although in the early days of economic geography, access was conceptualized in terms of simple distance as one of the key concepts underlying the spatial organization of the settlement system and industrial location, accessibility also depends on the communication and transportation networks that facilitate interaction” (Aoyama et al., 2010).

From a spatial perspective, the complex and multilayered effects of infrastructural accessibility on locations become clear with the example of airports and the spatial patterns that have evolved in and around them over the last decades. “Kasarda has prominently sought center-stage attention for airports in global metropolitan development, arguing that airports are shaping urban space in the twenty-first century much as highways did in the twentieth century, railroads in the nineteenth century, and seaport in the eighteenth century. He suggests that this fourth innovative wave of transportation technology impacts primarily through business locations and the new dictum ‘survival of the fastest’ with supply chain logistics and other time sensitive economic activity valuing proximity to airports as gateways and conduits for flows of people, materials, and information” (Freestone and Baker, 2011).

Particularly in Europe, many airports have emerged as new functional spaces within polycentric large-scale urban systems, so called Mega-City Regions (Hall and Pain, 2006). These large scale urban systems are based on two interwoven processes (for a detailed discussion see Chapter 3): 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 upgrading of agglomeration economies and spatial re-concentration process of network economies.

4.3 Main research question, main hypotheses and methodological approach

To understand the structure and the driving forces of current patterns of knowledge-based activities in and around the three biggest airports in Germany it is necessary to investigate

their functional logic and the networks in which knowledge-intensive firms interact. Based on these theoretical considerations discussed in chapter 3, an innovative approach was elaborated. Before introducing the methodological approach we will present the research questions and main hypothesis of the empirical investigation.

Starting from the theoretical considerations (see chapter 3) and the observation of airports as new powerhouses of knowledge-based activities and real estate development, we extract the following main research question, which reads as follows:

> What role do knowledge-intensive companies, with their locational requirements and spatial (business) practices, play in terms of the development and transformation of property markets in and around international airports?

Based on this research question, we propose the following main hypotheses:

- **Hypothesis 1**: Knowledge-intensive firms locate at and around hub airports in order to benefit from geographical and relational proximity to partners along the value chain and to different sources of knowledge.

- **Hypothesis 2**: If knowledge-intensive companies and their highly mobile employees demand accessibility, then the emergence of new real estate and functional space at and around international airports is stimulated.

As the chapter progresses, we will not rigorously test the above hypotheses but rather use them to structure the discussion of the empirical results. To lead into the empirical findings of our research, we present the research design consisting of an Interlocking Network Analysis, a value chain analysis and series of qualitative interviews.

4.3.1 Interlocking Network Model

In a first step we focus on the Functional Urban Areas (FUA) in which the three airports are located. These are the FUA of Frankfurt, Düsseldorf and Munich-Freising. The third is an aggregation of the FUA of Munich and Freising. The centres of the FUAs have been defined by the European Spatial Planning and Observation Network (ESPON) within the Project 1.1.1 (Schürmann, 2004). For these spatial entities, the connectivity patterns are estimated by using Peter Taylor's Interlocking Network Model (Taylor, 2004). The basic premise of the Interlocking Network Model approach is that the more important the office, the greater its flows of information will be to other office locations. Hereby, the flow of information can happen by establishing communication platforms, by developing common solutions or strategies, or by exchanging companies' employees between the different office locations (Thierstein et al., 2006). The primary outputs of the Interlocking Network Analysis are network connectivities, a measure that estimates how well connected a city is within the overall intra-firm network. Thus, firm-internal networks can serve as an approximation for the potential flow of information.

The sampling strategy for this research step follows a top-down approach. First of all, a reliable company database had to be created. To identify advanced producer service (APS) and High-Tech companies within the three case study areas the Hoppenstedt data bank was used. Based on the NACE-codes (see figure 12) knowledge-intensive firms were selected for inclusion.

Figure 12: Operationalization of the knowledge economy and its subsectors based on NACE codes

Advanced Producer Services (APS)	High-Tech
Banking & Finance 2330, 2413, 2414, 2416, 2417, 2420, 2441, 2442, 2451, 2461, 2463, 2464, 2466, 2511, 2513, 2615	**Chemistry & Pharmacy** 6511, 6512, 6521, 6522, 6523, 6711, 6712, 6713, 7011, 7012
Advertising & Media 7440, 2211, 2212, 2213, 2214, 2215, 9211, 9220, 9240	**Machinery** 2911, 2912, 2913, 2914, 2924, 2931, 2932, 2941, 2942, 2943, 2952, 2953, 2954, 2955, 2956, 2960
Information & Communication 6430, 7221, 7230, 7240, 7250, 7260	**Electronics** 3110, 3120, 3140, 3150, 3161, 3162, 3210, 3320, 3330
Insurance 6601, 6602, 6603	**Computer Hardware** 3001, 3002
Logistics (3p & 4p) 6030, 6110, 6220, 6230, 6340	**Telecommunication** 3220, 3230
Management & IT Consulting 7210, 7222, 7413, 7414, 7415	**Medical & optical instruments** 3310, 3340
Design, Architecture & Engineering 7420, 7430	**Vehicle construction** 3410, 3430, 3511, 3520, 3530
Law 7411	
Accounting 7412	

Author' figure, 2014
Data source: Statistisches Bundesamt Deutschland, 2003

In order to be selected, firms had to meet two criteria: first, a clear belonging to the knowledge-economy as defined in figure 12; second, the companies had to meet the criteria of being multi-branch, multi-location with at least one office within the study area. Through this process three basic sets of 143 APS and 60 High-Tech companies in Frankfurt, 151 APS and 87 High-Tech companies in Munich and 127 APS and 71 High-Tech companies in Düsseldorf were generated.

In practice, the calculation of the network connectivity follows a two-stage procedure. In the first step the office network of the selected firm needs to be surveyed in order to develop the so-called service activity matrix, the basis for the analysis. Usually office networks are available on the firm's website. These locations are rated on a scale from 0 to 5 with 0 for no presence to 5 for global headquarter. A typical office is scored 2. If there is a clear indication that an office takes higher functions within the office network, for example as a regional headquarter might, its value is upgraded to 3 or 4. These values are called services values.

In the second step, the connectivity between two cities (a,b) of a certain firm (j) is analysed by multiplying its service values (v) representing the so called elemental interlock (r_{abj}) between two cities for one firm:

$$r_{abj} = v_{aj} * v_{bj} \quad (1)$$

This approach seems reasonable when the following assumptions are made: "First offices generate more flows within a firm's network than to other firms in their sector. Second, the more important the office, the more flows are generated and these have a multiplicative effect on inter-city relations" (Derudder and Taylor, 2005).

To calculate the total connectivity between two cities, one has to summarize the elemental interlock for all firms located in these two cities. This leads to the city interlock (r_{ab}):

$$r_{ab} = \sum_j r_{abj} \quad (2)$$

Aggregating the city interlocks for a single city produces the interlock connectivity (N_a). This describes the importance of a city within the overall intra-firm network.

$$N_a = \sum_i r_{ai} \ (a \neq i) \quad (3)$$

Finally, if we relate the interlock connectivity for a given city to the city with the highest interlock connectivity, we gain an idea of its relative importance in respect to the other cities that have been analyzed. These scores – creating a scale from 0 to 1 – will be used to indicate hierarchical tendencies.

4.3.2 The value chain approach

Knowledge exchange and business activities do not come about through intra-firm branch office networks alone, but also from the division of labour between companies. In contrast to the era of Fordism in which the implemented production processes were mostly organizationally and spatially concentrated and distinguished by entities of production, plant and location, the transition towards a knowledge-based economy has led to a functional, organizational and spatial separation of the production process (Liefner and Schätzl, 2012). In many cases, outsourcing strategies with respect to single activities is often more efficient and leads to a higher quality of products and services. It is assumed that these extra-firm networks are strongly localized in and around urban nodes as a result of the availability of high quality accessibility and knowledge infrastructures such as airports, high speed railway

stations, and renowned universities or large concentration of globally operating corporations (Thierstein et al., 2006). By means of a web survey relational data on the firm's location was combined with the degree of importance of working interrelationships along the individual firm's chain of value. By overlapping a multiplicity of different value chains, patterns of spatial division of labor and localized value chain systems began to unfold.

Based on the Hoppenstedt company database and in accordance with the NACE code classification of the knowledge economy we generated a list of knowledge-intensive companies that are located directly on the airport premises or the immediate surroundings. One suggestion for defining the airport's immediate surrounding is provided by Schubert (2007) with reference to Pagnia's (1992) empirical study on the airports of North-Rhine Westphalia, one of Germany's 16 federal states. Pagnia's results clarify that the significance of the airport as location factor – of being based at and around the airport – diminishes as the distance from the airport increases (Pagnia, 1992). For the empirical cases of Cologne and Düsseldorf, Pagnia's research shows that an intensive relationship between airports and companies can be present up to 15 kilometers (Pagnia, 1992). Based on these findings, we focus our empirical investigations on the area around the terminal that can be reached by car within 10 minutes. For the Munich case, a radius of 20 minutes was chosen due to the isolated situation of the airport and its distances to the neighboring municipalities of Eching, Garching, Hallbergmoos, Ismaning, Neufahrn, Oberschleissheim, Unterföhring and Unterschleissheim.

The allocation took into consideration multi-location and owner-operated companies likewise. For quality control and to ensure that all selected companies fall into the NACE code classification of knowledge economy, the website of each company was checked. Following this approach, a total number of 1086 knowledge-intensive companies were identified and contacted via email providing a link to the online survey. After the first round, the firm list was adjusted to exclude those that did not reply to email contact and those who did respond but wished not to participate. Out of 1086 initial emails, a total of 160 responses were received, of which 143 were fully usable. Considering the scope of the web-survey and the small target group of difficult-to-grasp, high-level decision makers, the obtained response rate of approximately 13 per cent is considered adequate.

In the first step of the online survey, information was gathered about the firm's location, size and year of opening the branch etc. In an effort to keep the length and complexity of the survey manageable and given the fact that the target respondents were chief executive officers or other high-level business practitioners, we abstained from asking for extensive information about the company. In the second step, the companies were asked to localize and assess the importance of their extra-firm relations to other APS and High-Tech firms. Finally, in order to relate the extra-firm relationships to a stylized value chain, the firms had to localize their business activities along the individual value chain elements of 'research & development,' 'processing,' 'marketing,' 'sales & distribution,' 'financing,' and 'customers.' By doing so, we obtain a comprehensive status concerning the spatial value chain organisation of APS- and High-Tech firms around the three major German airports on global, European, national, and regional spatial level. Moreover, it provides a valuable analytical instrument for the researching of business organizations and networks that cut across regional, national, and international scales (Birch, 2008) and an indicator for the demand of air traffic services.

4.3.3 Qualitative network analysis

In addition to the quantitative network analysis, the research design also included a qualitative approach to data collection that took the form of personal interviews. The aim of the semi-structured interviews was not to acquire a representative sample, but rather to gain more in-depth insight concerning the research interest. It was particularly insightful in understanding more about the factors that were determinative in locating the company in and around the airport site, the demand for air services, and the role the airport has played within the site selection process.

The interviews revolved around four core thematic areas: the location strategies and dynamics, the intra- and extra-firm linkages along the value chain, the communications habits, and the role of spatial and relational proximity. To address interview partners we used the company pool of the web-survey. Based on this data set, the company selection followed interest-based according to the principle of “theoretical sampling” (Lamnek, 1995). In preparation for the interviews, 80 invitation letters were sent to potential experts to determine their willingness to respond and their availability. All in all, we received 22 positive responses, which equals a response rate of approximately 29%. Figure 13 provides an overview of the interviewed experts, their company-internal position and the sector in which the company operates.

Figure 13: List of interviewed experts

No.	*Sector*	*Expert's position*	*Location*
1	Accounting	Partner	Frankfurt
2	Management & IT consulting	Head of department	Frankfurt
3	Management & IT consulting	Principal	Frankfurt
4	Banking & finance	Head of department	Frankfurt
5	Information & communication	Managing director	Frankfurt
6	Information & communication	Head of department	Frankfurt
7	Management & IT consulting	Managing director	Frankfurt
8	Electronics	Head of department	Munich
9	Information & communication	Head of department	Munich
10	Information & communication	Principal	Munich
11	Medical and optical instruments	Principal	Munich
12	Banking & finance	Principal	Munich
13	Electronics	Managing director	Munich
14	Telecommunications	Head of department	Munich
15	Retailing	Head of department	Munich
16	Computer-Hardware	Head of department	Munich
17	Law	Principal	Düsseldorf
18	Management & IT consulting	Head of department	Düsseldorf
19	Electronics	Head of department	Düsseldorf
20	Advertising and media	Principal	Düsseldorf
21	Management & IT consulting	Head of department	Düsseldorf
22	Design, architecture and engineering	Principal	Düsseldorf

Author's figure, 2014

All scheduled interviews were conducted face-to-face between February and June 2013. For reasons of confidentiality the names and the companies of the interviewees are not mentioned.

4.4 Empirical results

In the following section, the main findings of the intra- and extra-firm connectivity analysis and the series of interviews are presented.

4.4.1 In between the flows: Airports as a localized system of value chains

Table 3, 4 and 5 show the top 20 agglomerations in terms of the interlock connectivity for APS and High-Tech firms located in the FUA of Frankfurt, Munich and Düsseldorf. In all three case studies APS firms show a strong connectivity patterns to the world's leading cities of New York, London and Hong Kong with "NY-LON as the undisputed dominant dyad" (cf. Derudder et al., 2010). Additionally, APS-firms also show relatively strong connections to at least two out of the three cities of the strategic Beijing-Shanghai-Hong Kong triad. Further important global destinations for APS-Firms are cities located in the emerging BRIC States – Brazil, Russia, India and China – underlining the growing importance of these countries within the global urban hierarchy (cf. Hales and Pena, 2012). Compared to APS firms, High-Tech companies construct their firm-internal networks much more globally and on European spatial scale. In the case of Frankfurt and Düsseldorf eight out of 20 agglomerations are located outside of Europe. In case of Munich even 50 per cent of the 20 most connected cities are located outside Europe. Taken together, east and south-east Asia are striking geographical demarcation and thus key economic areas for High-Tech firms based in the FUA of Frankfurt, Munich and Düsseldorf. Thus the conclusion can be drawn that High-Tech firms need to source most of their knowledge inputs on a European and global spatial level. These findings confirm findings by the OECD (2008). According to this analysis, High-Tech and medium-high tech industries are on average more internationalized than less technology-intensive industries or service sectors. However, as the interviews will clarify, the globalization of intra-firm networks does not mean that geographical proximity is unimportant. Simmie (2003), for example, argues that knowledge-intensive firms combine a strong local knowledge capital base with high levels of connectivity to similar regions in the international economy. By doing so they are able to combine and decode both codified and tacit knowledge originating from multiple regional, national and international sources.

On the European spatial scale APS and High-Tech firms in all three FUAs show the most pronounced connections with the western European cities of Paris, Vienna, Milan and Madrid. In Eastern Europe, APS and High-Tech firms based in Frankfurt, Munich and Düsseldorf are most strongly linked with the Russian capital of Moscow. Particular noticeable, however, are the strong connectivity patterns with the other German agglomerations like Hamburg, Berlin, Munich, Stuttgart, and Düsseldorf. This strong orientation towards the national spatial scale especially applies for APS-firms in all three FUAs. Exactly 25 per cent of the 20 most connected cities are located on this spatial scale. This is insofar surprising as one might assume that – in an increasingly globalized world – APS companies tend to organize their intra-firm linkages much more internationally. One

explanation for these empirical findings could arise from the existence of a huge domestic market. According to Lüthi “the German space economy seems to create enough demand and growth potential, leading to a strong national focus in terms of intra-firm locations and networks" (Lüthi, 2011). In contrast to APS-firms, High-Tech firms show weaker connections towards the German scale. In Frankfurt High-Tech firms are highly connected with Munich and Stuttgart while High-Tech firms in Düsseldorf also show a strong connection to Hamburg.

Table 3: Connectivity patterns of advanced producer services and High-Tech firms based in the FUA of Frankfurt

	Advanced Producer Services Firms		High-Tech Firms	
Rank	City	Proportionate Connectivity (1= New York)	City	Proportionate Connectivity (1= Singapore)
1	New York	1,00	Singapore	1,00
2	London	0,96	Paris	0,97
3	Paris	0,88	Moscow	0,90
4	Hamburg	0,87	Sao Paulo	0,89
5	Hong Kong	0,82	Shanghai	0,88
6	Vienna	0,78	Vienna	0,86
7	Berlin	0,78	Brussels	0,83
8	Milan	0,76	Milan	0,81
9	Singapore	0,76	Madrid	0,80
10	Munich	0,76	Tokyo	0,78
11	Shanghai	0,75	Buenos Aires	0,77
12	Tokyo	0,74	Stockholm	0,76
13	Stuttgart	0,74	Sydney	0,76
14	Warsaw	0,73	Budapest	0,75
15	Düsseldorf	0,73	Istanbul	0,75
16	Madrid	0,73	Stuttgart	0,74
17	Prague	0,71	Beijing	0,74
18	Moscow	0,71	Hong Kong	0,73
19	Sao Paulo	0,71	Munich	0,73
20	Zurich	0,70	Prague	0,73

Author’s figure, 2013
Data source: Author’s elicitation and calculation, 2013

Table 4: Connectivity patterns of advanced producer services and High-Tech firms based in the FUA of Munich-Freising

	Advanced Producer Services Firms		High Tech Firms	
Rank	City	Proportionate Connectivity (1= New York)	City	Proportionate Connectivity (1= Singapore)
1	New York	1,00	Singapore	1,00
2	Hamburg	0,96	Shanghai	0,96
3	London	0,94	Paris	0,94
4	Frankfurt	0,91	Sao Paulo	0,85
5	Paris	0,89	Moscow	0,83
6	Berlin	0,83	Madrid	0,82
7	Hong Kong	0,82	Tokyo	0,80
8	Stuttgart	0,81	Vienna	0,79
9	Vienna	0,81	Seoul	0,79
10	Singapore	0,79	Stockholm	0,78
11	Warsaw	0,78	Beijing	0,77
12	Milan	0,77	Stuttgart	0,75
13	Shanghai	0,76	Buenos Aires	0,73
14	Tokyo	0,73	Mexico City	0,73
15	Düsseldorf	0,73	Johannesburg	0,72
16	Moscow	0,72	Brussels	0,72
17	Madrid	0,72	Bangkok	0,72
18	Zurich	0,71	Budapest	0,72
19	Sydney	0,71	Prague	0,71
20	Prague	0,71	Milan	0,70

Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

Table 5: Connectivity patterns of advanced producer services and High-Tech firms based in the FUA of Düsseldorf

	Advanced Producer Services Firms		High Tech Firms	
Rank	City	Proportionate Connectivity (1= New York)	City	Proportionate Connectivity (1= Paris)
1	New York	1,00	Paris	1,00
2	London	0,95	Sao Paulo	0,97
3	Frankfurt	0,88	Singapore	0,94
4	Hamburg	0,87	Vienna	0,92
5	Paris	0,83	Moscow	0,92
6	Hong Kong	0,78	Munich	0,88
7	Vienna	0,78	Stuttgart	0,87
8	Singapore	0,77	Tokyo	0,84
9	Munich	0,76	Milan	0,83
10	Berlin	0,76	Shanghai	0,82
11	Milan	0,75	Stockholm	0,82
12	Tokyo	0,74	Madrid	0,82
13	Stuttgart	0,74	Brussels	0,81
14	Shanghai	0,73	Hamburg	0,81
15	Warsaw	0,72	Buenos Aires	0,80
16	Madrid	0,72	Beijing	0,79
17	Sydney	0,70	Istanbul	0,77
18	Prague	0,69	Helsinki Espoo Vantaa	0,76
19	Sao Paulo	0,69	New York	0,75
20	Moscow	0,67	Mexico City	0,75

Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

As mentioned above, knowledge and information exchange not only occurs through firm-internal networks, but also through an exchange process with a company's external partners and firms along the value chain, see Figures 14 to 19. It is important to note that all following figures are diagrams based on the number of interactions as stated by the firms who responded in the internet-based survey. The different shades of color in the legend illustrate the volume of interrelations along the value chain. The darker the color, the greater the number of interactions reported by the APS and High-Tech firms respectively. The portion of business relations on the FUA, national, European and global scale is mapped within each individual segment of the value chain. For example: within the value chain of financing for APS firms in Frankfurt, more than 50 per cent of business relations are concentrated within the FUA of Frankfurt.

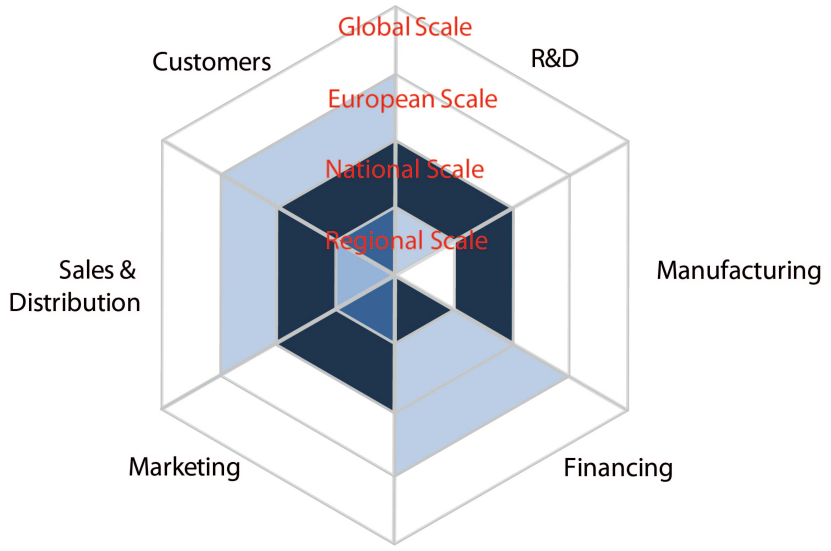
As Figures 14 to 19 indicated, airport-based knowledge-intensive companies in Frankfurt, Munich and Düsseldorf show strong value-adding relations towards the regional and national spatial scale. In Frankfurt, for instance, respondents localized more than 50% of their business relations in the field of customers, processing, marketing, sales & distribution, and research & development on the national spatial scale. These findings apply for both APS and High-Tech firms alike. By contrast, the most frequent interactions on the FUA scale occur within the field of finance. These value chain elements provide important services for APS firms and assume an important role as entrepreneurial support network within FUA of Frankfurt.

In contrast to APS-firms, a large number of High-Tech firms' relations are organized on the European spatial scale particularly in terms of sales & distribution, customers, and research & development. Between 31 and 40% of all relations in sales & distribution and with customers are European based while between 21 and 30% of all R&D partners are coming from inside Germany. In the field of finance, business relations on the global scale play virtually no role except for High-Tech companies. The empirical findings lead to the assumption that High-Tech companies have to acquire financial services for their cost intensive activities on a global base when compared to APS firms.

A similar distribution pattern of firm-external linkages can be observed for the cases of Munich and Düsseldorf. For APS firms, the strongest firm-external interrelations are located within the own FUA or on the national scale. Nearly all elements along the value chain show a huge number of firm-external relations towards Germany. The most international relations, in turn, appear in the segments of customer and sales & distribution. For High-Tech firms, the spatial configuration of firm-external networks is marginally different. As in the case of APS firms, strong relations appear with external network partners in Germany. Predominant extra-firm networks on the FUA level are shown in the field of finance and marketing.

Contrary one might assume, airport-based knowledge-intensive companies show weaker value-adding relations towards the European and global spatial scale. Similar to the results of the Interlocking Network Analysis the FUA and national scale are dominant spatial scale.

Figure 14: Value-adding relations of APS-firms located at and around Frankfurt airport



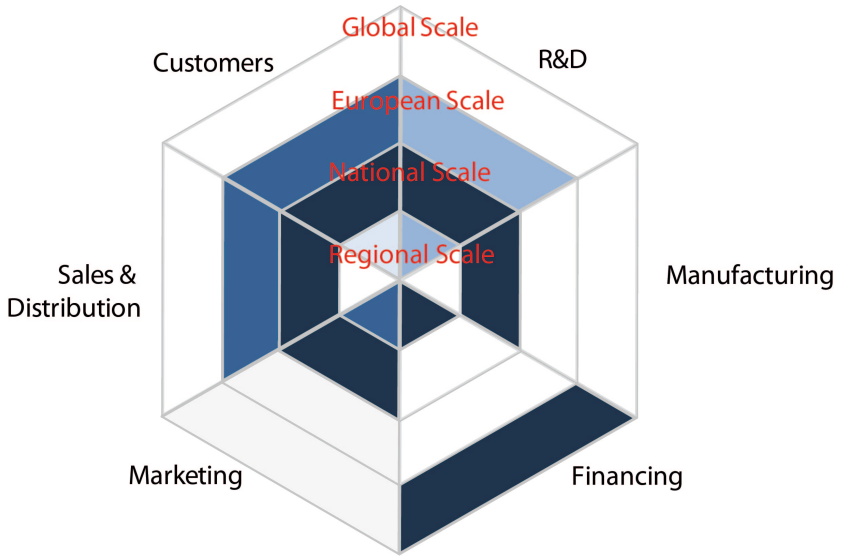
Proportion of business relations within each individual segment of the value chain (=100%).

0%	1-10%	11-20%	21-30%	31-40%	41-50 %	>50%

Sample: 26 firms; 67 business relations.

Author's figure 2013
Data source: Author's elicitation and calculation, 2013

Figure 15: Value-adding relations of High-Tech firms located at and around Frankfurt airport



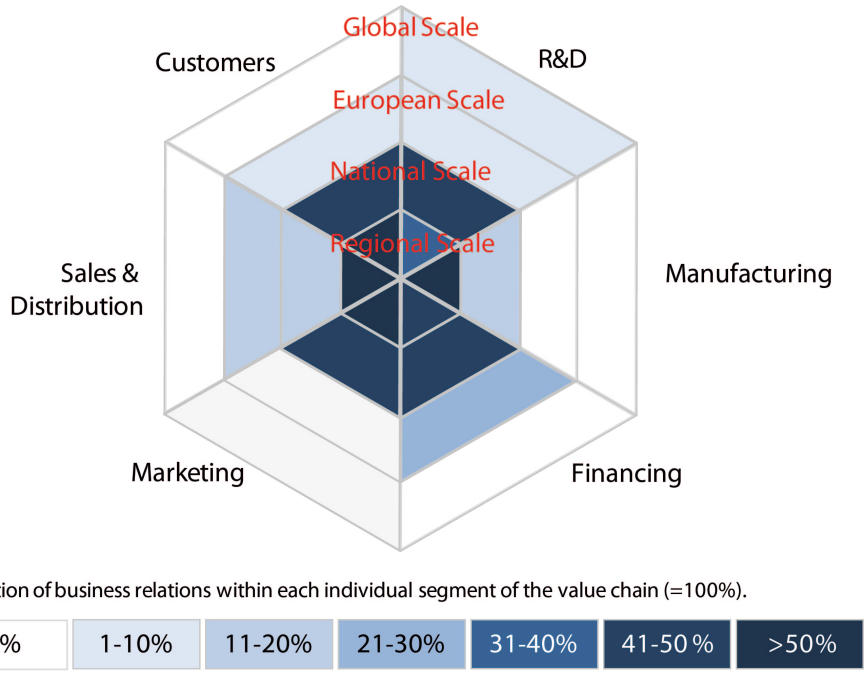
Proportion of business relations within each individual segment of the value chain (=100%).

0%	1-10%	11-20%	21-30%	31-40%	41-50 %	>50%

Sample: 10 firms; 45 business relations.

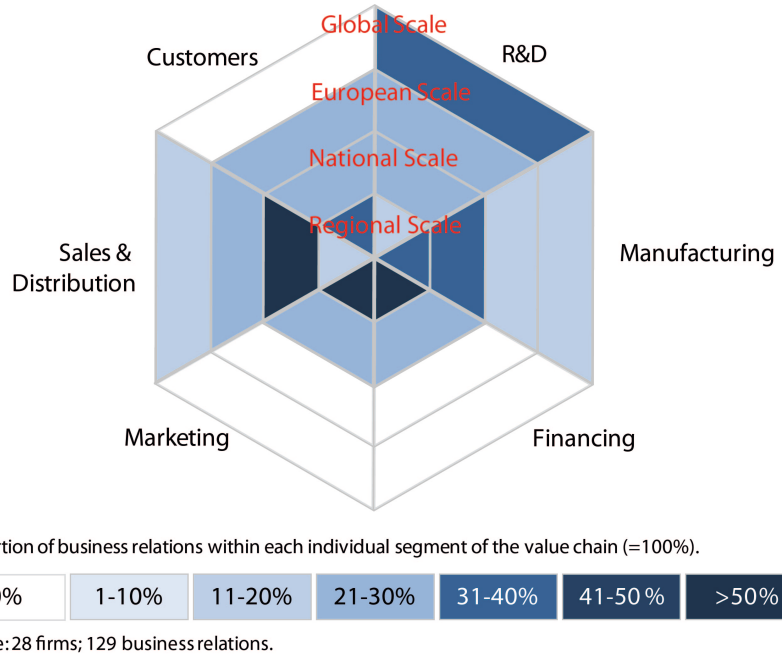
Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

Figure 16: Value-adding relations of APS-firms located at and around Munich airport



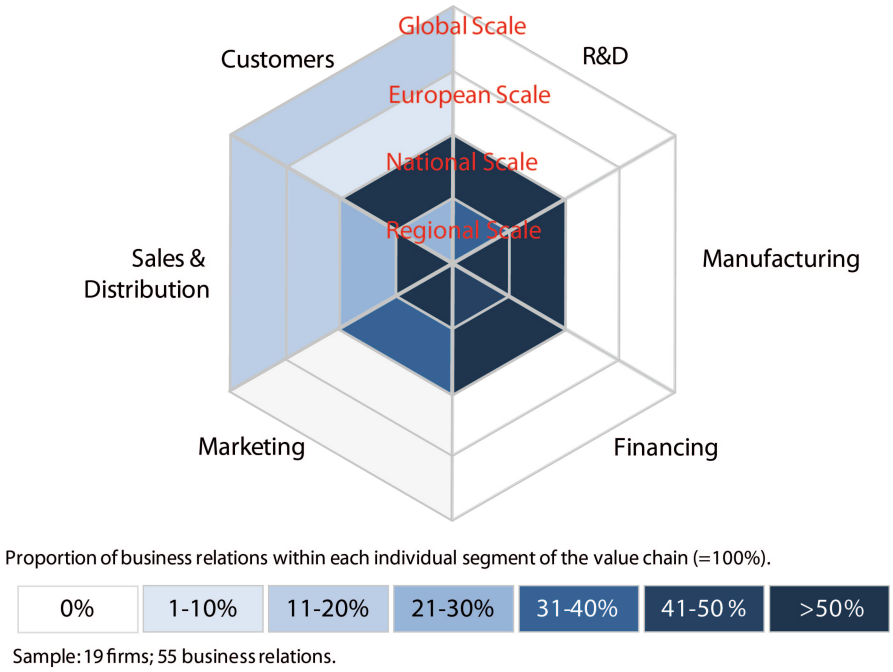
Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

Figure 17: Value-adding relations of High-Tech firms located at and around Munich airport



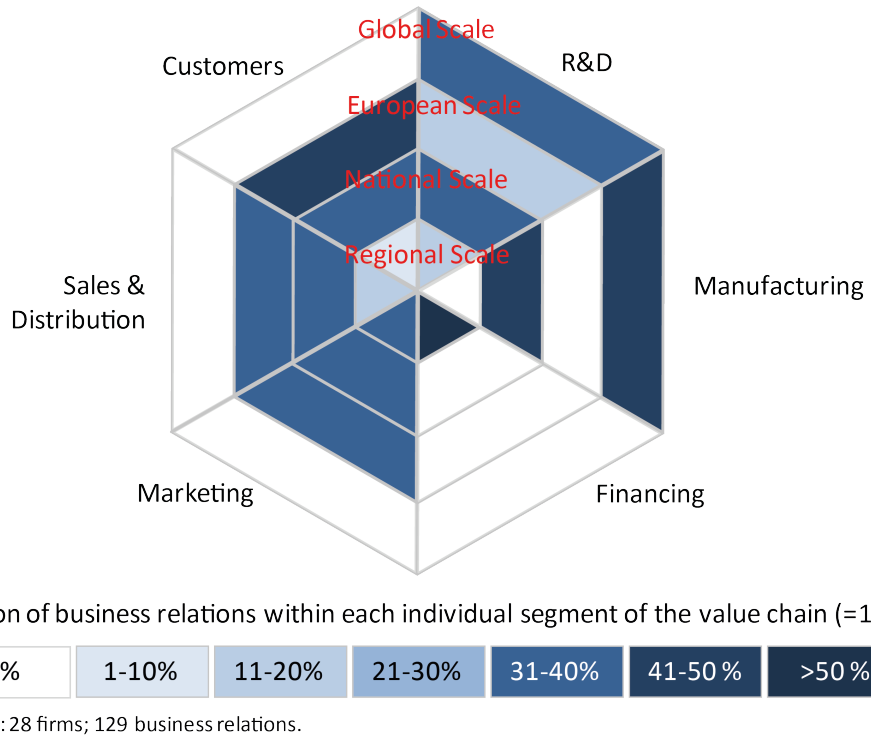
Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

Figure 18: Value-adding relations of APS-firms located at and around Düsseldorf airport



Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

Figure 19: Value-adding relations of High-Tech firms located at and around Düsseldorf airport



Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

4.5 A new locational quality: Airports as knowledge-exchange supporting spaces

In the following the results of the qualitative interviews will be presented.

4.5.1 Accessibility is key

The qualitative findings reinforce the quantitative findings of the Interlocking Network Analysis and the value chain approach. Airport based knowledge-intensive companies direct their value chains predominately towards Germany and adjacent European countries. In order to stay competitive within an often time-sensitive working environment, and carried by the idea of optimization of the company's knowledge flows, nearly all interviewed companies have relocated their office location over the last decade closer to the airport. Based on the qualitative interviews, accessibility considerations are the most important factor driving site selection. Especially at Frankfurt airport, knowledge-intensive companies are taking special competitive advantages from the double hub function and the multimodal nexus of airside and landside modes of transport. While the airport of Frankfurt serves as one of the major international hubs in commercial aviation, the railway train station functions as one of Germany's top interchanges in long-distance high-speed rail system. This worldwide unique interplay of air and landside transport modes has established Frankfurt airport and its immediate surroundings as one of the best connected places in the world. More and more this locational quality is strategically used by companies whose business models and success is primarily based on short-reaction times and a high frequency of company internal and external contacts (Interview 1-7). The potentiality to choose and transfer easily between air to long-distance rail, rail to rail, rail to bus etc. not only implies a higher flexibility in terms of re-scheduling business appointments and a broader choice concerning the mode of transportation, it also influences travel behavior, as the following statement illustrates:

> "For the consultants in the different projects teams our office here is a focal point […]. We are traveling around much. That's typically for our business. From our office we can easily travel to our customers and back home. The location also influences our travel behavior and the choice of transportation. Between Munich and Frankfurt we travel by train. In international projects the airplane is the dominant means of transport. […] This was one of the most important arguments to locate here. Frankfurt is easily reachable. That's especially important for our international board when they hold a meeting" (interview 2).

Although all interviewed companies reinforced the importance of physical accessibility to an interchange one has to understand that the need for proximity to airports is highly individual and extremely dependent on the implemented and preferred business models. While for some knowledge-intensive companies a car drive of 10 minutes to the airport is already sufficiently close and therefore a competitive advantage, other companies require, as a result of their time sensitive working environment, a pedestrian accessibility to terminal buildings (interviews 3, 5, 21, 22). The following quotes from two knowledge-intensive companies based in Düsseldorf underline the individuality of the question: "how close is close":

> "For us, our current location is close enough (10-15 minutes to the airport) and more than likely this will remain the case in the future. Generally, we schedule business

> trips as all-day appointments; we take an early morning flight and come back in the evening. It may happen that we return to the office in the afternoon but mostly we organize full-day trips. For our workflow, it does not make sense if you can reach the office in less than 10 minutes. If you come here during the day you can reach us from the airport within 10 minutes" (interview 22).
>
> "Walkability is very important. This is a crucial point. There are many who say "we are nearby the airport", but so, they must still take a taxi. (…) Close for us means when you don't have to take public transport or a taxi. Taking a taxi is always annoying. You have traffic jams on the motorway or the feeder roads. (…) This place is different. Our business partners arrive at the airport and within three minutes they can reach our office here on foot. (…) Except for the final meters, they can walk the entire length under a cover starting from the terminal" (interview 21).

Locational attractiveness also arises from the increased centralization of high-quality facilities and urban and business service formerly localized in the CBD, coupled with the altered image of airports (interviews 3, 4, 17, 22). As the interviews in Frankfurt, Munich, and Düsseldorf indicate, airports are no longer primarily perceived as infrastructural facilities but as advantageous business sites providing new and efficient environments to interact, collaborate and exchange information and knowledge either on a temporary or permanent basis. The spatial concentration of high-quality facilities like hotels, meeting and conference facilities, and urban services like medical services, kindergartens, supermarkets, laundry service or restaurants, has contributed to a more urban-like appearance and atmosphere while also establishing the airport as a service infrastructure and as knowledge exchange enriching environment. The unique combination of intermodal transport networks on the one hand and centralized urban functions on the other hand have been further arguments for knowledge-intensive companies to select the airport as new office site. Especially in Frankfurt and Düsseldorf, two airport locations characterized by their compactness, walkability, and multimodality, knowledge-based activities have started to strategically take advantage of these locational qualities within the complex process of knowledge production and exchange (interviews 1-4, 20, 22). As the analysis of the interviews show, most of the surveyed companies host various events throughout the year; These may include employee training courses, recruitment events, congresses, or other forms of networking events and face-to-face interaction. From the business perspective, short and walkable distances between the transport node, the office sites, and other service facilities are an advantage for an array of reasons. First, this spatial configuration ensures an efficient procedure of meetings. In comparison to previous office sites, most companies have registered a noticeable increase of firm-internal and firm-external events; a fact that companies trace back to better accessibility and infrastructure advantages of the new office site (interviews 1, 2, 4, 22). Second, spatial proximity between the different facilities helps companies to reduce time-consuming journeys, to realize valuable time advantages, and to cut costly overnight stays. In contrast to the former office location, where business trips by plane affected the daily routine and required overnight stays (interview 1), the new office location allows more efficient working processes and a more flexible scheduling of business appointments. In most cases, external network partners arrive and depart the same day or schedule an appointment while they are in transit by train or transferring from train to airplane (interviews 1, 4, 10, 17, 21, 22).

Hence, formerly unproductive transit time is converted into productive business-related meetings, either in a formal or informal setting, heightening the competitive edge and contributing to cost-savings for all participants.

For certain global operating companies in Frankfurt and Düsseldorf, the new airport office has furthermore risen in status as a "hub office" within the internal office hierarchy, benefiting from the multimodal hub quality of the interchange and the urban services in its nearer surroundings (interviews 1, 2, 4, 20-21). Targeting this network potentiality is used to optimize the knowledge creation and knowledge sharing process, be it within firm-internal or firm-external relations.

4.5.2 Face-to-face interaction

As the interviews show, the role of face-to-face contact and the degree of substitution by virtual communication are assessed and implemented differently by the various interviewees and are highly dependent on business culture. Despite multiple options of new communication devices and virtual connections, the role of face-to-face still remains of absolute importance within the knowledge creation process and in management of projects and business organization. As one expert describes:

> "virtual communication is less used than assumed". […] In consulting binding values and personalized relations are of major importance. When important international offers are made we try to bring people together spatially. Face-to-face is absolutely crucial. Especially within informal meetings information is exchanged. Of course we have advanced knowledge-management-systems but these systems don't include everything. […] Thus, it is important that people encounter physically and not communicate remote solely" (interview 2).

For other knowledge-intensive companies, for example in human resource consultancy, face-to-face meetings are the preferred method and a key component of being successful in competition (interviews 3, 21).

In order to get a more differentiated picture about the importance of face-to-face within the process of knowledge generation and network activity of airport-based APS and High-Tech firms it is important to distinguish between company-internal and company-external communication. Company-internal communication is mainly organized around virtual forms of communication, especially if highly standardized knowledge, so called "analytical knowledge" (Asheim et al., 2007), is involved. Company-external communication is still characterized by the predominance of face-to-face communication. This preference results from the circumstance, that face-to-face interaction involves trust and "synthetic knowledge" (Asheim et al., 2007), which is created during the process of interaction with network partners.

4.5.3 Property-related aspects

Relating to firm-internal knowledge production and face-to-face interaction, the interviews showed that the quality of the office property and property-related aspects, such as workspace utility, have become additional factors of significance driving the site selection (interviews 1-4, 7, 9, 12, 17, 19, 20, 21). For some companies (interviews 1, 4, 12, 13,) the office estate and the implemented office structures, e.g. open-plan offices, have become strategic tools within the company internal knowledge generation and knowledge sharing process and thus, a critical component of a successful business practice. Generally speaking, companies search for state-of-the-art, high-class office floor space. In demand is office floor space with flexible and efficient layouts that make it possible for tenants to react to constantly changing spatial needs and which establish better communication and knowledge exchange throughout the company (interviews 9-13, 15, 17, 20, 21). The fact that knowledge-intensive companies, especially in the airport cities of Frankfurt and Düsseldorf, have been able to influence the form of office floor space in accordance with the company's individual demands was another variable considered positively evaluated in the selection process (Interview 1, 2, 4, 9, 17, 20, 21).

Finally, softer location factors referring to location image, prestige, and singularity of the office real estate were brought forward. Such reasons for settling were predominately raised by large-scale and globally oriented office tenants with a highly competitive environment (interviews 1, 2, 4, 20, 21). According to these companies, "iconic architecture" and the airport location are used for marketing purposes and compliment the self-image of the own company as a globally operating enterprise. Within the increasingly fierce "war" for highly talented employees and the highly competitive market for mandates, offices buildings are constantly and actively encouraged to create a unique selling proposition. Based on the interviewed companies, sophisticated architecture and a unique location like an airport draw attention and help set the company apart from the competition (interviews 1, 2, 4).

4.6 Summary and discussion

The methodological mixed approach enables us to understand better the knowledge-based spatial patterns around the three airport of Frankfurt, Munich and Düsseldorf. Within the transformation process of airports into urban-like multifunctional entities the knowledge-economy and their demand for accessibility and urban function can be identified as an important spatial driver. Taken together, the analysis shows three important findings.

Firstly, the airports of Frankfurt, Munich and Düsseldorf serve as centres of new functional spaces on the intersection of "physical and non-physical interaction" (Bentlage et al., 2013) where knowledge-intensive companies generate, transform, and enhance knowledge within firm-internal and firm-external office networks on different spatial scales. Similar to other accessibility nodes like high-speed railway stations, more and more urban projects in general and office developments in particular are connected to airports, converting airports and their vicinities into what Bertolini and Dijst call "mobility environments and network cities" (Bertolini and Dijst, 2003). In contrast to railway stations, airport sites benefit from one rare competitive edge: multimodal and multiscale accessibility. As the results of the three research steps show, knowledge-intensive companies direct their value chains predominately towards the

German spatial scale and adjacent European countries. In this context companies, especially those which consider geographical and relational proximity as crucial to their business models, make use of the accessibility, time and infrastructure advantages of airports in order to optimize their value-added chains as well as the process of knowledge generation. Especially in Frankfurt and Düsseldorf, where the airports are integrated into long-distance high-speed railway systems, companies take additional advantages from the multimodal accessibility and thus a higher flexibility in terms of the choice of means of transport.

Secondly, beside accessibility considerations, the office real estate itself is becoming of growing importance within the knowledge-creation process. Knowledge generation is a highly interactive process which requires frequent personalized interaction and spatial proximity (Vissers and Dankbaar, 2013). In many cases outdated office floor space was one of the major drivers of relocating. Despite technological changes and virtual forms or communication, the majority of interviewees highlighted the strategic importance of adequate office space especially with regard to firm-internal creation and sharing of knowledge, innovation processes and the optimization of the internal business organization. Against the background of bottlenecks on office supply that is keeping with the market, airport locations have been able to position themselves with a market-compliant property supply specifically customized to the needs of knowledge-intensive companies and their needs for spatial proximity.

Thirdly, airports and their nearer surroundings have undergone a commercialization process (Kasarda, 2000). In this context, the knowledge economy can be identified as an important driving force with the transformation process. This confirms previous findings by Yigitcanlar et al. (2008), Einig and Schubert (2008) and Conventz (2010) who illustrate the morphogenesis of airport locations into new nuclei of knowledge-based activities.

In Frankfurt, Munich, and Düsseldorf air traffic and land-based means of transport assemble into multimodal accessibility nodes, establishing a high potential for interaction. This in turn leads to the development of new segments of property markets. By settling a diverse functional mix, formerly mono-functional airport space has been transformed into mixed-used network and service locations. In this process the knowledge economy and its locational requirements for complementarity between geographical and relational proximity, plays an ever-increasing role. As the analysis of the interviews show, knowledge-intensive companies do not only ask for office space and air and land-bounded transport services, but also for business related infrastructures, services, and the retail offerings now found at and around airports (cf. Squaire, 2013). In Frankfurt and Düsseldorf the knowledge economy increasingly uses the airport locations for events and conferences (cf. Conventz and Thierstein, 2014). Cafes, bars, and restaurants provide further possibilities for informal and spontaneous interaction with colleagues and business partners, for example during lunch breaks at the end of a working day. This demand in turn drives the second main source of revenues of airport operators: the non-aviation sector. Airport operators, retailers, and other involved actors react to the changing market conditions by providing new concepts, expanded services, and real estate developments. For the future it can be assumed that the demand for airport office space will continue on a high level and will attract further demand of knowledge-based activities (Schulze, 2013a, b). Moreover, it is expected that airports, especially those with a hub function, will continue attracting further high-quality urban functions and properties.

4.7 Conclusion and future outlook

Like other kinds of transportation modes in the past, the airplane is gradually creating a completely new human environment and spatial patterns. The rapid development of air traffic over the last decades has led to a new economic geography. These days international airports are perceived as powerful economic engines capable of having considerable economic and spatial impacts on cities and regions by acting as nodes of multi-scalar value creation. Based on the results of our multi-facetted analysis we can verify the assumed cause-and-effect relationship presented in our impact model in chapter 3. With regard to their network activities with firm-internal and firm-external partners along the value chain, knowledge-intensive companies optimize their locations according to their demand for accessibility. By relocating office and thus knowledge-based activities closer to airports and by demanding urban functions at and around the airport platform, the knowledge economy has turned out to be an important driving force within the multilayered transformation of airports into urban-like entities and the development of commercial real estate markets. In order to foster the locational advantages airport operators again have started to improve the supply of urban functions.

The results presented in this chapter are among the first of their kind. In order to get a deeper understanding of the spatial processes centered around international airports and the underlying drivers, future research must specifically focus on the following aspects: First, we need a conceptualization that also includes non-economic sectors, economic sectors that are not subsumed under the knowledge economy like the food business or international textile companies, and other actors such as lobbyist and knowledge-creating institutions. Empirical investigations reveal that these actors are increasingly settling at and around airports, as the case of Amsterdam-Schiphol shows, where international retailers have chosen the airport as their new location. What are their underlying drivers for locating in close spatial proximity to the airport and what demand for air traffic services do those companies require in comparison to knowledge-intensive industries? Are there more similarities or differences between these actors concerning their spatial logic? By doing so, we will gain a deeper and richer insight into how and who transforms airport space. In investigating this connection, a future research agenda must also focus on the role of private households. Especially in the knowledge economy context, the complex interplay between living, working, and mobility is growing in importance while also posing a major challenge with respect to the future success of airport regions and knowledge-intensive companies alike. With particular regard to the latter, whose business success is greatly dependent on its ability to attract a highly qualified workforce, interrelation between the availability of an adequate supply of housing space on the one hand, and the accessibility between place of residence and place of work on the other hand, will play an ever-greater role. As some interviews have indicated, knowledge-intensive companies have recognized this challenge and are successively integrating these criteria in their own assessments of potential locations. Third, and finally, future investigations must place a special focus on international comparative analysis. Worldwide knowledge-based patterns have evolved around international airports. The future success of the airport and the airport locations as sites for knowledge-based activity will highly depend on the ability to retain the attractive locational characteristics while extending the competitive advantage centered around multimodal accessibility in combination with extensive business.

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5 From hub-airport to hub-office: New focal points of multi-scalar knowledge generation. The case of Amsterdam-Schiphol and Frankfurt Rhine-Main

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The chapter has been slightly edited to fit the format of this dissertation.

Abstract

The following paper continues with the methodology introduced in the second and third article, puts the methodology into international perspective, and specifically looks at airports with a hub function. By using the cases of Amsterdam and Frankfurt – two of Europe's hub airports of international standing – the article takes a closer look at the nature and organization of networks of knowledge-intensive companies at and around hub airports, the airport's role within the daily business of knowledge-intensive companies, and the significance of airports within the site selection process for such companies.

Accessibility is the prerequisite of today's globalized, knowledge-driven, and networked economies, especially in terms of the movement of commodities, people, and information. Moreover, accessibility and good transportation linkages are the key to and a focus for sustained real estate developments. Where accessibility is the highest and agglomeration advantages can unfold their positive cumulative effects, the likelihood increases that people meet other people: interacting, exchanging information, learning from each others successes and failures, and eventually generating new knowledge through personal interactions.

Not long ago, Amsterdam and Frankfurt airports were considered purely infrastructural facilities. This situation is changing, and increasingly both airports resemble urban entities. New urbanized location patterns at and around airports evolve that featuring floor space for a variety of office uses. Within this transformation of the airports, the knowledge economy has proved to be a major driver. Findings show that knowledge-intensive companies – and here globally operating multi-branch firms in particular – make strategic use of the location and the hub competence of the airport by installing a highly accessible "hub office" within their internal office hierarchy. The findings also show that both airports and their adjacent areas are attracting a significant share of companies that have only a little or even no affinity to air transportation networks.

Contribution of the PhD candidate:

- Accomplishment of the desk and field research for the cases of Frankfurt and Amsterdam
- Interpretation and discussion of the results

5.1 Introduction

In recent decades, global passenger traffic has strongly grown. According to aviation experts, a medium-term growth of approximately 5% is expected during the next 20 years (Boeing, 2013). Against the backdrop of an increasingly networked world economy and the rise of the knowledge economy, airports have gained additional and new functions, be it as network infrastructures within the "space of flows" (Castells, 1996), or as service infrastructures within the process of knowledge exchange. Today, worldwide international airports are recognized as drivers of employment growth (Hakfoort et al., 2001), as powerful motors of urban, regional and national economies, and as the new nuclei of airport-linked spatial development often labeled with the term "aerotropolis" (Kasarda, 2000a). Brueckner's investigations, for instance, provide strong evidence for the link between the growth of airline passenger numbers and regional employment growth (Brueckner, 2003). According to his results, "a 10% increase in passenger enplanements in a metro area leads approximately to a 1% increase in employment in service-related industries" (Brueckner, 2003). In addition to this effect, the wider economic effects of airports, so called catalytic effects, have become a focus of attention in the recent past. "The catalytic effect of an airport operates largely through enhancing business efficiency and productivity by providing easy access to suppliers and customers, particular over medium to long distance" (Airports Council Europe, 2004). One indicator for the above-mentioned economic effects is the growth of commercial and industrial real estate at and around international airports (Schubert, 2007). Particularly pronounced are the different economic effects around airports with hub competence (Bowen, 2010).

Thus, airports have become a critical prerequisite for a successful positioning of cities within the global urban hierarchy and for cities' economic prosperity. According to Neal, "a city's economic fortunes are closely tied to its position in networks of interurban exchanges, with cities occupying more central positions experiencing relatively greater growth and stability" (Neal, 2011). As a result, cities around the world have started to strategically build upon the potential of their airports and the areas in the vicinity. Amsterdam-Schiphol and Frankfurt Rhein-Main are two advanced European examples in which airports have morphed into gravitational centers of a new spatial entity, increasingly attracting economic activities that go far beyond the traditional logistic-oriented activities. In consideration of the growing importance of the knowledge economy, which is mostly a "relational" phenomenon, gateway locations like high-speed railway stations and international airports are experiencing a re-evaluation as advantageous business sites. Although the spatial concentration of knowledge-intensive companies at and around international airports is becoming more physically visible as time goes on, little is known about the motivation that drives knowledge-intensive companies to settled in close spatial linkage to airports (Appold and Kasarda, 2012). Using this as a starting point, this paper aims to take existing airport-related literature further by understanding the underlying drivers of the site selection process of knowledge-intensive companies.

The paper is structured as follows: the first section discusses the emerging concept of the knowledge economy and the ways in which the knowledge economy contributes to the reconfiguration of urban and regional systems. The following section introduces the guiding research hypotheses, the study area, and the methodology. Subsequently the focus is placed on the case studies of Amsterdam and Frankfurt and the most important results of the

empirical investigations are summarized. The final section elaborates upon the findings and closes with concluding remarks.

5.2 Knowledge economy as driver of urban change

The knowledge economy has been singled out as a powerful driver of urban and regional change for some time now (Kujath and Zillmer, 2010). Generally speaking, the concept of the "knowledge economy" refers to an interdependent system of advanced producer service (APS), High-Tech industries, and knowledge-creating institutions, such as universities and research establishments. This system can be defined as the "part of the economy in which highly specialized knowledge and skills are strategically combined from different parts of the value chain in order to create innovations and to sustain competitive advantage" (Lüthi et al., 2011).

Recently however, changes in transportation technologies and the rise of new kinds of more efficient communication devices have led to an erosion of the formerly-established, core-periphery relationships. These changes have stimulated the evolution of a complex, dispersed, polycentric spatial structure in which several cities and sub-centres have emancipated themselves to a certain degree from the core city. Hall and Pain have thus introduced the term

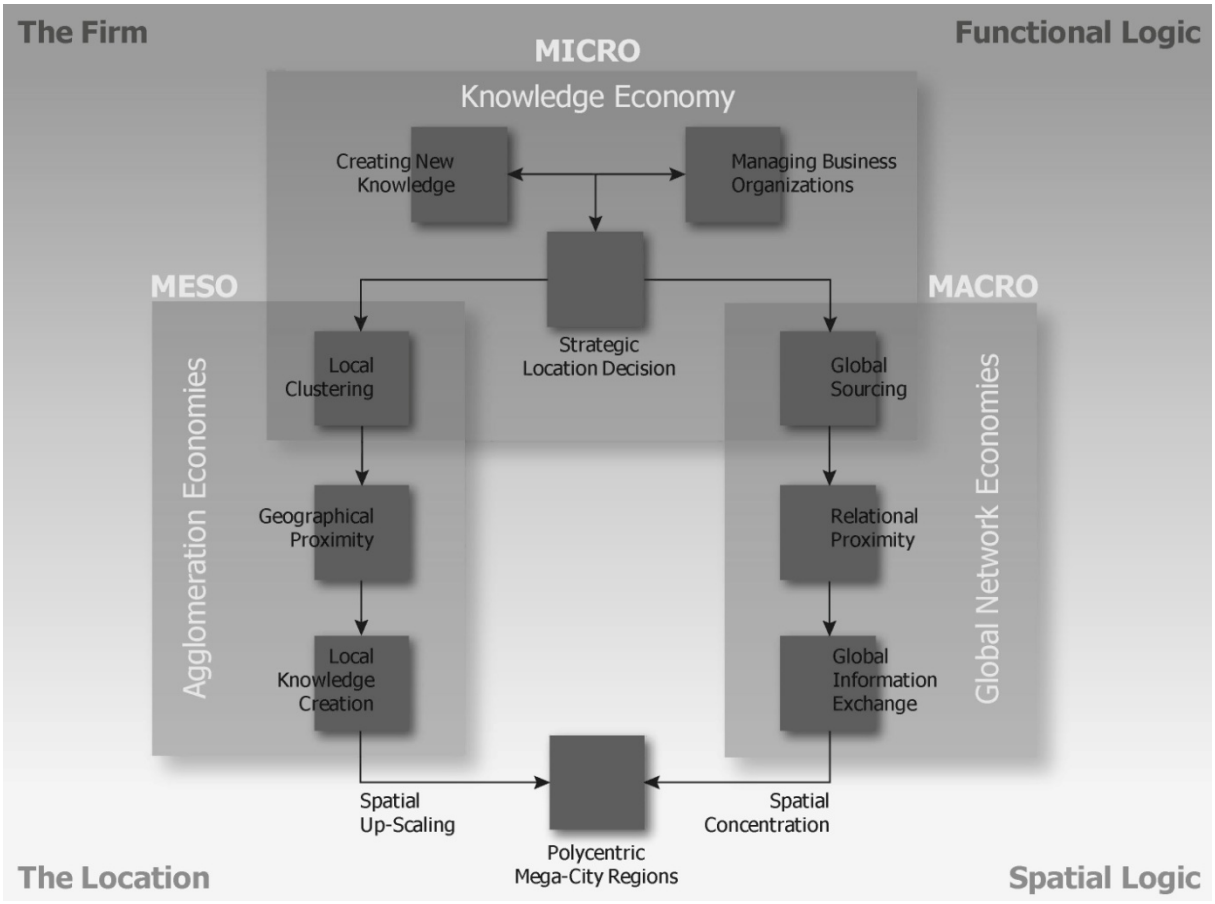
> "Mega-City Region" as "a series of anything between ten and 50 cities and towns physically separate but functionally networked, clustered around one or more larger central cities, and drawing enormous economic strength from a new functional division of labour. These places exist both as separate entities,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

Building off of this statement, it is argued that polycentric Mega-City regions are the outcome of a spatial up-scaling of agglomeration economies and a spatial re-concentration process of network economies. Figure 20 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 effects of a specific spatial logic at work.
Agglomeration economies result from the local clustering of knowledge-intensive firms in certain areas, enabling them to benefit from spatial proximity and local knowledge spillovers (Gallié, 2009). By locating within close geographical proximity, economic entities are able to enhance the innovation process and to realize competitive advantages by increasing their productivity and stimulating the formation of new businesses (Lüthi et al., 2013). Geographical proximity supports personalized interactions, which in turn enhance the exchange of tacit and experienced-based knowledge. According to Howells, this leads to the tendency for localised knowledge pools to develop around specific activities, which then influence the communication, scanning, and learning patterns, and the sharing of localised knowledge and the innovation capabilities of knowledge- intensive firms (Howells, 2000).

The spatial up-scaling process of agglomeration economies is closely related to advancements in transportation and telecommunication technologies. The costs of certain modes of transport and communication have declined drastically, and speed and reliability have significantly improved. Consequently, polycentric Mega-City Regions are able to achieve agglomeration economies of comparable magnitude to those of large mono-centric cities.

The functional logic of the knowledge economy does not only impact agglomerations economies (Bentlage et al., 2013). On a different operational scale, the spatial re-concentration of network economies results from global sourcing strategies of knowledge-intensive firms and is largely determined by the location behaviour of knowledge-intensive companies. In order to stay competitive and to support better market access, knowledge-intensive companies tend to spread their networks on a global scale. Global sourcing strategies, again, lead to relational proximity between different involved economic actors and economic entities. 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 like airports and high-speed train nodes, and easy access to communication devices. This global information exchange brings an enormous number of potential suppliers and customers within the reach of knowledge-intensive firms, without demanding co-location and local embedding (Amin and Cohendet, 2004).

Figure 20: Agglomeration and network economies in the context of Mega-City Region development



Source: Lüthi et al., 2013, p.279

Within this process airports have evolved as powerful locations with far reaching impacts on the spatial structure. Simultaneously, airports have become the center of spatial concepts like City Ports (Wijk, 2007), Aerotropolis (Kasarda, 2000a), Airport Corridor (Schaafsma et al., 2008) or Airport City (Güller and Güller, 2003).

5.3 Hypotheses, study area and methodology

Starting from and building upon the theoretical and conceptual considerations discussed above, and aiming to shed light on the spatial knowledge-based dynamics at and around hub airports two central hypotheses are proposed:

Hypothesis 1: Knowledge-intensive firms locate at and around hub airports in order to benefit from geographical and relational proximity to partners along the value chain and to different sources of knowledge.

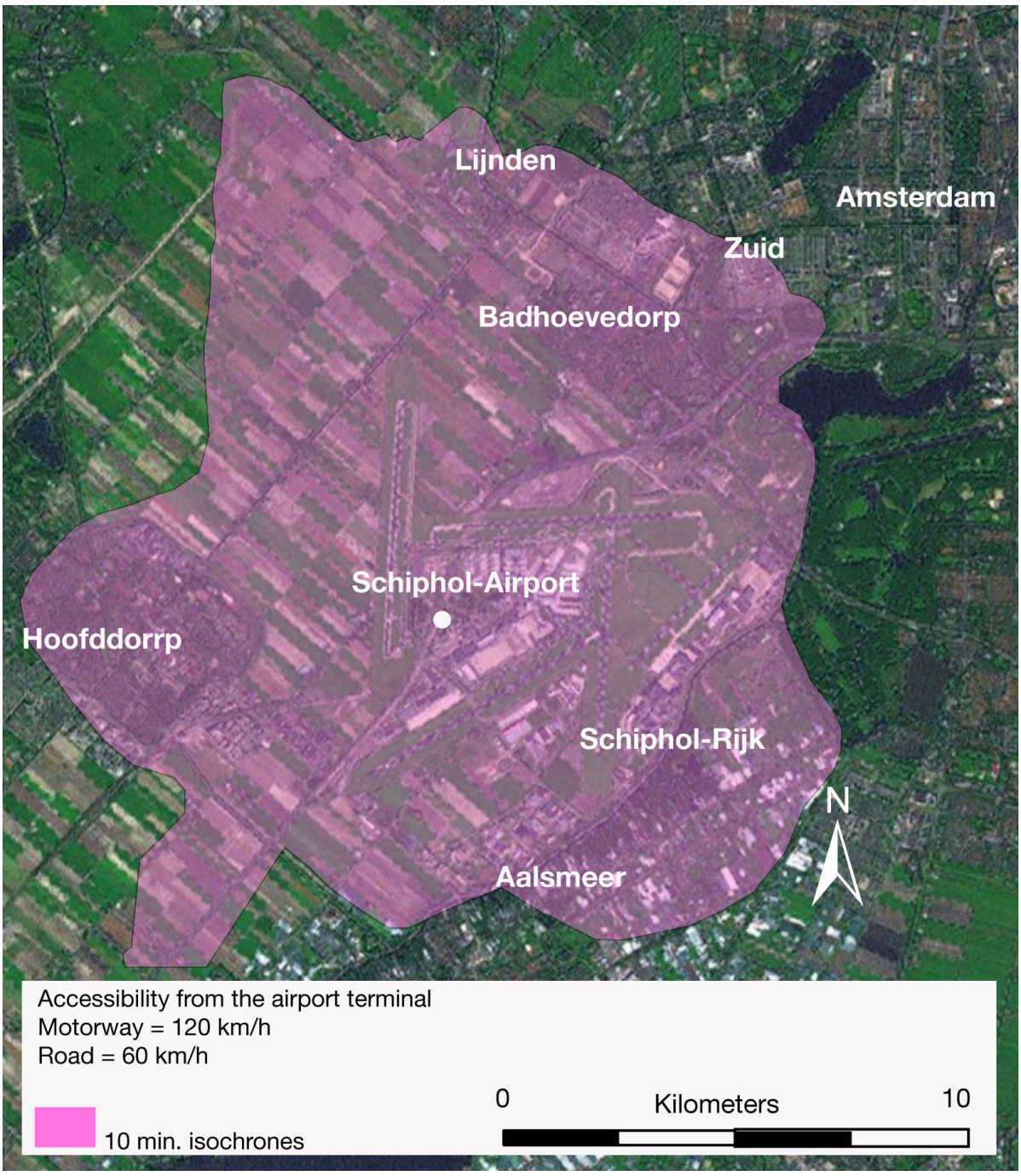
Hypothesis 2: If knowledge-intensive companies and their highly mobile employees demand accessibility, then the emergence of new real estate and functional space at and around international airports is stimulated.

To segue into the empirical findings, the study area is presented next, followed by the research design consisting of a trio of Interlocking Network Analysis, a value chain approach, and series of qualitative interviews. By triangulating quantitative and qualitative network analysis alike, a new approach is applied to more thoroughly understand the spatial alteration around hub-airports.

5.3.1 Study area

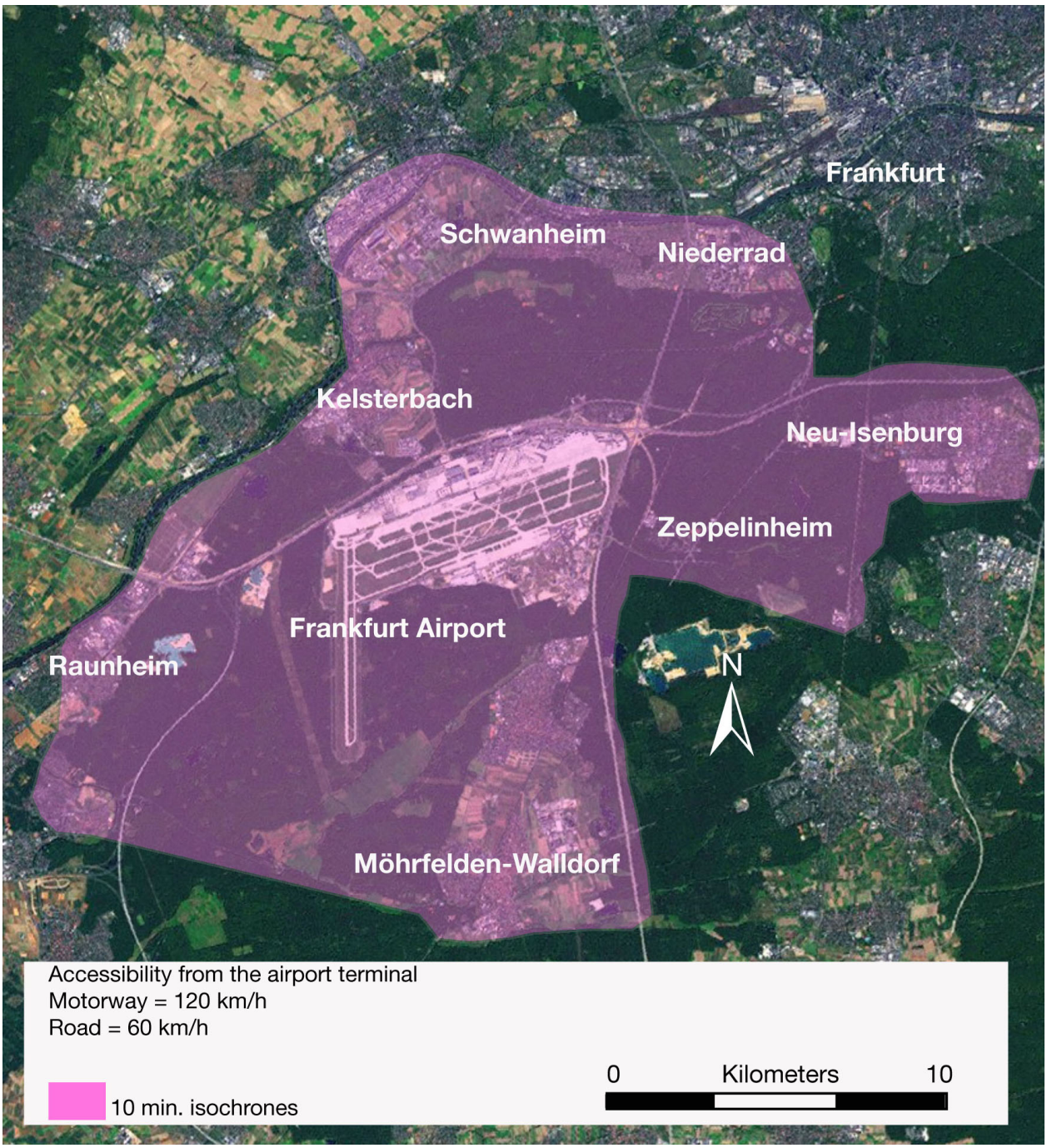
In the first step, the Functional Urban Area (FUA) is used as the basic spatial unit of analysis, in particular the FUA of Frankfurt for the Frankfurt airport area and an aggregation of the FUA of Amsterdam and Haarlemmermeer for Amsterdam Schiphol. The centres of the FUAs have been identified by the European Spatial Planning and Observation Network (ESPON) within the Project 1.1.1 (Schürmann, 2004). The second step zooms in on a micro-spatial scale and analyses the value chains and required site factors of knowledge-intensive companies, that have their office locations either on the airport's premises or in the immediate surroundings of the airport. One suggestion for defining the immediate airport surroundings is provided by Schubert (2007) with reference to Pagnia (Pagnia, 1992). In general, the impacts of airports on businesses decrease as the distance from the airport terminal increases (Einig and Schubert, 2008). These findings by Schubert and Einig confirm earlier empirical findings of Pagnia's research related to airports of the federal state of North-Rhine Westphalia in Germany showing that the influence of airports and their significance as a location factor decreases as the distance from the airports increases. According to Pagnia such an intensive relationship between airports and companies can range up to 15 kilometres (Pagnia, 1992). Calibrating on these findings, the investigations took place at the terminal and the area reachable by car within 10 minutes. Figures 21 and 22 provide an overview to the spatial extension of the two study areas.

Figure 21: The study area of Amsterdam



Author's figure, 2014
Source: Google Maps 2014,

Figure 22: The study area of Frankfurt



Author's figure, 2014
Source: Google Maps 2014,

5.3.2 Methodological combination

In the following section the methodological mixed approach is introduced.

5.3.3 The Interlocking Network Analysis

The analysis of the intra-firm networks is based on the methodology of the GaWC at Loughborough University (Taylor, 2004). The basic premise of the model is that the more important the office, the greater its flow of information to other office locations. The primary outputs of the Interlocking Network Analysis are network connectivities, a measure that estimates how well-connected a city is within the overall intra-firm network.

In the first stage of this empirical work, a reliable company database had to be created for both case study areas. To identify knowledge-based firms the Hoppenstedt Database was used for the case of Frankfurt and the Dun & Bradstreet Database for the case of Amsterdam. Based on the NACE-codes, knowledge-intensive firms with the highest employment size are selected. In order to be selected, firms first have to fall into the knowledge economy sector (Figure 23), and second, the companies have to be multi-branch, multi-location firms with at least one office within the study area.

Figure 23: Operazionalization of the knowledge-economy with NACE codes

Advanced Producer Services (APS)	High-Tech
Banking & Finance 2330, 2413, 2414, 2416, 2417, 2420, 2441, 2442, 2451, 2461, 2463, 2464, 2466, 2511, 2513, 2615	**Chemistry & Pharmacy** 6511, 6512, 6521, 6522, 6523, 6711, 6712, 6713, 7011, 7012
Advertising & Media 7440, 2211, 2212, 2213, 2214, 2215, 9211, 9220, 9240	**Machinery** 2911, 2912, 2913, 2914, 2924, 2931, 2932, 2941, 2942, 2943, 2952, 2953, 2954, 2955, 2956, 2960
Information & Communication 6430, 7221, 7230, 7240, 7250, 7260	**Electronics** 3110, 3120, 3140, 3150, 3161, 3162, 3210, 3320, 3330
Insurance 6601, 6602, 6603	**Computer Hardware** 3001, 3002
Logistics (3p & 4p) 6030, 6110, 6220, 6230, 6340	**Telecommunication** 3220, 3230
Management & IT Consulting 7210, 7222, 7413, 7414, 7415	**Medical & optical instruments** 3310, 3340
Design, Architecture & Engineering 7420, 7430	**Vehicle construction** 3410, 3430, 3511, 3520, 3530

Law
7411

Accounting
7412

Author‘s figure, 2014
Data source: Statistisches Bundesamt Deutschland, 2003

In the second step, companies’ websites were consulted and the individual office networks were rated on a scale from 0 to 5, with 0 for no presence and 5 for global headquarters. A typical office was scored with 2. By contrast, larger offices were scored with 3 and offices with extra-city jurisdiction, e.g. a regional headquarter, were ranked 4. Smaller agencies and offices with a clear indication of a low importance within the overall office network were downgraded to the score of 1. Through this process two basic sets were generated: 143 APS and 60 High-Tech in Frankfurt, and 100 APS and 64 High-Tech companies in Amsterdam. The results of the Interlocking Network Analysis serve as an approximation for the potential flow of information. Through its underlying approach, this method allows for an estimation of the connectivity patterns to not only other FUAs within Germany and the Netherlands, but also to other European and global destinations. Thus, the particular strength of this approach is its multi-scale perspective.

5.3.4 The value chain approach

The shift towards a knowledge economy has led to new organisational and spatial arrangements of knowledge generation in addition to a division of labour between companies and their business partners. In many cases, outsourcing strategies with regard to single activities are efficient and lead to a higher quality of products and services. In order to reveal information about the extra-firm relationship, a web-survey has been undertaken. The Internet-based survey, which was addressed to business executives, combined relational data on their respective firms’ locations with the degree of importance of working interrelationships along individual firm’s value chain elements of “research and development”, “processing”, “marketing”, “sales & distribution” and “customers.” All in all, 71 fully completed surveys were received (Frankfurt: n= 37, Amsterdam: n= 34). Through the analysis of extra-firm relationships, the spatial configuration of value chains of airport-based knowledge-intensive companies differentiated according to regional, national, European and global spatial scale began to emerge.

5.3.5 Qualitative interviews

The quantitative data gathered in the previous empirical research steps were complemented by qualitative research activities in the form of interviews. Aiming to understand the “why” behind locating a company at Frankfurt or Amsterdam airport, a series of 11 in-depth, face-to-face interviews on executive level were conducted. Thematic cores of the interviews were: the location strategies and dynamics, the role of the hub airport within site selection process, the intra- and extra-firm linkages along the value chain, the communication habits, and the need for geographical and relational proximity. Figure 24 provides a list of conducted

interviews differentiating according to sector, experts' position, number of employees, and location of the interview.

Figure 24: List of interviewees

No	Sector	Expert's position	No of employees	Location
1	Accounting	Partner	>2.000	Frankfurt
2	Management & IT Consulting	Head of department	100	Frankfurt
3	Management & IT Consulting	Principal	12	Frankfurt
4	Banking & Finance	Head of department	136	Frankfurt
5	Information & communication	Managing director	62	Frankfurt
6	Information & communication	Head of department	28	Frankfurt
7	Management & IT Consulting	Managing director	437	Frankfurt
8	Computer hardware	Head of department	>250	Amsterdam
9	Machinery	General Manager	155	Amsterdam
10	Management & IT Consulting	Managing director	>200	Amsterdam
11	Design, Architecture Engineering	Partner	60	Amsterdam

Source: Author's figure, 2014

The methodological enhancement by qualitative research actions compliments the collected quantitative data.

5.4 The case studies of Amsterdam-Schiphol and Frankfurt Rhine-Main

The subsequent part discusses the two case studies of Amsterdam-Schiphol and Frankfurt Rhine-Main.

5.4.1 The case of Amsterdam-Schiphol

For a long time, Amsterdam and its growth patterns were perceived as a "prototypical expansion of the mono-centric city" (Salet and Majoor, 2005). Beginning in the early 1960s and continuing into the present day, the historical inner city has been unable to fulfil the increased demand of large-scale leasing required by the rise of the service and knowledge economy. As a consequence, and as a result of new accessibility requirements, companies started settling near the urban ring road and sometimes even farther away. This trend has led to the gradual transformation of the spatial formation of Amsterdam into a polycentric urban landscape. New concentrations of urban activities and functional specialisations appeared, for example, at the southern edge of Amsterdam, reshaping the area into a dynamic growth zone (Bontje and Burdack, 2005). Schiphol has evolved into a prominent growth engine and one of the largest employment concentrations in the metropolitan area (Bontje, 2005). Today, Amsterdam-Schiphol is the Netherlands' main airport and one of the world's major hubs in international air traffic.

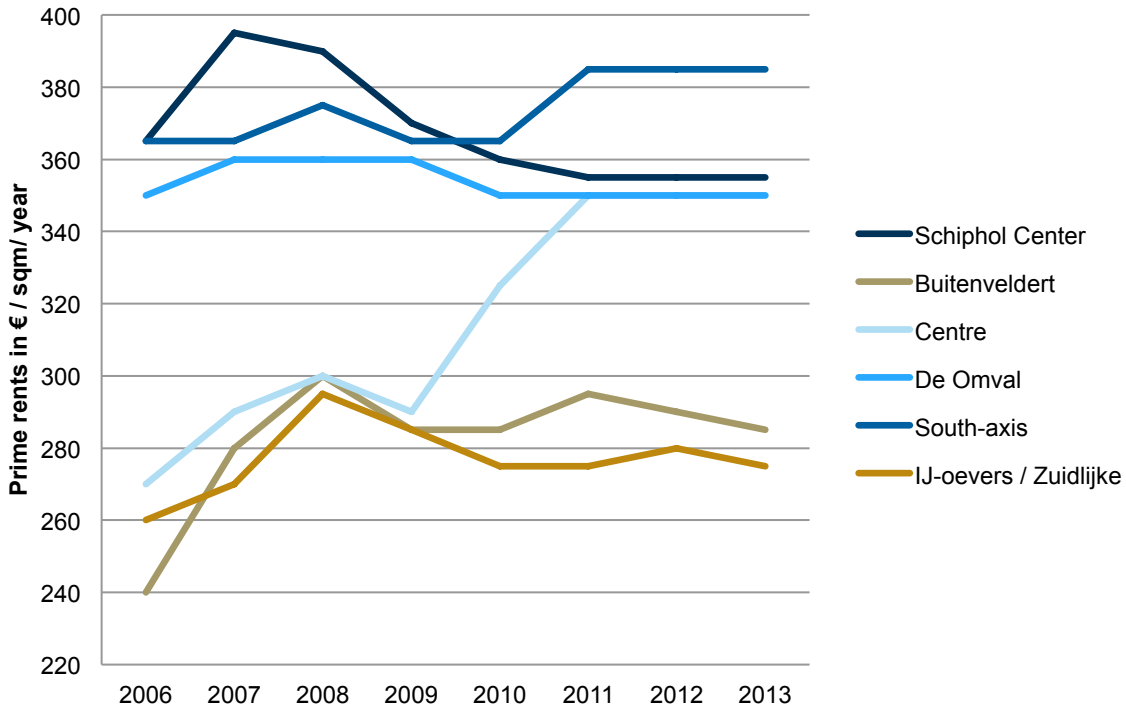
Starting in the 1990s, the Schiphol area had success in attracting companies, predominantly from Japan and the United States (Wijk et al., 2011), with supra-regional, national, European jurisdiction. The construction of office complexes was simultaneously accompanied by the construction of various high-quality urban functions including but not limited to hotels, meeting and conference facilities, gastronomic facilities, medical services and retail establishments. Forced by new general conditions within the aviation sector, Schiphol pioneered the field of activity that is known today as the non-aviation sector in which commercial facilities and services play a key factor in terms of future growth and supplementing the traditional core business of an airport operator.

This new direction and diversification effectively transformed formerly mono-functional airport space into what is frequently circumscribed today with the term 'the airport city': "... the more or less dense cluster of operational, airport related activities, plus other commercial and business concerns, on and around the airport platform" (Güller and Güller, 2003).

Schiphol's unique locational profile, comprised of high quality office space, the existence of near-by business-related infrastructures, and the strong integration of air and ground transportation systems, has caused prices for office space to rise resulting in the unique situation that office rents were until recently higher than rental prices in downtown Amsterdam or in the South Axis "Zuidas", the actual Central Business District of Amsterdam. For years, Schiphol was the premium office location in the country with annual top rents per square meter of approximately €400, as shown in Figure 25. In 2013, approximately 325.000

sqm of office space was available at Schiphol airport (CBRE, 2013). By comparison, the total office stock of the local market of Haarlemmermeer, where the submarket of Schiphol is located, comprised approximately 1.410.000 sqm. The office market of Amsterdam, including the South Axis, encompassed a stock of roughly 6.956.000 sqm (DTZ-Zadelhoff, 2013). The recorded annual office rents at Schiphol-Centre were between €200 and €350 per sqm in comparison to the South Axis were the rental range was between €230 and €385 per sqm, Old South with €225 and €400 per sqm or Centre with €160 and €350 per sqm (DTZ-Zadelhoff, 2013).

Figure 25: Annual prime rents of Schiphol in comparison to selected office submarkets in Amsterdam



Author's figure, 2014
Data source: DTZ Zadelhoff, 2006-2013

In the recent past, the structure of office users has undergone a process of diversification, and internationally oriented companies, particular those with knowledge-intensive background and a lower affinity to the aviation business, have started to seek out and demanding office floor space at and around Schiphol airport. Between 2012 and mid-2013, the strongest demand stemmed from the industry, trade and transport sector with 50% of the total take-up, followed by business services with 37%, public and non-profit with 12% and banking and insurance with 1% (DTZ-Zadelhoff, 2013).
The emergence of these knowledge-based spatial patterns gives rise to questions about the motivation of settling an office at and around the airport.

From a relational perspective, the FUA of Amsterdam-Haarlemmermeer is characterized by a strong connectivity pattern toward the European and global scale. Table 6 summarizes the 20 most-connected cities in terms of interlock connectivity of APS and High-Tech firms. Based on the Interlocking Network Analysis for APS firms, London, New York, Hong Kong, Paris, and Milan are ranked among the most connected cities. By contrast, High-Tech firms tend to organize their networks much more globally. Represented by cities like Singapore and Bangkok, or the city triad of Shanghai-Beijing-Hong Kong, east and southeast Asia are the most striking geographical demarcation of this global preference. In addition to this, High-Tech firms also show a strong connectivity pattern towards the emerging BRIC states. Dutch cities however, are not listed among the most connected cities, showing the strong international orientation of the Dutch spatial economy. The results illustrate that knowledge-intensive companies in FUA of Amsterdam-Haarlemmermeer are well integrated into international networks of knowledge-exchange. Interlocking networks bridge these geographically separated but functionally networked spaces.

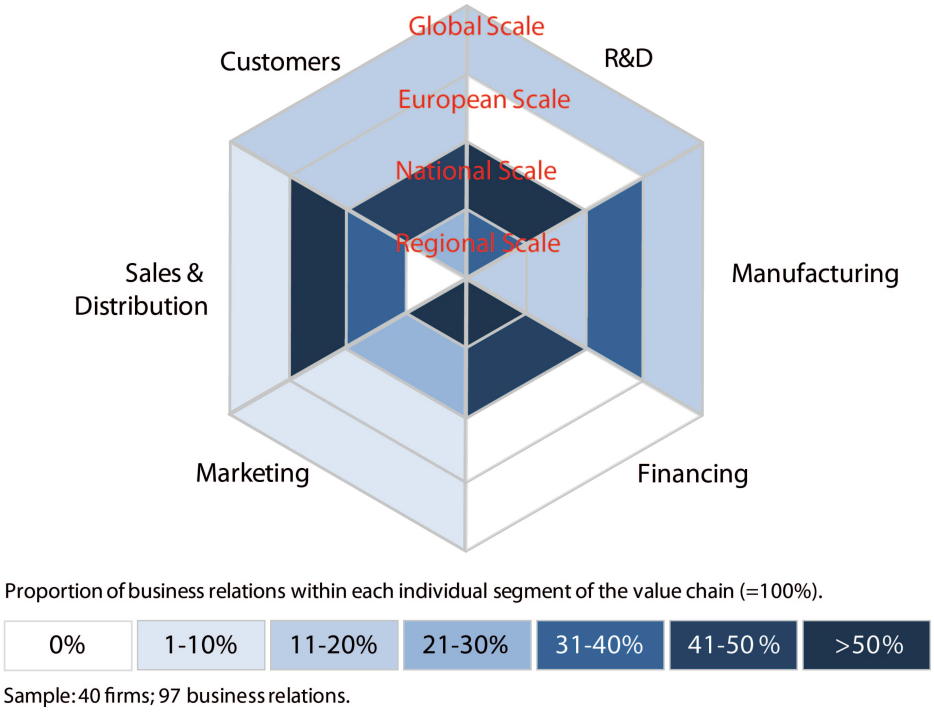
Table 6: Numerical values of global connectivity of Advanced Producer Services and High-Tech firms in the FUA of Amsterdam and Frankfurt

	Advanced Producer Service Firms						High-Tech Firms					
	Frankfurt		Amsterdam				Frankfurt		Amsterdam			
Rank	City	Proportionate Connectivity (1= New York)	City	Proportionate Connectivity (1= London)			City	Proportionate Connectivity (1= Singapore)	City	Proportionate Connectivity (1= Singapore)		
1	New York	1,00	London	1,00			Singapore	1,00	Singapore	1,00		
2	London	0,96	New York	0,94			Paris	0,97	Paris	0,87		
3	Paris	0,88	Hong Kong	0,89			Moscow	0,90	Shanghai	0,87		
4	Hamburg	0,87	Paris	0,84			Sao Paulo	0,89	Sao Paulo	0,81		
5	Hong Kong	0,82	Milan	0,82			Shanghai	0,88	Stockholm	0,81		
6	Vienna	0,78	Singapore	0,81			Vienna	0,86	Moscow	0,79		
7	Berlin	0,78	Frankfurt	0,78			Brussels	0,83	Tokyo	0,77		
8	Milan	0,76	Tokyo	0,78			Milan	0,81	Madrid	0,77		
9	Singapore	0,76	Madrid	0,75			Madrid	0,80	Brussels	0,76		
10	Munich	0,76	Shanghai	0,74			Tokyo	0,78	Milan	0,76		
11	Shanghai	0,75	Sao Paulo	0,74			Buenos Aires	0,77	Beijing	0,76		
12	Tokyo	0,74	Sydney	0,74			Stockholm	0,76	Mexico City	0,75		
13	Stuttgart	0,74	Warsaw	0,74			Sydney	0,76	Buenos Aires	0,74		
14	Warsaw	0,73	Prague	0,72			Budapest	0,75	Bangkok	0,73		
15	Düsseldorf	0,73	Mumbai	0,72			Istanbul	0,75	Dubai	0,73		
16	Madrid	0,73	Stockholm	0,71			Stuttgart	0,74	Prague	0,72		
17	Prague	0,71	Vienna	0,71			Beijing	0,74	Hong Kong	0,71		
18	Moscow	0,71	Hamburg	0,70			Hong Kong	0,73	Seoul	0,71		
19	Sao Paulo	0,71	Brussels	0,70			Munich	0,73	Munich	0,70		
20	Zurich	0,70	Dubai	0,68			Prague	0,73	Johannesburg	0,70		

Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

Relationships along the value chain do not only arise firm-internally, but also to external firm partners. Figure 26 indicates the share of business relations within the individual segments of the value chain for knowledge-intensive companies at and around Schiphol.

Figure 26: Value-adding relations of knowledge-intensive firms at and around Schiphol airport



Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

As shown in Figure 26, the largest proportion of value-added relations is localized at the regional and European spatial scale. By contrast, business relations directed toward the global spatial scale are visibly less pronounced. In total, approximately 38% of all external-oriented business activities are directed to the regional spatial scale, while 37% are concentrated on the European spatial scale. Only 12% are focused on the national scale, and only 13% of all business relations are globally oriented. Especially in the segments of finance and marketing, knowledge-intensive companies at and around Schiphol source their inputs from the regional spatial scales, while in the segments of manufacturing and sales and distribution, the European spatial scale is dominant. Simmie (2003), for example, explains this empirical finding with the fact that knowledge-based activities tend "to combine a strong local knowledge capital base with high levels of connectivity to similar regions in the international economy. In this way they are able to combine and decode both codified and tacit knowledge originating from multiple regional, national and international sources" (Simmie, 2003).

Interviewees in Amsterdam have confirmed these empirical findings. The results of the interviews with knowledge-intensive companies at and around Schiphol show that companies mostly cooperate with external partners that are localized on the regional, national, and to some extent, on the European spatial scale. As the interviews indicate, in this context the biggest benefit of the Schiphol site comes from the landside accessibility advantages, which were the most important site selection criteria for interviewed companies. This applies especially for the unique landside accessibility at the intersection of rail and road.

For certain globally operating companies in Amsterdam as well as Frankfurt, the airport office has risen in status as a “hub office” within the internal office hierarchy. In this context, “hub office” signifies a “meeting point” for knowledge-exchange benefiting from a fast and smooth organization of face-to-face interaction and spatial proximity to urban services and functions. Targeting this network and service potentiality is used to optimize the knowledge-creation and knowledge sharing process, be it within firm-internal or firm-external relations. In comparison to events at previous office sites, most companies have registered a noticeable increase of firm-internal and firm-external events through their relocation to Schiphol; a fact that companies trace back to better accessibility and infrastructure advantages of the new office site.

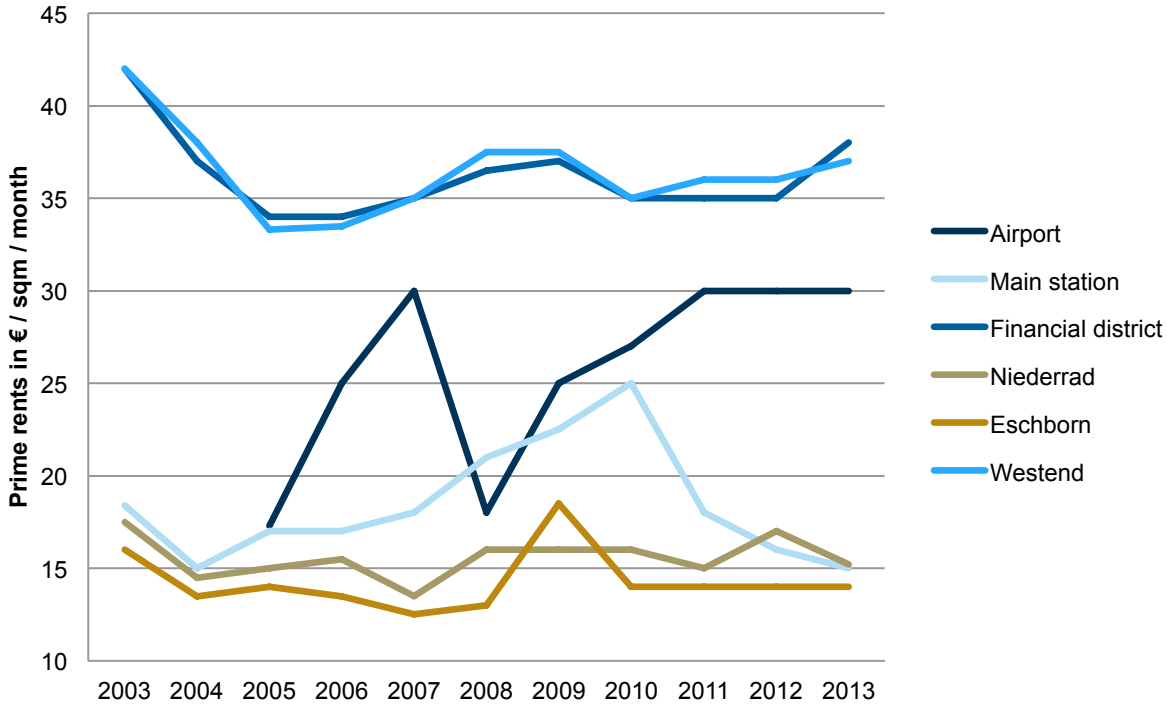
In contrast to other office location, for example in the downtown area of Amsterdam, offices at Schiphol allow a fast and convenient combination of knowledge capital bases from different spatial scales. The centralization of urban functions formerly localized in the inner-city areas and the increase in high-quality office real estate have formulated a new, multifunctional dimension of office space precisely tailored to the needs of knowledge-intensive companies. The spatial concentration of different business facilities at Schiphol and the proximity to locations with a strong international orientation, like Zuidas or Amsterdam, help network partners reduce time-consuming journeys and avoid the costs of overnights stays as the these partners can arrive and depart on the same day.

5.4.2 The case of Frankfurt Rhine-Main airport

Frankfurt is Germany’s premier airport of international standing and serves not only as the international „gateway“ of the polycentric Rhine-Main Metropolitan Region and Germany, but also as one of the busiest hub airports in international aviation. Additionally, it is one of Germany’s most important railway stops in high-speed railway system. This unique synergistic interaction of landside and airside modes of transport makes Frankfurt airport perhaps one of the most accessible locations worldwide. The multimodal accessibility lays part of the foundation needed for successful real estate developments that have increased significantly since the late 1980s. Since the late 1980s, the quantity of office floor space has decidedly grown and a variety of commercial property developments have been initiated at the airport platform and its environments. Prominent office projects of the last years include “The Squaire”, Main Airport Centre, and the Gateway Gardens Area (cf. Fraport 2013). Currently, the submarket Frankfurt-Airport holds a total stock of 371.200 sqm out of 1.329.000 sqm (Naiapollo, 2014).

Like in Amsterdam, Frankfurt's airport location is ranked among the top locations within the local office real estate, pulling in top rents equivalent to prime downtown area office locations such as the "Financial District" or "Westend". Figure 27 illustrates the development of the prime rents for office floor space at and around the airport of Frankfurt in comparison to other selected office locations within the total market.

Figure 27: Monthly prime rents of Frankfurt airport in comparison to selected office submarkets in Frankfurt



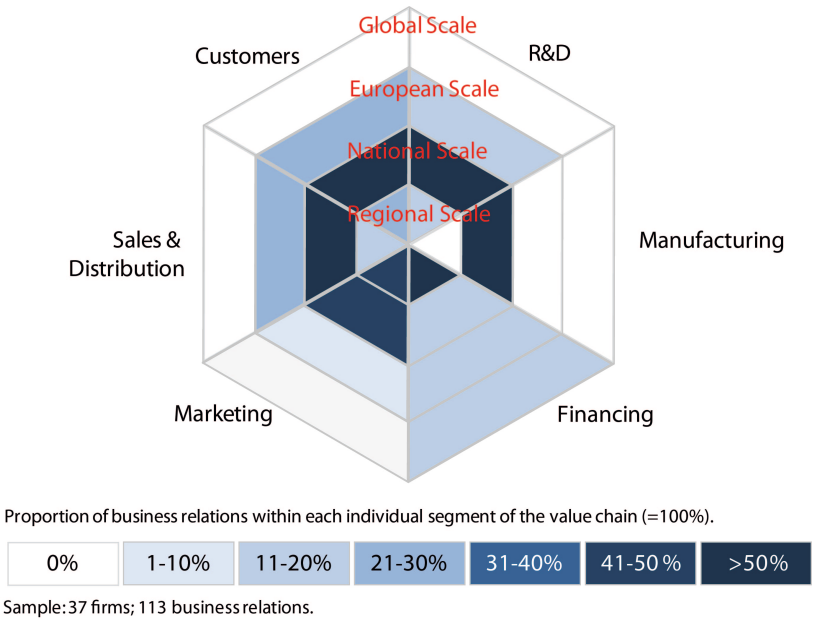
Author's figure, 2014
Data source: BNP Paribas Real Estate Consult GmbH, 2013

Figure 27 shows that the monthly prime rents per square meter have increased from €17.30 in 2005 to €30 in 2013. By comparison, the monthly prime rents per square meter within the top locations in the downtown area were approximately €34 in 2005 and €36 in 2013 (BNP Paribas Real Estate Consult GmbH, 2013). A noticeable source of demand for airport office floor space has been generated by industries like human resources consulting, traffic and transportation, finance, business consulting, healthcare and IT and telecommunication (BNP Paribas Real Estate Consult GmbH, 2013).

From a relational perspective, the FUA of Frankfurt is characterized by strong connectivity patterns with the world's most important economic regions including the BRIC States and Asia, as well as New York and London, which are recognized as the world's leading financial hubs. Table 6 summarizes the results for the Interlocking Network Analysis and shows the 20 most-connected agglomerations for APS and High-Tech firms. Particularly remarkable are

the strong connectivity patterns of APS firms with the agglomerations of Hamburg, Berlin, Munich, Stuttgart, and Düsseldorf underscoring the strong national focus of APS firms in terms of intra-firms location and networks. One explanation for this result might be Germany's strong domestic demand and its dense market. Especially for APS firms, the German domestic market seems to generate enough demand and growth potential. This would explain the strong orientation of intra-firm networks towards the national spatial scale. APS firms located in smaller economies tend to internationalize their business activities at an earlier stage due to weaker domestic demand, as example studies for Switzerland and Austria plainly show (cf. Stadt Wien 2011). The findings for the Interlocking Network Analysis correspond with the results of the external value chain analysis for companies located at and around the airport, which are highlighted in Figure 28.

Figure 28: Value-adding relations of knowledge-intensive firms at and around Frankfurt airport



Author's figure, 2013
Data source: Author's elicitation and calculation, 2013

Similar to the results of intra-firm networks, the spatial patterns of extra-firm connectivity of knowledge-intensive companies within a 10 minute radius around the airport show very strong relations with other APS or High-Tech firms located either within their own mega-city region or on the German spatial scale. On the scale of mega-city region, the most frequent interactions are with other APS firms, in particular finance and marketing. Conversely, on the German spatial scale, the most frequent interaction are with partners in manufacturing, research and development, customers, and sales and distribution. On the European spatial scale, a large number of extra-firm relations with customers and sales and distribution occur.

The empirical findings of the intra- and extra-firm analysis are astonishing insofar as knowledge-intensive companies located at and around the airport of Frankfurt show less pronounced international connectivity patterns than expected.

Business practitioners confirmed these empirical findings during the qualitative network analysis. Usually business activities of the interviewed companies at and around Frankfurt airport focused on the regional and German spatial scale, and were much less oriented towards the global spatial scale. In this context and especially with regard to the internal and external process of knowledge creation and sharing of information, all firms highlighted the necessity of knowledge sourcing and periodic face-to-face interaction in order to stay innovative. This fact gives rise to frequent business travels, which in turn require convenient access to accessibility nodes. According to all interviewed firms, the locational attractiveness owes primarily to the multimodal interplay between air, road, and rail-bounded traffic systems. This represents a significant advantage for knowledge-intensive companies over other office locations, embedding higher flexibility in terms of rescheduling business appointments and allowing for a much broader choice concerning mode of transport.

However the functional logic of the knowledge economy requires not only highly accessible locations, but also supportive environments that enable and enhance the exchange of knowledge. These two pivotal criteria for knowledge-intensive companies found and validated at airports have further underlined the role of airports as service infrastructure of a broad spectrum. Similar to Schiphol, Frankfurt has increased its attractiveness for knowledge-intensive activities by improving business-related infrastructures and by opening up high-quality facilities like hotels, conference centres, and event locations. All of these facilities formulate a new, multifunctional dimension in which modern office space can exist. According to interviewees, the ease of accessibility of the location via walking enhances the process of face-to-face interaction and helps businesses to get in contact with distant firm-internal and firm-external partners. This advantage was also highlighted as an important site selection criterion for many companies interviewed in Frankfurt. For example, internal and external network partners arrive and depart the same day or schedule an appointment while they are in transit by train or transferring from train to airplane.

5.5 Discussion and conclusion

The multi-faceted analysis undertaken here enables a better understanding of the way in which airport-based, knowledge intensive companies spatially organize their firm-internal and firm-external networks. The results provide a deeper and richer insight into the site selection process and its underlying drivers. Based on the outcomes of the quantitative and qualitative research activities, the initially formulated hypotheses can be verified. With regard to hypothesis 1, the results clearly show that Amsterdam and Frankfurt airport have been extremely successful in attracting companies beyond a naturally given affinity to the aviation business sector. In particular, companies with a knowledge-intensive background have located at and around the airports transforming the airport space into what Yigitcanlar et al. once labeled as “airport knowledge precincts” (Yigitcanlar et al., 2008). “Access to global knowledge networks has a remarkable influence on growth and innovation, and airports play a significant role in linking local knowledge precincts and knowledge-intensive service activities with other knowledge clusters and activities both nationally and internationally so the value chain is integrated at the global level and key knowledge circulates throughout the whole chain” (Yigitcanlar et al., 2008). In this context, the combination of air and landside traffic systems has contributed to the emergence of airports as exchange platform ensuring geographical proximity to local and regional knowledge sources and relational proximity to distant partners. Intercontinental air-travel provides a fast and convenient opportunity to arrange face-to-face meetings on a global spatial scale while easy access to powerful landside means of transport not only fulfills the function of shuttle to the airport, but increasingly also the role of an attractive alternative for short-haul routes. The integration of airports into the networks of high-speed rail creates a second accessibility advantages as the results of the interviews have shown. In Amsterdam and Frankfurt, the high-speed railway is used as an attractive alternative to flying particularly within the organization of domestic business activities and activities directed to adjacent European countries. This applies in particular for travels of up to three hours or, depending on the speed, for distances between 500 to 800 kilometers (European Commision, 2010, Peters and Novy, 2012).

Contrary to the assumption that the immediate environments of airports attract predominantly aviation-oriented companies (Kasarda, 2004), the findings of this research and article indicate that airports are also attracting a significant share of companies that have only a minimal or even no affinity to air transportation networks. For these companies the locational advantages result less from the accessibility provided by airline networks, and more from convenient landside accessibility, especially by car or by high-speed trains. This confirms earlier findings of Warffemius (Warffemius, 2007), whose results for European Distribution Centers (EDC) around Schiphol show that “almost 40 percent of the warehouse, that represent the EDC population in the Schiphol Area Development Cooperation (SADC) area, is non-Schiphol-dependent” (Warffemius, 2007). Similar to Warffemius, this investigative undertaking found that these companies predominantly located at Schiphol and Frankfurt because of the powerful landside ground transportation links, the positive image of the airport locations, and the market-compliant availability of properties. For many airport-based companies, the biggest locational advantage results from operational efficiency through improved access to transport infrastructure and thus spatial proximity to partners along the

value chain. The results of the value chain analysis for airport-based companies in Germany show that a high concentration of these partners along their individual value chain are located on the local, regional, and national spatial scale, while in the Netherlands, either the regional or European spatial scale dominates. One explanation for the inward-orientation of the German spatial economy lies in the strong and dense domestic market that is able to generate sufficient demand and growth potential. By contrast, smaller economies, like such as those of the Netherlands, Austria, or Switzerland, are forced to internationalize their business activities due to the comparatively low domestic demand.

The findings confirm the second hypothesis as well. Amsterdam and Frankfurt airport have managed to attract different spatial uses that are engendering new nuclei of knowledge-based activities. This confirms earlier findings by Kasarda (Kasarda, 2000b) and Einig and Schubert (Einig and Schubert, 2008) that illustrate the morphogenesis of airport locations into new focal points of spatial development. The knowledge economy has turned out to be an important driver within the reshaping of airports and adjacent areas into new functional spaces due to its commitment to sites at and around airports. Through the demand for urban functions, such as hotels and business related facilities and services, and the regular use by knowledge-based activities, the development of the non-aviation sector is continually propelled. This in turn promotes the constitution of mixed used, multi-functional spatial structures that become destinations in themselves.

Over all, Amsterdam and Frankfurt provide two sophisticated examples in which the complex and multifaceted multi-scalar accessibility / knowledge-economy nexus becomes spatially manifested. The empirical analysis shows two important findings:

Firstly, knowledge generation is a highly interactive process. The functional logic of the knowledge economy requires access to high-quality accessibility infrastructures, knowledge hubs, and knowledge sources on varying spatial scales. In light of the growing knowledge economy, airports are experiencing a “functional reinterpretation” and a growing appreciation as knowledge-exchange-enriching locations, advantageous for all kind of businesses. Knowledge-based activities make strategic use of the locational advantages distinguished by well-developed, multi-modal accessibility. This applies in particular to those knowledge-intensive companies that consider geographical and relational proximity as crucial to their business models.

As the empirical results reveal for both case studies, airports are not only attracting international knowledge-intensive firms with a high affinity to air transportation networks, but they are also attracting firms that act solely on regional or national scales. To maintain and extend this competitive advantage, and to reinforce these locations’ robustness towards the volatility of the aviation industry, future efforts must focus on improving the multi-modal competence of airport locations by better integrating them into urban and regional transportation networks.

Secondly, knowledge-intensive companies are promoters and initiators of the spatial transformation of airports and their adjacent areas. One important future challenge is to

ensure the locations' attractiveness for knowledge-based economic activities. This can be achieved by raising the locations' urban quality while continuing to enable the potential for physical human interaction and information and knowledge exchange.

Today airports are areas of opportunities. This contribution and the proposed methodology form a starting point for future research and can easily be transferred to other case studies as more global airports undergo similar transformations. By doing so, our understanding about the redefined role of airports within a knowledge economy context will be sharpened further.

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6 Conclusion

The overarching aim of this dissertation is to nuance the understanding of airport-linked knowledge-based spatial patterns and their underlying drivers. The principal points of reference are Germany's three main airports – Frankfurt, Munich and Düsseldorf – and the main airport in the Netherlands, Amsterdam-Schiphol. The focus has been on knowledge-intensive companies – here considered as APS and High-Tech firms – their network activities and, derived from that, their location requirements. Special attention has been given to the relational processes and to the spatial configuration related to these processes. The applied methodological approach, utilizing an Interlocking Network Analysis, a value chain approach and a series of qualitative interviews with general managers and site selection specialists has generated a rich tranche of data. The results gathered in this way contribute to an international academic discussion specifically focusing on the complex interplay between the knowledge economy on the one hand and spatial development on the other (cf. Krätke, 2007; Lüthi, 2011; Thierstein et al., 2013; Conventz et al., 2014). Furthermore, the results make an important contribution to the emerging body of literature on airport-induced spatial development (cf. Freestone, 2011; Kasarda, 2000; Sonneburg, 2014; Conventz and Thierstein, 2014; Schubert, 2007).

The following chapter is devoted to answering the research hypotheses. The principal findings and the lessons drawn from them will be summarized. Following this, recommendations for future directions of research are made. Finally, future key challenges, which might arise for different actors, such as cities and regions, planning institutions, airport authorities or real estate developers, are formulated. In addition to this, suggestions on how to meet these challenges are made successfully. Based on the results of the different research steps, the following conclusions can be drawn.

6.1 Closer to the world or in-between the flows

Based on the research findings, the first research hypothesis can be verified:

> Knowledge-intensive firms locate at and around hub airports in order to benefit from geographical and relational proximity to partners along the value chain and to different sources of knowledge.

The results for all four airports show that airports and their adjacent areas have become places of knowledge-based interaction and hubs of firm-internal and firm-external knowledge exchange. In all four cases, airports and their surroundings have emerged as new functional space within a wider metropolitan region contributing to the spatial-functional shaping of locational systems. All airports have attracted an array of knowledge-based activities in

various sectors and have thus morphed into what Yigitcanlar et al. have phrased “airport knowledge precincts” (Yigitcanlar et al., 2008).

As the empirical results indicate, knowledge-based activities increasingly use airports and their vicinities in order to generate, transform or enhance specific knowledge within their company-internal and company-external networks. In this context airports and their immediate surroundings serve as knowledge-hubs and places of permanent or temporary face-to-face interaction. Knowledge-intensive companies, especially those which consider geographical and relational proximity as crucial to their business models, make use of the accessibility, time, cost and infrastructure advantages of airports in order to optimize their value-added chains as well as the process of knowledge generation (Conventz and Thierstein, 2014) (see chapter 4 and 5). In contrast to other infrastructural facilities, airports provide a distinctive competitive edge: multimodal accessibility. Accessibility comprises two important dimensions: a physical and non-physical dimension (Bentlage et al., 2013: 50). Physical accessibility refers to the time and cost invested in order to get from a starting point to another location, either by air, road or rail traffic, and can be associated with network economies and agglomeration economies (see chapter 3). The empirical results reveal that knowledge-intensive companies at and around airports tend “to combine a strong local knowledge capital base with high levels of connectivity to similar regions in the international economy” (Simmie, 2003). By doing so, these companies are able “to combine and decode both, codified and tacit knowledge originated from multiple regional, national and international sources” (Simmie, 2003). Through the integration into intra-local and intra-regional traffic systems, tacit local knowledge and expertise become directly accessible. By contrast, efficient integration into national and international transport systems warrants fast accessibility to distant, personalized knowledge carriers.

Non-physical accessibility, in turn, is constituted through internal company networks (Bentlage et al., 2013: 50), which are not “directly morphologically graspable” (Thierstein et al., 2007: 56). These non-physical corporate networks of knowledge-intensive activity require periodical face-to-face meetings in order to exchange experience-based knowledge. The need for face-to-face interaction drives intensive travelling on a local, regional, and national international scale.

As the process of knowledge creation has become increasingly complex – requiring access to knowledge sources from local to global spatial scale global – it is precisely the interplay between physical and non-physical accessibility that makes all four airports sites highly interesting places for knowledge-intensive companies. All companies interviewed have stressed the unique multimodal accessibility profile as the biggest locational advantage and the biggest competitive edge with regard to the optimization of their value-added chains, and their permanent and temporary knowledge production. This applies to globally operating knowledge-intensive companies and companies with purely regional or national operations alike.

In comparison to their previous office location, all companies have improved their accessibility through relocating their office closer to the airport. This has been particularly

emphasized by companies from finance, real estate development or management consultancy in Frankfurt, Amsterdam and Düsseldorf. The process of knowledge creation among firms belonging to these sub-sectors of the knowledge economy is characterized by the need for frequent face-to-face interaction with partners along the value chain. By contrast to other forms of communication, and despite of all kinds of substitute personalized interaction by virtual forms of communication, face-to-face communication is still the predominant and preferred form of communication for these knowledge-based activities. Face-to-face communication around these sub-branches does not only fulfill the role of confidence-building; aside from promoting trust, it also promotes "synthetic knowledge" (Asheim et al., 2007), which is created within a personalized process of interaction between different partners along the value chain, such as customers and suppliers.

Some of the companies interviewed have even consciously sought an office location in close spatial linkage, that is to say walking distance to the airport terminal, in order to optimize the process of face-to-face interaction (cf. chapter 4). This locational decision-making on the part of knowledge-intensive companies underlines the significance of multimodal integrated airports for knowledge-intensive companies, and the key role which airports have gained as network infrastructure within the multi-layered and spatial scale-crossing process of knowledge generation, service provision and global information exchange.

However, the empirical results for all four airports also show that an array of mostly regional and nationally oriented knowledge-intensive companies have located independently of consideration of the airport. Although these companies appreciate the existence of airport infrastructure as a locational advantage, their choice of location was mostly motivated by the integration of the airport site into powerful landside traffic systems, such as high-speed railway or highways, real estate qualities and the existence of a business related infrastructure. These empirical findings confirm earlier results by Warffemius (Warffemius, 2007) for Schiphol airport. Warffemius' research for European Distribution Centres (EDC) shows that "almost 40% of the warehouses that represent the EDC population in the SADC are non-Schiphol-dependent (Warffemius, 2007: 148). Thus, similar to the results for knowledge-intensive companies, air accessibility was not the primary reasons for all companies for locating at and around the airport. Rather, landside accessibility, availability of land, land prices, transportation costs, image of the airport location, and agglomeration economies were the main drivers for EDCs locating at and around Schiphol airport (Warffemius, 2007: 148 & 168).

Added together, findings confirm Kasarda's observation that "major airports are becoming key nodes in global production and commercial systems" (Kasarda, 2004: 92). In light of the growing knowledge economy, the three biggest German airports and the main gateway to the Netherlands – Schiphol – are increasingly attracting knowledge-intensive companies that depend on rich and diversified accessibility and communication infrastructure within the complex process of knowledge generation. Airports with multimodal combinations of air- and landside transport carriers meet the locational requirements of the knowledge economy the best. This requires – due to its functional logic – that locations are supportive of the creation of knowledge and that facilitate smooth organization of knowledge inputs from different spatial scales. However, in contrast to Kasarda, who argues that only aviation-oriented businesses are drawn to airports (Kasarda, 2004: 92), the findings show that knowledge-intensive firms with low to no affinity to aviation also make strategic use of the airports' business infrastructure and its efficient landside accessibility by road and rail to local, regional and national markets areas and partners along the value chain.

6.2 Knowledge-based activities as driver of a new functional space

The second hypothesis of the present dissertation can also be confirmed based on the empirical findings for the four cases studies of Frankfurt, Munich, Düsseldorf and Amsterdam:

> If knowledge-intensive companies and their highly mobile employees demand accessibility, then the emergence of new real estate and functional space at and around international airports is stimulated.

The research findings show that airports have developed beyond the stage of being pure infrastructural facilities and that the number of functions devoted to activities other than aviation has increased massively in the recent past (see chapter 2). For a long time, airports were designed as spatial solitaires at the periphery, as pure transit spaces and service providers for airlines. As spatially fixed real estate, airports primarily ensure the smooth running of air traffic. This traditional role, however, is changing, and airports have taken on more functions: Firstly they serve as important economic activity centers and economic growth engines unfolding far-reaching direct, indirect and induced economic effects. In addition to being critical components of efficient city infrastructure, airports are today key assets for cities and regions and a catalyst for investment. Secondly, airports are increasingly perceived as urban activity centers and urban growth generators, that transform real estate markets and locational qualities (see chapter 4). This especially applies to hub airports, which are considered supra-regional and international gateway infrastructures having a decisive impact on firms' competitiveness and stimulating urban and regional development.

In the knowledge economy context, airports have gained center stage as network and service infrastructure. In this context too, airports have been successful in establishing their locations for knowledge-intensive activities by offering a unique locational quality distinguished by two core, contemporary spatial characteristics: Worldwide connectivity by air and multimodal landside accessibility on local, regional and national scales. This spatial quality of airports has attracted knowledge-intensive companies from different sectors, as our empirical analysis for Frankfurt, Munich, Düsseldorf and Amsterdam reveals. This finding once again confirms previous results by Yigitcanlar (2008), Conventz (2008), Wijk, Brattinga and Bontje (2011), who have already noted the growth of office-based operations at and around airports.

In order to stay competitive, knowledge-intensive companies are forced to re-examine their locational requirements with regard to their implemented business models and network activities at periodical intervals. Based on the research outcomes, the second research hypothesis can be verified. The knowledge economy promotes, through its location choice and its demand for urban functions, the spatial transformation of airports towards more mixed use and multi-functional centers of competences. This not only applies to the demand for office space, where knowledge-intensive companies are proving to have the strongest demand. Owing to this demand, the knowledge-economy drives the second business tier of airport operators: The non-aviation sector, where real estate developments play a key role in terms of generating additional revenue streams. These non-aviation activities not only involve office real estate developments but also developments in the field of airport retailing or the provision of business related services such as conference or catering facilities. In the recent past, airport operators have moreover built up a conference and seminar infrastructure, allowing companies to hold events and meetings. As interviews among business practitioners in the airport cities of Frankfurt, Düsseldorf and Amsterdam have indicated, these facilities and services are used by knowledge-intensive firms and their employees, for example, during lunch breaks, in order to host meetings with firm-internal or firm-external business partners or to do daily shopping in one of the supermarkets or grocery stores. The longer the process takes, the more companies from the knowledge economy are attracted, and the more new urban structures emerge.

6.3 Limitations or where to continue future research

The results presented in the current dissertation are the first of their kind and – as often in scientific research – the final results raise as many new questions as they answer. This particularly holds for the spatial patterns around international airports, which have been analyzed in the present dissertation through the lens of the knowledge economy. In order to understand better the new spatial articulations around airports and the role of airports as focal points of urban and regional development, much more – and most probably very different – research remains to be undertaken. The following section provides an overview of possible avenues for future research. In the view of the results, several possible directions open up for continuative research activities.

6.3.1 Third pillar of the knowledge economy

As stated earlier, the knowledge economy relies on three pillars (see chapter 2 and 3), although in this dissertation the main attention has been devoted to two of them: Advanced producer services and High-Tech firms. Knowledge creating institutions such as universities and research establishments have not been analyzed and this is one possible point of departure for future research. The empirical analysis of the cases of Amsterdam, Frankfurt, Munich and Düsseldorf shows that a growing number of research institutions, university-related institutions, and educational centers are opening at airports, either directly and in walking distance to the terminal building, or in the immediate surroundings of the airport. For example, the Gateway Gardens area and the Main Airport Center (MAC), both located directly at Frankfurt airport, are home to the Institute for Arbeits- and Sozialhygiene (IAS) or the House of Logistics and Mobility (HOLM) which also includes a satellite campus of the European Business School (EBS). In Amsterdam, the Schiphol World Trade Center (WTC) hosts the American Chamber of Commerce (AmCham), while Düsseldorf's Airport City accommodates the VDI House, the headquarter of the Association of German Engineers. Similarly, around Munich airport a growing number of knowledge creating institutions are located. Famous examples are the McKinsey Capability Center (MCC) in Hallbergmoos, or the BMW Training Academy in Unterschleissheim, both approximately 15 minutes away from Munich airport. All these institutions facilitate knowledge creation and function as networking platforms for knowledge carriers from private businesses, politics or science, and thus have a real impact on the spatial structure. Future research should also shed light on the site selection process of these knowledge-creating institutions. Why do knowledge-creating institutions locate at and around the airport? How are these knowledge creating institutions interwoven with companies from the knowledge economy? What is their demand for urban functions? How do knowledge-creating institutions organize their networks spatially?

6.3.2 Non-knowledge-intensive companies

Since this thesis deals with knowledge-intensive companies which are advanced producer services and High-Tech companies, the main focus is solely on their network activities and their location requirements. However, knowledge-intensive companies do not exclusively drive spatial structures and real estate developments at and around international airports. Airports are increasingly attracting non-knowledge-intensive companies such as retailers, companies from the food industry, or international textile companies. In order to gain a deeper understanding of the spatial development processes anchored at and around international airports, a conceptualization is needed which also focuses on economic sectors that are not subsumed under the knowledge economy. What are the underlying drivers of these economic sectors for locating in close geographical proximity to the terminal? What role does the airport play for these companies within their daily business and what demand exists for air traffic services? Are there more similarities or differences compared to the demands of knowledge-intensive companies? Are there more similarities or differences between these actors concerning their spatial logic? What demand for urban functions do non-knowledge-intensive companies express? By answering these questions, we will gain a deeper and richer insight into how and who transforms airport space.

6.3.3 Private households

A future research agenda must also focus on households and their role as a driver of the spatial transformation process of areas adjacent to airports. As shown in the stylized impact model (see chapter 3), households are considered another crucial driver. The economic prosperity of airport locations creates new job opportunities and a demand for employees. These attractive local job opportunities attract employees, which in turn leads to population growth around airports and an increased demand for housing space (cf. Ernst Basler + Partner GmbH, 2010; Droß and Thierstein, 2011). The migration dynamic initiates a far-reaching structural change with deep impacts on residential real estate markets. A good example of this evolutionary process are the municipalities around Munich airport, which have experienced an above-average growth with regard to newcomers since the airport's inauguration at the beginning of the 1990s. This development process may generate problems regarding the social integration of newcomers within the existing social and spatial structures on the one hand, and regarding existing local identities on the other. Local communities might be confronted with radical transformation caused by the influx of new working populations and their social habits. There is also the risk that so called "sleeper cities" emerge, that is to say, cities where new inhabitants live without active participation at community level (cf. Ernst Basler + Partner GmbH, 2010). In order to stay attractive and competitive within the international location competition, further research and knowledge is required. This especially holds when considering ways to develop and to design robust and sustainable airport locations. In this context, future research should specifically concentrate on households and their demand for locational qualities and infrastructural facilities.

6.3.4 Longitudinal analysis

Another way to expand a future research agenda and to sharpen our understanding of the spatial developments that are taking place at and around international airports is to put the spatial developments into diachronic context. In the present dissertation, data was collected synchronically. Thus the empirical investigation in this thesis is static. In order to obtain a more comprehensive picture, time series comparisons are necessary. Research conducted by Einig and Schubert (2008) for the 19 most important German airports provides a starting point for such a time-series survey for Germany. The applied methodology can be repeated by future research and the results generated would give a deeper insight into the spatial dynamics taking place around German airports. How has the spatial structure been altered through time? What types of spatial uses have emerged?

6.3.5 International perspective

The transformation process of airports into focal points of spatial development is taking place worldwide (Michaeli et al., 2011; Scharfenort, 2014; Sonneburg, 2014; Appold and Kasarda 2012; Panatropolis, 2014; Aviapolis, 2014; Alkaabi et al., 2013). Although the current dissertation has also directed its attention to an international case, the main focus is on Germany. In order to gain more insight into the drivers of the airport's morphogenesis and the role the knowledge economy plays within this context, future investigations must place special attention on international comparative analyses. What role does the knowledge economy play within the urbanization of airport space at other airports around the world? What role does the airport play for knowledge-intensive activities at and around other airports within their daily business? Do the locational dynamics and real estate patterns around other European airports, or around airports in other parts of the world differ from those of the cases studied here?

Since the research triangulation and the methodological mixed approach has turned out to be a beneficial tool for analyzing and understanding knowledge-based patterns around the four airports and the role airports play within the knowledge-economy context, future research could repeat the survey by applying the same combination of quantitative and qualitative research methods for other case studies, for example in Europe and other parts of the world. In this way, different cases can be directly compared. Furthermore, further valuable knowledge would be obtained, sharpening our understanding of the spatial drivers and the new role of airports as service and network infrastructure.

6.3.6 High-speed railway stations

Knowledge-intensive activities are not only increasingly concentrating around international airports, but also around other accessibility nodes such as high-speed railway stations. In the course of the extension of the high-speed railway in Europe, many new decentralized high-speed train stations have been established. This especially applies to Germany with Frankfurt airport, Montabaur, Limburg or Siegburg as the most prominent examples for new

high-speed train stations outside the traditional city centers. As with airports, these accessibility nodes have increasing economic and spatial impacts. At the same time, the areas surrounding high-speed train stations have become home to knowledge-based activities. As in the case of airports, little is known about the role of high-speed train stations as locations within the knowledge economy context. So far, there is very little – if any – scientific understanding of the effects of this type of train station on its adjacent areas (cf. Peters and Novy, 2012: 27). The methodological mixed combination of quantitative and qualitative research actions provides a tried and tested approach to studying the spatial development around high-speed railway station.

As stated in the introductory chapter, research on airport-linked spatial development is in its infancy. Thus more research work is necessary to sharpen our understanding of the evolving knowledge-based patterns at and around international airports. The foregoing section has suggested different ways to expand a future research agenda.

6.4 Considerations for future success of robust airport locations

The previous section has described and explained the rapid change of airports into urban-like entities and centers of permanent and temporary knowledge exchange. In the knowledge-economy context, airports have evolved as places of opportunity and knowledge-intensive companies increasingly recognize the potential and the advantages of airports and their adjacent areas for their business activities. For cities and regions, airports are a key perquisite within the global competition amongst locations and for future oriented businesses. Liberalization of world trade as well as commodity, capital and service markets, increased global mobility, new communication options, or the free movement of labor and capital will further intensify this competition in the future. For companies – and knowledge-intensive firms in particular – airports are essential for implementing new business models and continuing to penetrate new markets. In order to survive in this highly dynamic market environment in the long-term, and in order to support long-term growth, knowledge-intensive companies will be forced to open up new markets outside the traditional market areas of Europe and North America. The airports of Frankfurt, Munich and Amsterdam, and also Düsseldorf – with its increasing hub function – provide valuable accessibility advantages and hence a good starting position for breaking new markets.

In order to secure the future success of airports as a new spatial category within the urban-regional system and heightened the attractiveness for the knowledge economy, local, regional and national authorities, real estate developers and airport authorities will face an array of key challenges. If the results of this dissertation are converted into recommendations for actor groups involved in the arena of airport-linked spatial development, two aspects must be taken into account: Urban design qualities and multimodal accessibility. These aspects will be briefly discussed in the following closing section of this dissertation.

6.4.1 Need for improved urban design qualities

The quantity of office space at and around the airports of Frankfurt, Munich, Düsseldorf, and Amsterdam has continued to grow rapidly during recent years. This results in a first challenge for airports and their adjacent areas: Maintaining the attractiveness for the knowledge economy and reducing the risk of evolving mono-functional office-based spatial patterns. The principal challenge will be to keep serving the constantly changing demand for location and real estate quality on the part of knowledge-intensive companies. The provision of efficient urban functions and knowledge exchange supporting environments is a further necessary condition that has to be faced when developing attractive real estate sites for knowledge-intensive activities.

Linking functional demands with architectural and urban design quality will be one of the main challenges in the future. In this context, planning of open public space will be of importance as well as the development of office locations in walking distance. Due to their accessibility by foot and the optimal spatial qualities, it is most likely that airport office locations will enter into competition with more traditional office sites, for example, in the core cities. Through an upgrading of urban design quality in combination with improved land and airside accessibility services, airport locations will become premium office space offering high-quality conditions for the establishment of knowledge-intensive enterprises. The settlement of knowledge-intensive companies, in turn, will not only stabilize the future economic development of the city or the region, but will also have catalytic effects on urban structures. With their affinity for urban environments and urban functions, knowledge workers will drive the development of both: Urban infrastructure and urban quality. This in turn, will advance the transformation process of mostly suburban and poorly developed spatial structures towards more urban-like locations. In this way, the knowledge-economy will make a contribution towards more sustainable spatial development at and around international airports.

6.4.2 Multimodal accessibility

All the airports studied here face the challenge of maintaining and expanding the attractive locational characteristics for knowledge-intensive activities. This especially applies to accessibility, the biggest locational advantage of airports and their adjacent areas. The process of knowledge creation is heavily dependent on the ability to source knowledge from different spatial scales. Despite all kinds of new communication devices and ways to substitute personalized interaction, face-to-face communication is still important. Diverse and rich physical infrastructures facilitate these face-to-face interactions and thus the exchange process of knowledge and information. As airports become increasingly important within the knowledge economy context, they should be developed to serve as multimodal hubs within polycentric urban regions. On the one hand, airports need to be better integrated into local and regional transport systems. If this can be achieved, knowledge-based activities will benefit from improved accessibility to local sources of tacit knowledge and easier organization of face-to-face meetings. Moreover, airports and their platforms need to be

better connected with the adjacent surroundings as a whole. This especially applies to the business parks around the airports. The first steps in this direction have been taken in Frankfurt, where the city of Frankfurt, the state of Hessen, Deutsche Bahn and the Rhein-Main Verkehrsverbund (RMV) – a regional transport company – have decided to integrate the Gateway Garden area into Frankfurt's public transport system (Riebsamen, 2013). In Düsseldorf, the city is planning a new metro line in order to better integrate the airport into the local and regional rail systems (Landeshauptstadt Düsseldorf, 2014). From the environmental point of view, better landside accessibility will also provide a way to reduce the need for private cars, which is still the most frequently used means of transport to get to or from the airport (Airport Regions Conference, 2008).

On the other hand, to fully exploit the airport's potential as a locus of knowledge-intensive activity, airports must be more widely integrated into the national and international high-speed railway system. For knowledge-intensive businesses, this high-access quality brings with it the potential to flexibilize the arrangement of business meetings on the one hand and a greater choice with regard to the choice of the means of transport. Better landside accessibility by high-speed railway will further help to overcome "the last mile paradox" (Airport Regions Conference, 2008: 7). This paradox is the "ability to travel quickly and at low prices across Europe but where the final leg of the trip is often the most physically demanding, time consuming, and expensive of the whole journey" (Airport Regions Conference, 2008: 7). This paradox becomes most obvious in Munich, where the airport is well integrated into international airline networks but landside accessibility, especially into railway systems, is poorly developed or – as in case of high-speed trains – non-existent.

The multimodal integration of airports into landside transport systems makes airports and their surroundings more attractive for investments (Hartwig, 2013), and supports the process of knowledge creation, sharing and diffusion. Less vulnerable towards cyclical exogenous shocks, powerful landside integration also enhances the robustness of the airport system and the airport location as a whole. Airport sites that are characterized by powerful landside accessibility will continue to benefit from their central position and intermodality – independently of the developments within the international aviation industry. Moreover, the value of the airports and their adjacent areas will be increased for the knowledge economy and its operations.

6.5 References

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7 Appendices

7.1 Appendix A: List of firms in the Interlocking Network Analysis

Amsterdam (n= 164)

Advanced producer services (n= 100)

Banking & Finance	
Deutsche Bank AG	Commerzbank
HypoVereinsbank	Credit Suisse
Citibank	United Bank of Switzerland (UBS)
ING Group	Berlin Hyp
Eurohypo AG	ABM AMRO Bank BV
Svenska Handelsbanken	CVC Capital Partners

Logistics	
Deutsche Post World Net	Schenker AG
GLS	Rhenus Logistics
Kühne und Nagel	Hellmann Logistics
TNT	DSV
Geodis Wilson	Röhlig

Design, Architecture & Engineering	
UNStudio	Benthem & Crouwel
AECOM	SNC-Lavilan
Next Architects	Storeage

Design, Architecture & Engineering

Arcadis	Tahal Group
Grontmij NV	Arup
Rücker	Brune
Tauw	

Advertising & Media

McCann Erickson	Young & Rubicom
Euro RSCG	Thomas Reuters
grey global group	Mindshare
Elservier	Mediaedge
BBDO	Gruner+Jahr
HBMEO B.V Endemol	LexisNexis Publisher

Law

Freshfields Bruckhaus Deringer	CMS,
Clifford Chance	Linklaters
Lovells	DLA Piper
Simons & Simons	Clyde & Co
Baker & McKenzie	Allen & Overy

Accounting

PriceWaterhouseCoopers AG	Ernst & Young
KPMG	Aon Accurrancy
MUNKERT PARTNER	MAZARS
Moore Stephans	DHPG
Deloitte	

Information & Communication Technology

Software AG	Computacenter
Arvato	BTplc.
Teleplan	Activision Inc.

Information & Communication Technology

Net Appliance Inc.	F5 Networks
Iconik Plc.	BMC Software

Management & IT Consulting

Abeam Consulting	Logica
GfK SE	Accenture
McKinsey	msg systems
Bearing Point	Booz & Company
Colliers International	Stanton Chase International
The Boston Consulting Group	Roland Berger Strategy Consulting
Arthur D. Little	Mercer Consulting

Insurance

Allianz	Chartis Memsa
International SOS	Generali
D.A.S	Swiss RE
Atradius	Aegon

High-Tech firms (n=64)

Medical and optical instruments

Analytic Jena	Omron
Nikon Instruments Europe B.V.	Philips Medical Systems
Icon Clinical Research	Smith & Nephew
Abott	

Machinery

LM Wind Power	Stork
Delta	van Dam Machines
New Long Machines	Hitachi Construction Machines

Machinery

Kawasaki Heavy Industries
Honeywell Life Safety
Heidelberg
KSB

Computer-Hardware

BM
Juniper Networks
TOM TOM International
Canon
Ikon
HP
Kyocera
Thales
Ricoh

Telecommunication

BMC
QAD Software
Oracle
Niscayah
Nokia
Nortel Networks
Nokia-Siemens Systems
Grundig

Vehicle construction

VOLKSWAGEN
Bombardier Transportation
Johnson Controls
Delta
Rheinmetall
Robert Bosch
Airbus
Fokker
EADS
Airbus

Chemistry & Pharmacy

MERCK
Shell Chemicals
Grünenthal
Akzo Nobel
Celanese
Novartis
Wanhua Group
Cognis
Sanofi Pasteuer
DSM
Nycomed

Electronics	
Jabil Circuit	General Electrics Power Systems
AMD	ST Microelectronics
Cegelec	Cisco Systems
ABB	Thyssen Krupp
Heraeus	Sumida Electronic

Frankfurt (n=203)

Advanced producer service (n=143)

Banking & Finance

Deutsche Bank AG
HypoVereinsbank
DZ Bank
Landesbank Berlin
Landesbank Hessen-Thüringen
SEB
Deutsche Börse
Eurohypo AG
Commerzbank
Citibank
Westdeutsche Landesbank
Deutsche Postbank
KfW Bankengruppe
DekaBank
ING Group
Schwäbisch Hall

Logistics

Deutsche Post World Net
Dachser
Rhenus Logistics
Hellmann Logistics
DSV
M&M
HAPAG - LLOYD
Logwin AG
Schenker AG
Fiege
Kühne und Nagel
DEMATIC
Mosolf
Lehnkering
Panalpina

Design, Architecture & Engineering

Bilfinger Berger
FERCHAU Engineering
Altran
Tauw
Drees & Sommer
Arup
HOCHTIEF
Brunel
euro engineering
Luwa
Lahmeyer Holding
ALTEN Group

Advertising & Media

Verlagsgruppe Georg von Holtzbrinck
Springer Science+Business Media
Mindshare
Mediaedge
BBDO
M. Dumont Schauberg
Cornelsen Verlagsgruppe
Süddeutscher Verlag
McCann Erickson
Thomas Reuters
Young & Rubicam
DSV Gruppe
Frankfurter Allgemeine Zeitung Verlag
grey global group

Law

Rölfs Partner
Freshfields Bruckhaus Deringer
CMS
Clifford Chance
Linklaters
Lovells
Hengeler Mueller
Taylor Wessing
NÖRR
White & Case
LUTHER
Beiten Burkhardt
Gleiss Lutz
Rödl & Partner
Baker & McKenzie
Allen & Overy
Latham & Watkins
Buse Heberer Fromm
Shearman & Sterling
Mayer Brown
GSK Stockmann & Kollegen
SJ Berwin

Accounting

PriceWaterhouseCoopers AG
Ernst&Young
KPMG
BDO Deutsche Warentreuhand
ADS
Warth & Klein
Susat & Partner
MUNKERT & Partner
Mazars
LBH-Steuerberatungsgesellschaft
RoeverBrönnerSusat
Solidaris Revisions
Dr. Dornbach & Partner
FALK & Co
ALPHA Steuerberatungsgesellschaft
WIKOM AG
WTS AG

Information & Communication Technology

GAD
E-plus
IDS Scheer
Arcor
Finanz Informatik
Versatel
Vodafone
DB Systel
Atos Origin
Computacenter Deutschland
Bechtle
SAP
Lufthansa Systems

Management & IT Consulting

Logica
a&o systems
Research International
msg systems
Cancom
The Boston Consulting Group
GFT Technologies
SQS
Roland Berger
Oliver Wyman
Arthur D. Little
Accenture
Sybase
McKinsey
BearingPoint
Materna
itelligence AG
Capgemini
Cirquent
Deloitte
Mercer

Insurance

Allianz
Generali
AXA
SIGNAL IDUNA
DEVK
Zurich
Barmenia
INTER
R+V Versicherungen
HUK-COBURG
DKV
WWK Versicherungen
VHV
Alte Leipziger - Hallesche
Concordia
ROLAND

High-Tech firms Frankfurt (n=60)

Medical and optical instruments	
Carl Zeiss	Leica Microsystems
Flemming Dental	GEERS Hörakustik

Machinery	
YIT	Honeywell Life Safety
ZF Friedrichshafen	Voith AG
Salzgitter	Benteler
FESTO	DIEHL Group
GEA Group	

Computer-Hardware	
Siemens	IBM
HP	Wincor Nixdorf
Avaya	TA Triumph-Adler
Thales	EMC
AVM	eplan
Interflex Datensystemen	

Telecommunication	
Deutsche Funkturm	Nokia
Ericsson	Niscayah

Vehicle construction	
Bombardier Transportation	Robert Bosch
General Motors Corporation	Airbus
DB International	deugro
Johnson Controls	

Chemistry & Pharmacy

Symrise AG	Stahlgruber
SGL Carbon	Bayer
Continental	MERCK
Sanofi-Aventis Deutschland	Novartis
STADA Arzneimittel	ThyssenKrupp Xervon
Fluorchemie	Sandoz
Clariant	Celanese

Electronics

ABB	Hager Group
Thyssen Krupp	Moeller
Endress	Honeywell
Avaya	Marquardt
Cegelec	Cisco Systems
Huwai	

Munich (n=238)

Advanced producer service (n=151)

Banking & Finance

Deutsche Bank AG
Dresdner Bank
DZ Bank
Westdeutsche Landesbank
HSH Nordbank
Deutsche Postbank
Eurohypo AG
Commerzbank
HypoVereinsbank
Bayern Landesbank
Nord Landesbank
BHW Bausparkasse
Aareal Bank
VR Kreditwerk Hamburg

Logistics

Deutsche Post World Net
Dachser
Kühne und Nagel
D+S Europe AG
M&M
HAPAG - LLOYD
Röhlig
Willi Betz
Schenker AG
Rhenus Logistics
Hellmann Logistics
DSV
Emons
Panalpina
Logwin AG

Design, Architecture & Engineering

Bilfinger Berger
HOCHTIEF
Bertrandt AG
M+W Zander
Rücker
mb-technology
euro engineering
IABG
PCL Group
YACHT TECCON
EDAG
FERCHAU Engineering
IAV
Brunel
Semcon
Tintschl AG
Drees & Sommer
MVI Group

Advertising & Media

WAZ Mediengruppe
Verlagsgruppe Georg von Holtzbrinck
Pro Sieben Sat 1 Media AG
Sony BMG
G+J
Schlott Gruppe
RTL Group
Heinrich Bauer Verlag
Hubert Burda DLD
Mediaedge
Cornelsen Verlagsgruppe
Süddeutscher Verlag
DSV Gruppe
Vogel

Law

Rölfs Partner
CMS
Hoffmann-Eitle
Lovells
Taylor Wessing
White & Case
Beiten Burkhardt
Baker & McKenzie
Latham & Watkins
Maiwald Patentanwalts
Freshfields Bruckhaus Deringer
Clifford Chance
Linklaters
Hengeler Mueller
NÖRR STIEFENHOFER LUTZ
Luther
Rödl & Partner
Allen & Overy
GSK Stockmann & Kollegen

Accounting

PricewaterhouseCoopers AG
KPMG
ECOVIS
Susat & Partner
MAZARS
Solidaris Revisions-
Curacon
Ernst&Young
BDO Deutsche Warentreuhand AG
Ebner Stolz Mönning Bachem
MUNKERT & PARTNER
RöverBrönner
FALK & Co
WTS AG

Information & Communication Technology

Swisslog	Microsoft
DB Systel	E-plus
Atos Origin	Kabel Deutschland
IDS Scheer	Fiducia IT
telegate	Autodesk
United Internet AG	computacenter
Mentor	Arcor
Datev	Arvato Consulting
SAP	Lufthansa Systems
Vodafone	BTplc

Management & IT Consulting

Logica	Accenture
a&o systems	CSC
EXACT Software	McKinsey
msg systems	BearingPoint
CANCOM	Materna
The Boston Consulting Group	itelligence AG
Aareon	Capgemini
Cirquent	Real Tech
Roland Berger	Deloitte
Oliver Wyman	Mercer

Insurance

Allianz	R+V Versicherungen
Münchner Rück	Generali
HUK-COBURG	Victoria
NÜRNBERGER VERSICHERUNGSGRUPPE	DKV
SIGNAL IDUNA	WWK
DEVK	VHV
Die Continentale	Alte Leipziger - Hallesche
Barmenia	D.A.S

Insurance

Concordia

High-Tech firms (n=87)

Medical and optical instruments

Carl Zeiss	Drägerwerke
JENOPTIK	Karl Storz
Gambro	Richard Wolf
GEERS Hörakustik	DeguDent
Linos Photonics	Analytik Jena

Machinery

MAN	Voith AG
Heidelberg	Freudenberg Gruppe
KSB	SEW - Eurodrive
DIEHL	Jungheinrich
Tognum	Tognum
MTU Aero Engines	TRUMPF
Bauer	

Computer-Hardware

Siemens	IBM
HP	Wincor Nixdorf International
Boewe Systec AG	Avaya
Telindus	Kontron
AD Triumph-Adler	Thales
Oce	Süss
Pharmatechnik	Intel
AVM Deutschland	eplan
Interflex Datensysteme	primion Technology

Computer-Hardware

Ikon

Telecommunication

Dambach Werke
S.Siedle & Söhne
Nokia
Ericsson
Alcatel Lucent
Spinner
Niscayah
Deutsche Funkturm
Adva
Motorola
Harman Becker
Rhode & Schwarz
Nokia Systems Network

Vehicle construction

VOLKSWAGEN
Robert Bosch
General Motors Corporation
EADS
Webasto AG
Knorr-Bremse
Rheinmetall
BMW
Johnson Controls
Huf

Chemistry & Pharmacy

Süd-Chemie
Stahlgruber
Linde
MERCK
Sanofi-Aventis
HEXAL
Siltronic
Continental
Henkel
WACKER
Novartis
ALTANA

Electronics

Osram
Dräxlmaier
NXP
Cegelec

Electronics

Epcos	Qimonda
Thyssen Krupp	Infineon
AMD	KOSTAL

Düsseldorf (n=198)

Advanced producer service (n=127)

Banking & Finance

Commerzbank	HypoVereinsbank
Landesbank Berlin	BHW Bausparkasse
Citibank	Deutsche Postbank
Westdeutsche Landesbank	Deka Bank
Norddeutsche Landesbank	NG Group
Eurohypo AG	

Logistics

Deutsche Post World Net	Schenker AG
Dachser	Rhenus Logistics
Kühne und Nagel	Hellmann Logistics
DEMATIC	DSV
Fiege	HAPAG - LLOYD
Panalpina	Röhlig
Logwin AG	Chemion

Design, Architecture & Engineering

Bilfinger Berger	euro engineering
YACHT TECCON	Arup
HOCHTIEF	Drees & Sommer
FERCHAU Engineering	Chapman Taylor
Brunel	Alten Group

Advertising & Media

WAZ Mediengruppe	mindshare
Rheinisch-Bergische Verlagsgesellschaft	BBDO
Springer Science+Business Media	Cornelsen Verlagsgruppe
Mediaedge	McCann Erickson

Advertising & Media

Thomas Reuters
Süddeutscher Verlag
grey global group
Weltbild Verlagsgruppe
DSV Gruppe
Vogel

Law

Rölfs Partner
CMS
Linklaters
Hengeler Mueller
White & Case
Beiten Burkhardt
Baker & McKenzie
Buse Heberer Fromm
Shearman & Sterling
Maiwald Patentanwalts
Freshfields Bruckhaus Deringer
Clifford Chance
Lovells
Taylor Wessing
Luther
Heuking Kühn Lüer Wojtek
Allen & Overy
Bird & Bird
GSK Stockmann & Kollegen

Accounting

PriceWaterhouseCoopers AG
BDO Deutsche Warentreuhand AG
Ernst & Young
Ebner Stolz Mönning Bachem
MAZARS
Arthur D. Little
Lohr + Company
WTS AG
KPMG
ECOVIS
Treuhand Hannover
Warth & Klein
Verhülsdonk & Partner
Stuettgen & Haeb AG
Curacon

Information & Communication Technology

E-plus	IDS Scheer
Atos Origin	Software AG
United Internet AG	computacenter
Mentor	Arcor
Bechtle	Datev
Hansa Projekt	SAP
Versatel	Vodafone

Management & IT Consulting

Logica	GfK
Accenture	a&o systems
Sybase	Colliers International
McKinsey	BearingPoint
CANCOM	The Boston Consulting Group
GFT Technologies	Capgemini
Roland Berger	Deloitte
Oliver Wyman	Mercer
Booz & Company	

Insurance

R+V Versicherungen	HUK-COBURG
AXA	INTER
Victoria	SIGNAL IDUNA
DKV	ARAG AG
WWK Versicherungen	Die Continentale
Alte Leipziger – Hallesche	Barmenia
Nürnberger Versicherungsgruppe	

High-Tech firms (n=71)

Medical and optical instruments	
Hoya Lens	JENOPTIK
Medisana AG	Seiko Instruments
Medtronic	Boston Scientific
Johnson & Johnson	Flemming Dental
Richard Wolf	GEERS Hörakustik
DeguDent	Analytik Jena

Machinery	
Voith AG	Salzgitter
Benteler	Heidelberg
GEA Group	FESTO
SEW	SMS
DEMAG	

Computer-Hardware	
Siemens	IBM
HP	Wincor Nixdorf International
Avaya	Telindus
Novell	JCM Europe
Eplan	interflex
Ricoh	Ikon

Telecommunication	
Siemens	IBM
Nokia	Ericsson
Alcatel Lucent	Niscayah

Vehicle construction	
Daimler	Robert Bosch
TRW	Kolbenschmidt Pierburg
Rheinmetall	General Motors Corporation
Airbus	GRAMMER
Vossloh AG	Huf

Chemistry & Pharmacy	
Süd-Chemie	Bayer
Henkel	LANXESS
Rütgers	Gerresheimer
Boehler Welding Group	Huettenes Albertus Chemische Werke
ThyssenKrupp Xervon	Cognis

Electronics	
Thyssen Krupp	Vossloch Kiepe
ALPS Electric Europe	Moeller
Valtech	Elpida Memory Europe
APC by Schneider Electric	Huwai
Niscayah	Sick
Cisco Systems	Cegelec

7.2 Appendix B: Technical appendix

Websurvey

In welcher Branche ist Ihr Unternehmen hauptsächlich tätig?

Dienstleistungsbranche

- ○ Wirtschaftsprüfung
- ○ Versicherung
- ○ Werbung und Medien
- ○ Design, Architektur, Engineering
- ○ Rechtsberatung
- ○ Bank- und Finanzdienstleistung
- ○ Management- und IT-Consulting
- ○ Informations- und Kommunikationsdienstleistung
- ○ Logistik
- ○ Andere:

High-Tech-Branche

- ○ Chemie, Biotech, Pharma
- ○ Computer, Hardware
- ○ Elektronik und Elektrotechnik
- ○ Fahrzeugbau
- ○ Maschinenbau
- ○ Medizintechnik, Optik
- ○ Rundfunk- und Nachrichtentechnik
- ○ Andere:

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ZURÜCK WEITER

Um welche Art der Niederlassung handelt es sich bei Ihrem Unternehmen ?

- ○ Hauptsitz
- ○ Regionale Niederlassung mit weiteren Geschäftsstellen
- ○ Selbstständige Niederlassung ohne weitere Geschäftsstellen
- ○ Vertriebsstelle
- ○ Agentur
- ○ Andere:

Wo befindet sich der Standort des antwortenden Unternehmens?

Ort

Postleitzahl

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Seit wann befindet sich Ihr Unternehmen am Standort?

Jahreszahl: ____

○ Keine Angabe

Wie viele Beschäftigte hat Ihr Unternehmen hier am Standort?

○ Weniger als 10	○ 250 - 499	○ Keine Angabe
○ 10 - 49	○ 500 - 999	
○ 50 - 99	○ 1000 - 4999	
○ 100 - 249	○ 5000 und mehr	

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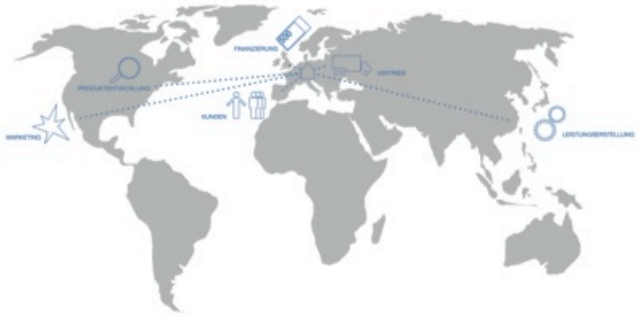
Die Wertschöpfungskette Ihres Unternehmens

Die Fragen auf den nächsten Seiten beziehen sich auf die Wertschöpfungskette Ihres Unternehmens auf regionaler, nationaler und internationaler Ebene. Die Wertschöpfungskette definiert sich durch folgende Elemente: **Produktentwicklung**, **Leistungserstellung**, **Finanzierung**, **Marketing**, **Vertrieb** und **Kunden**.



Bitte nennen Sie im Folgenden für jedes Element dieser Wertschöpfungskette die Standorte Ihrer **wichtigsten** Partner. Sie können max. drei Partner angeben. Wichtige Partner sind zum Beispiel Firmen, mit denen Ihr Unternehmen große Umsätze generiert, oder die sich in strategisch wichtigen Märkten befinden.

Bitte nennen Sie zudem, ob es sich dabei um einen firmen-internen oder firmen-externen Partner handelt. **Firmen-interne** Partner sind Unternehmen, die rechtlich zwar selbständig sein können, wirtschaftlich aber einer einheitlichen Leitung, z.B. einer Holdinggesellschaft, unterstellt sind. **Firmen-externe** Partner sind Unternehmen, die nicht zur Unternehmensgruppe oder Holdingsgesellschaft gehören.

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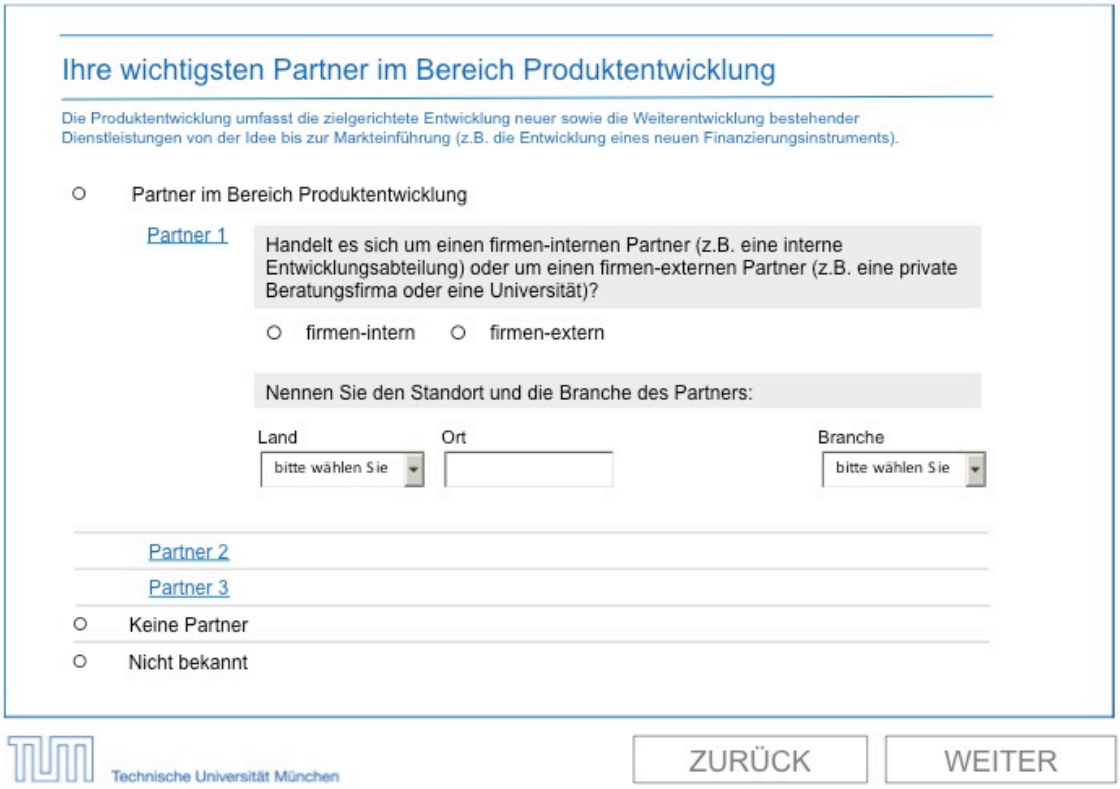
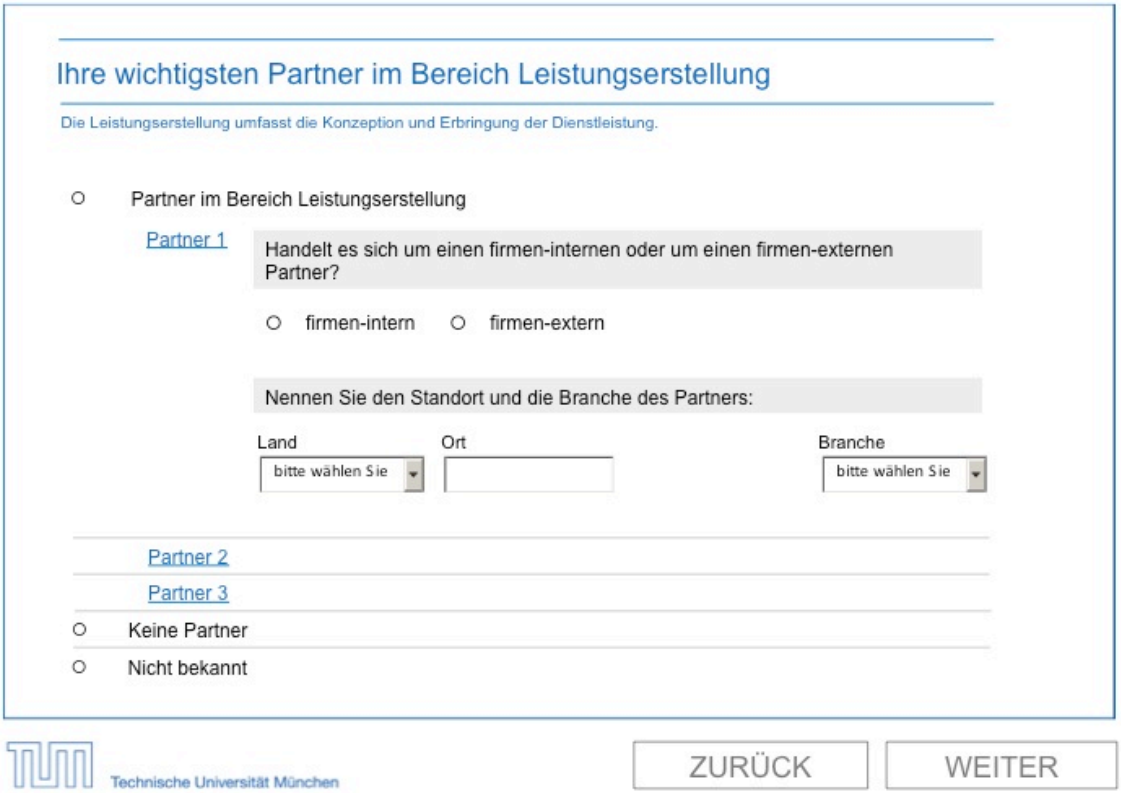
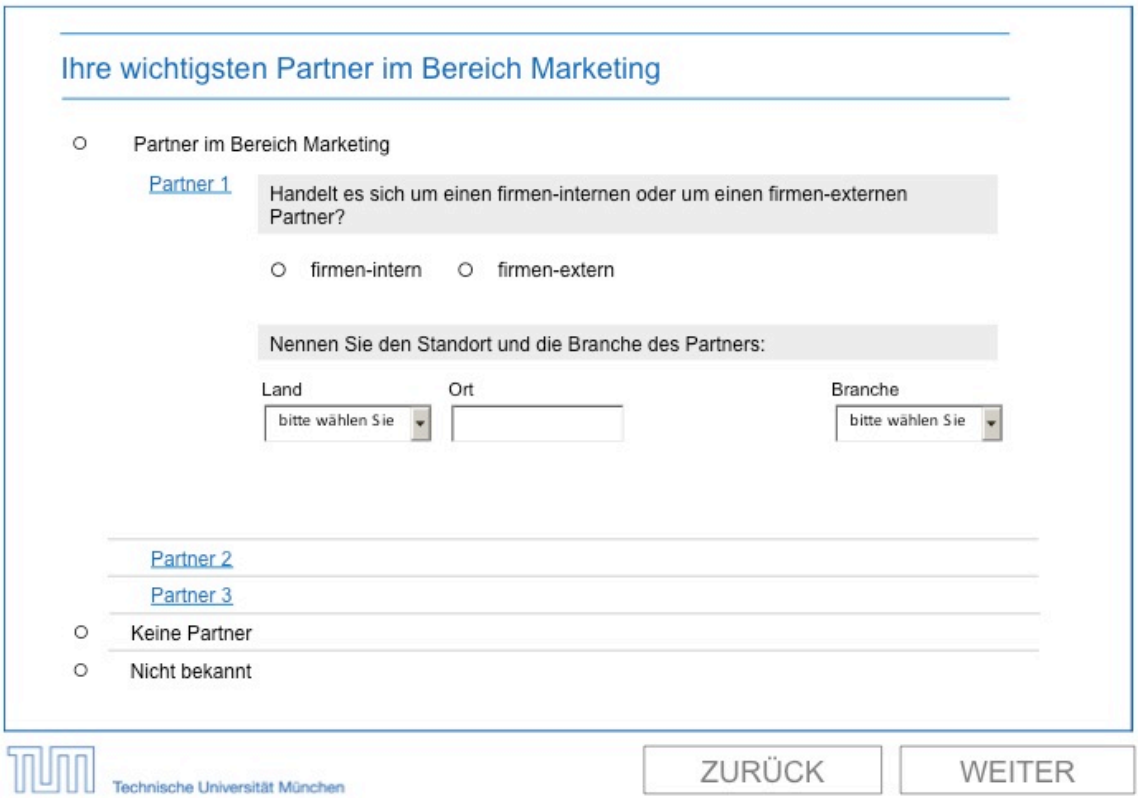
ZURÜCK WEITER


Ihre wichtigsten Partner im Bereich Produktentwicklung
Die Produktentwicklung umfasst die zielgerichtete Entwicklung neuer sowie die Weiterentwicklung bestehender Dienstleistungen von der Idee bis zur Markteinführung (z.B. die Entwicklung eines neuen Finanzierungsinstruments).
Partner im Bereich Produktentwicklung
Partner 1
Handelt es sich um einen firmen-internen Partner (z.B. eine interne Entwicklungsabteilung) oder um einen firmen-externen Partner (z.B. eine private Beratungsfirma oder eine Universität)?
firmen-intern
firmen-extern
Nennen Sie den Standort und die Branche des Partners:
Land
bitte wählen Sie
Ort
Branche
bitte wählen Sie
Partner 2
Partner 3
Keine Partner
Nicht bekannt
Technische Universität München
ZURÜCK
WEITER


Ihre wichtigsten Partner im Bereich Leistungserstellung
Die Leistungserstellung umfasst die Konzeption und Erbringung der Dienstleistung.
Partner im Bereich Leistungserstellung
Partner 1
Handelt es sich um einen firmen-internen oder um einen firmen-externen Partner?
firmen-intern
firmen-extern
Nennen Sie den Standort und die Branche des Partners:
Land
bitte wählen Sie
Ort
Branche
bitte wählen Sie
Partner 2
Partner 3
Keine Partner
Nicht bekannt
Technische Universität München
ZURÜCK
WEITER


Ihre wichtigsten Partner im Bereich Finanzierung
Die Finanzierung umfasst sowohl Fremdkapitalgeber (z.B. Betriebskredite, Darlehen) als auch Eigenkapitalgeber (z.B. Private Equity).
Partner im Bereich Finanzierung
Partner 1
Handelt es sich um einen firmen-internen Partner (z.B. ein interner Finanzdienstleister) oder um einen firmen-externen Partner (z.B. eine Bank oder ein Investor)?
firmen-intern
firmen-extern
Nennen Sie den Standort und die Branche des Partners:
Land
bitte wählen Sie
Ort
Branche
bitte wählen Sie
Partner 2
Partner 3
Keine Partner
Nicht bekannt
Technische Universität München
ZURÜCK
WEITER


Ihre wichtigsten Partner im Bereich Marketing
Partner im Bereich Marketing
Partner 1
Handelt es sich um einen firmen-internen oder um einen firmen-externen Partner?
firmen-intern
firmen-extern
Nennen Sie den Standort und die Branche des Partners:
Land
bitte wählen Sie
Ort
Branche
bitte wählen Sie
Partner 2
Partner 3
Keine Partner
Nicht bekannt
Technische Universität München
ZURÜCK
WEITER

Ihre wichtigsten Partner im Bereich Vertrieb

○ Partner im Bereich Vertrieb

Partner 1

Handelt es sich um einen firmen-internen oder um einen firmen-externen Partner?

○ firmen-intern ○ firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land: bitte wählen Sie | Ort: | Branche: bitte wählen Sie

Partner 2

Partner 3

○ Keine Partner

○ Nicht bekannt

Technische Universität München

ZURÜCK WEITER

Ihre wichtigsten Kunden

○ Kunden

Kunde 1

Handelt es sich um einen firmen-internen Kunden (z.B. ein interner Abnehmer) oder um einen firmen-externen Kunden?

○ firmen-intern ○ firmen-extern

Nennen Sie den Standort und die Branche des Partners:

Land: bitte wählen Sie | Ort: | Branche: bitte wählen Sie

Kunde 2

Kunde 3

○ Keine Kunden

○ Nicht bekannt

Technische Universität München

ZURÜCK WEITER

Möchten Sie per Email einen Ergebnisbericht als PDF-Datei erhalten? (Voraussichtlich verfügbar ab Mai 2013)

○ ja ○ nein

Darf ich Sie für ein Interview kontaktieren?

○ ja ○ nein

Kontaktdetails

Bitte geben Sie Kontaktperson, Telefon und E-Mail an. Die Angaben werden ausschließlich projektbezogen gespeichert und nicht weitergegeben bzw. veröffentlicht.

Kontaktperson:

Telefon:

E-Mail:

Technische Universität München

ZURÜCK ENDE

Vielen Dank für Ihre Teilnahme und die Unterstützung meines Promotionsvorhabens

Sie können das Fenster nun schließen.

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Semi-structured questionaire

Technische Universität München

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Interviewleitfaden

Airports as Cities of intersections: The redefined role of airport locations within knowledge economy context.

Gesprächsziele

Im Rahmen der Interviews soll eruiert werden

- welche Standortstrategien wissensintensive Unternehmen verfolgen und welche Rolle die Netzwerkinfrastruktur Flughafen im Rahmen der Standortentscheidung gespielt hat.
- welche regionalen, nationalen und internationalen Netzwerke die Unternehmen nutzen, um neue Produkte und Dienstleistungen zu entwickeln und welcher Bedarf nach Luftverkehrsleistungen sich hieraus ergibt.
- welche persönlichen Interaktionen und Kommunikationsgewohnheiten die Interviewpartner praktizieren.
- welche Bedeutung räumliche Nähe zu firmeninternen und firmenexternen Partner hat.
- welche Standort- und Immobilienqualitäten gefordert werden.

Konzeptioneller Hintergrund

Der im Vergleich noch junge Verkehrsknotenpunkt „Flughafen“ hat sich in den zurückliegenden Jahrzehnten sukzessive zu einem Ort wissensbasierter Aktivitäten verdichtet. Eine verstärkte Immobilienentwicklung direkt an und im unmittelbaren Umfeld von vor allem Hub-Flughäfen dokumentiert diesen Entwicklungsprozess.

Um die Entwicklung dieser neuen Raumsituation verstehen zu können, ist es notwendig, die Ursachen zu untersuchen. Ein wesentlicher Schlüssel zum Verständnis dieser raumstrukturellen Prozesse sind die veränderten Standortanforderungen wissensintensiver Unternehmen. Wissensbasierte Firmen wählen optimale marktorientierte Standorte in Abhängigkeit ihrer individuellen Wertschöpfungsketten sowie des Vernetzungsgrades der an der Herstellung der Dienstleistung, der Produktlösung und des Endprodukts involvierten Unternehmen. Was als Standortstrategie und Investitionsentscheidung eines einzelnen wissensorientierten Unternehmens erscheint, ist in der Summe Auslöser und Treiber einer neuen räumlichen Entwicklung im urban-regionalen Raumgefüge.

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Gesprächsrahmen

Für die einzelnen Interviews sind 30 bis max. 40 Minuten veranschlagt. Ihre Antworten werden streng vertraulich behandelt und für die Auswertung anonymisiert.

Fragebereiche

Konkret werden in den Gesprächen u.a. folgende Fragen thematisiert:

Standortstrategie und -dynamik

- Welche Stärken und Schwächen weist der Unternehmensstandort auf, an dem Sie tätig sind?
- Bestehen Absichten, sich am gegenwärtigen Unternehmensstandort zu vergrößern bzw. zu verkleinern?
- Wie verändert sich Ihre Branche als gesamtes? Wo befinden sich die Zukunftsmärkte Ihrer Branche?

Firmeninterne und -externe Netzwerke

- Von wem beziehen Sie Informationen bei der Entwicklung und Umsetzung neuer Produkte und Dienstleistungen?
- Welchen Beitrag leisten dabei die verschiedenen firmeninternen Niederlassungen, und welchen Beitrag leisten externe Partner?
- Welche anderen Branchen sind dabei besonders wichtig?

Kommunikation

- Wie und wie häufig kommunizieren Sie mit anderen Niederlassungen Ihrer Firma?
- Wie kommunizieren Sie mit Personen, die weit entfernt sind?
- Wie wichtig sind räumliche Nähe und face-to-face Kontakte bei der Entwicklung neuer Produkte und Dienstleistungen?

Kontaktdaten

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