

## Understanding the Conditions for the Emergence of Airport Knowledge Precincts: A Framework for Research

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### 1 ABSTRACT

Knowledge precincts are becoming an increasingly important part of the development of airport regions as they play a significant role in knowledge production, which strengthens the knowledge-based development of city-regions. The purpose of this paper is to engage critically with understanding of airport knowledge precincts (AKPs), and to suggest the need for both empirical and theoretical expansions. The paper investigates the role of knowledge precincts at international airports, and contributes to the conceptualisation of AKPs. The methodology of this paper includes review of the literature, analysis of the global good practices, and development of a research framework to understand the emergence of AKPs. The findings of the paper provide insights and build a substantial base for further research and a theoretical understanding of the integration of knowledge precincts and the development of airports.

### 2 INTRODUCTION

Knowledge precincts, such as Silicon Valley, DNA Valley, One-North, can be regarded as the spatial core of knowledge-based urban development (KBUD) that chiefly refers to clustering of R&D activities, high-tech manufacturing of knowledge-intensive industrial and business sectors linked by mixed-use environment and transport hubs within an urban-like setting (Yigitcanlar & Martinez-Fernandez, 2007). These precincts play a significant role in knowledge production, which strengthens the knowledge-based development of cities. International airports provide an ideal location for knowledge precincts because of their national and international connections, strong infrastructure support, and importance as a mobility node and a logistics hub (Button et al., 1999). There has been a major policy focus for the knowledge-based development of cities through investment on knowledge production, by development of knowledge precincts, building human capital, and providing quality of life and place for knowledge workers (Baum et al., 2007). However, very little research deals with the planning and development of knowledge precincts at airports. This paper investigates the role of knowledge precincts at international airports, and aims to contribute to the conceptualisation of airport knowledge precincts (AKPs) by underlining conditions for the emergence of this type of production spaces. The paper also examines how AKPs are becoming magnets of attracting and retaining international investment and talent. The study develops a framework for research that is particularly invaluable for further analysis on the theoretical understanding of the integration of knowledge precincts and the development of airports.

### 3 KNOWLEDGE ECONOMY, INDUSTRY CLUSTERING, AND KNOWLEDGE PRECINCTS

The new economy in the knowledge era has pushed cities and their economies to become more competitive (Castells, 2000; Clarke, 2001). This strong pressure has led urban economies and development to be formed in a way different than they used to be. Now a more knowledge, innovation and creativity oriented development approach, so called KBUD, is shaping city-regions that are claimed to be creative, where knowledge production, competitiveness and triple bottom line sustainability are the buzz themes for these city-regions (Yigitcanlar et al., 2008a; 2008b).

#### 3.1 Knowledge-based urban development: a novel development approach in the knowledge economy

In the course of history knowledge production has always been a vital source for creating and sustaining a strong economy, society and culture. However, the stock of knowledge on which economic activity is based today is definitely much larger than previous eras. Neo-classical economic thought recognised only three

factors of production: 'land, labour and capital', and only considered 'knowledge, creativity, education, and intellectual capacity' as secondary parameters of production (Li et al., 1998). During the last quarter of the 20th century, however, it has become apparent that knowledge in and of itself is sufficiently important for production, and the new growth theory and economic geography recognised 'knowledge' as a primary factor of production (Romer, 1990). Consequently, during the last two decades a global, knowledge-based, and technology-driven economy has emerged, so-called 'knowledge economy' (Castells, 2000; Howells 2002, Baum et al., 2007). In this new economy, knowledge related activities, including creativity as a tacit knowledge form, have become central for creating employment and wealth, and sustaining economic growth (Ofori, 2003; Howells, 2002). The main novelty of knowledge economy consisted of the need to manage those intangible assets that does not depreciate through use but rather becomes more valuable the more it is used (Laszlo & Laszlo, 2006). The sustenance of the economic activities, in the knowledge economy, requires a constant renewal of human resources and organisational capacities and creating conducive environments for creativity, innovation, learning, and change to thrive (Knight, 1995). Sustainability in the knowledge era is highly associated with knowledge economies (Castells, 2000).

Knowledge economy creates, distributes, and uses knowledge to generate value and gives rise to "a network society, where the opportunity and capability to access and join knowledge and learning intensive relations determines the socio-economic position of individuals and firms" (Clarke, 2001:189). The development of knowledge economy, globalisation, and international competitive pressure has increased the importance of creativity and innovation in local economies, as well as national economies (Porter 1990; Feldman 1994; Camagni, 1995; Malmberg 1997; Storper, 1995; Ritsila, 1999). There has also been increasing recognition that creativity as one of the major forces behind knowledge production (Corey & Wilson, 2006; Landry, 2000; Florida, 2005; Henderson, 2005). This implies the view of environmental and cultural assets of the cities and communities as economic resources. It also emphasises knowledge work and workers as vital parts of a new emergent mode of production in the knowledge economy (Yigitcanlar et al., 2007). The knowledge economy of a city creates high value-added products using research, technology, and brainpower. In such cities, the private and the public sectors value knowledge, spend money on supporting its discovery and dissemination and, ultimately, harness it to create goods and services (Carrillo, 2006).

Urban and regional planning's lack of success in responding to the challenges and opportunities of the global knowledge economy, have led policy-makers and urban scholars consolidate their interest in the paradigm of post-modern social production under the rubric of KBUD (Carrillo, 2004; Yigitcanlar et al., 2008a). KBUD is a novel development approach in the knowledge economy that could bring both economic prosperity and sustainable socio-spatial order to a contemporary city. The goal of KBUD is a knowledge-based city purposefully designed to encourage the production and circulation of abstract work (Cheng et al., 2004), and regarded as a powerful strategy to nourish the renewal of cities and their economies to participate in the knowledge economy for economic growth and post-industrial development (Yigitcanlar et al., 2008c). It is not about the strict government control on the development, rather it is the initiation and provision of the knowledge incubation environment (e.g. incentives, knowledge and urban infrastructures, quality of life) jointly by public-private-academia for entrepreneurs (e.g. knowledge-enterprises, knowledge workers, artists). It is a strategic management approach, applicable to purposeful urban human organisations in general (Carillo, 2002). Literature indicates that KBUD has three purposes: The first one is, it is an economic development strategy that codifies technical knowledge for the innovation of products and services, market knowledge for understanding changes in consumer choices and tastes, financial knowledge to measure the inputs and outputs of production and development processes, and human knowledge in the form of skills and creativity, within an economic model (Lever, 2002). The second one is that, it indicates the intention to increase the skills and knowledge of residents as a means for human and social development (Gonzalez et. al., 2005). The later one is that to build a strong spatial relationship between urban development clusters. Broad KBUD policies include: developing capital systems (i.e. human, social, intellectual), distributing instrumental capital, developing and adopting the state of art technologies, providing hard and soft infrastructures, and providing quality life and place (Carrillo, 2002; Yigitcanlar et al., 2008a).

### 3.2 Knowledge-intensive industry clustering and the formation of knowledge precincts

Promoting conditions for the generation of knowledge is a significant part of a strategic KBUD vision of the rising cities in the knowledge economy. KBUD sees urban geography and knowledge-intensive industry

clustering among the active ingredients of economic development and growth. Concentration of knowledge-intensive industrial activity in a geographic location affects firm performance as the local competition and knowledge production within the cluster requires firms to innovate in order to remain competitive (Porter, 1998). Clusters provide 'thinking business spaces' in which to develop potential solutions to skill shortage, lack of attraction of new talent, and the challenge of up-skilling and re-skilling the workforce. A cluster location may better facilitate the transfer of tacit knowledge, which is not yet codified and best conveyed through face to face interactions. Particularly, this is highly relevant for knowledge-intensive industries, as these companies benefit from a clustered location through meeting colleagues repeatedly and in person allowing for the exchange of tacit knowledge (Howells, 2002). A cluster can help to decrease three sources of barriers to knowledge generation, which are industrial, institutional and communication barriers (Krafft, 2004). During the last three decades knowledge-intensive industries have become of increasing importance as source of job growth and revenue to communities seeking to develop their economies. The success of clustered knowledge-intensive industries in promoting knowledge production and transfer and attracting highly innovative firms and talented workers has motivated cities around the world to promote KBUD (Tan, 2006). Government support in KBUD for knowledge cluster formation has increased in the last years, because of the increasing policy attention for local urban and economic development in the knowledge era (Martinez-Fernandez et al., 2007). McCann and Arita (2006) categorised knowledge-intensive industrial cluster types as: (1) pure agglomeration, (2) industrial complex, and (3) social network, which is spatial industrial cluster of spatial network model. Combination of these three types of knowledge-intensive industry clusters, in many cases, formed a new land use type of so called 'knowledge precinct'.

Knowledge precincts are regarded as the spatial core of KBUD, and depending of their focus these precincts are named differently, such as science/technology/high-tech park, knowledge/innovation hub, urban/digital village, mainly indicating a clustering of R&D activities, high-tech manufacturing of knowledge-intensive industrial and business sectors with a commercial mix of urban life and culture, predominantly within central urban locations (Yigitcanlar & Martinez-Fernandez, 2007). According to Tan (2006:828) a knowledge precinct is a property-based activity configured around: (1) formal operational links with a university or other higher educational or research institution, (2) the formation and growth of knowledge-based business and other organisations on site, (3) a management function that is actively engaged in the transfer of technology and business skills to the organisations on site, (4) living and recreation facilities for its knowledge workers and their families, and (5) a territorial system of small and medium size enterprises (SMEs) clustered together, with spatially concentrated networks, often using flexible production technology and characterised by extensive local inter-firm linkages, and in a sense, can be seen as a collective entrepreneur. These precincts facilitate knowledge transfer and become centres of gravity for attracting innovation. Smaller firms are considered more dynamic innovators compare to larger ones (Acs, 2002), which may explain the increasing presence of SMEs in knowledge precincts. Presence of SMEs in knowledge precincts allows these firms to exhibit flexible inter-firm relations, thereby allowing these firms to both compete and cooperate with each other according to the changes in their competitive environments (Saxenian, 1994). Knowledge precincts can be categorised in terms of their orientations as: (1) innovation or incubation-oriented, (2) R&D-oriented, (3) production-oriented, and (4) combination of two or more of these orientations (Hu et al., 2005). Nevertheless, the new generation knowledge precincts are formed with a strong sense of community by providing a mixed-use environment including housing, business, education and leisure within an urban-like setting (i.e. One-North Singapore, 22@bcn Barcelona, Helsinki Digital Village), where urban planning is used as an instrument for establishing an integrated live, work and play environment.

### **3.3 Connectivity of knowledge precincts and knowledge-intensive service activities**

Knowledge precincts constitute a special type of production space; a cluster of high knowledge-intensive occupations and operations that can be quite precise technologically and very dynamic in management and non-technological aspects. All this constitute an incubator of innovation where knowledge-intensive service activities (KISA) flourish. KISA are defined as the activities originated by the production and integration of knowledge-intensive services crucial for the innovation process of the firm. They may be undertaken by firms in manufacturing or service sectors, and in combination with manufactured outputs or as stand-alone services (OECD, 2006). Typical examples of KISA include R&D services, management consulting, IT services, human resource management services, legal services (such as those on IP-related issues),

accounting, financing, and marketing services. These activities, oriented towards the use and integration of knowledge are instrumental for building and maintaining a firm's innovation capability. In practice, KISA in a firm are achieved by the use of in-house, or the combination of in-house and external, expertise. The capacity of the firm to perform these KISA more effectively may indeed be what differentiates a firm from its competitors. However, the interaction of these different KISA remains an ad hoc and largely informal process that firms are not totally aware of. We know very little about the behaviour of firms in knowledge precincts; how they access and use the variety of innovation-related KISA available to them, in different industries and at different times of the life-cycle of the firm and of the product/service? Answering these questions can help to understand the dynamics of knowledge precincts and what strategies and programs can actively stimulate innovation in the precinct. KISA exemplifies the complex ways in which firms seek and acquire external services, and integrate them with other capabilities (including internal service provision) at the firm level.

The relevance of these activities in knowledge precincts is critical due to their influence in the co-production of knowledge in firms. Recent research on innovation focuses attention on understanding particular patterns of innovative activity (Fagerberg et al., 2004) seen in an economy as a function of the characteristics of the major players (institutions and private organisations), and the ways in which they link public and private sectors together (Hales, 2000; 2001; Martinez-Fernandez, 2004). The players may link in different ways at different spatial levels (national, regional or local), through activities such as R&D provided through public and/or private enterprises, or through the development and use of management and other business-related skills and expertise. Again, they may be linked through their entrepreneurial activities as suppliers and customers. This extension of our view of the learning space of the firm from the organisational unit to the wider community has been recently addressed by Amin and Cohendet (2004); this new view is encapsulated by Hales (2004) when he says the community should be given central status as the all-important site of knowledge formation. The focus on this wider space in which the firm operates has brought more understanding of the elements involved in the co-production of knowledge by different actors. The main formal external intermediaries of knowledge linked to firm innovation and capability building that act as functions in the co-production of knowledge in the firm are knowledge-intensive business services (KIBS), and public and hybrid research and technology organisations (RTOs). In recent work, KIBS are the most intensively studied of the intermediaries of knowledge. Den Hertog (2000:505) expands upon Miles et al.'s (1995) work and defines KIBS as "private companies or organisations who rely heavily on professional knowledge, i.e., knowledge or expertise related to a specific (technical) discipline or (technical) functional domain to supply intermediate products and services that are knowledge-based". Although this knowledge covers a wide range of activities, they have in common a high level of knowledge-intensity and interactivity in service provision, as well as a consulting or problem-solving function (Den Hertog, 2000). Therefore, KIBS provide a platform to study a group of services which are very actively integrated into innovation by jointly developing knowledge with their clients. KIBS also play multiple roles in innovation system. They serve as innovators, facilitators of innovation, carriers of innovation, or sources of innovation (Den Hertog, 2000; Muller & Zenker, 2001; Wong & He, 2002).

In addition to KIBS, other types of organisations involved in the co-production of knowledge are RTOs. RTOs are publicly funded organisations that play a bridging role in innovation systems. The term RTO is often applied differently across countries, which reflects the different institutional structures and policy frameworks. Hales (2001) defines RTOs as organisations with significant core government funding (25% or greater) which supply services to firms individually or collectively in support of scientific and technological innovation and which devote much of their capability (50% or more of their labour) to remain integrated with the science base. More informal providers of knowledge-intensive services are actors from the network space of the firm: competitors, customers and other organisations from their own industry sector or from other sectors that share problems with them, contacts made through professional and standards-setting associations. Provision of inputs to KISA can also come from more organised network sources through business networks and industry clusters or industry associations. The activities the firm carries out in terms of the integration of these services are considered important to building and maintaining their innovation capability.

Knowledge precincts in airports are geographically and functionally privileged to provide the 'medium' for KISA to be carried out within firms and between firms and organisations in the precinct and also to develop

strong linkages with other organisations outside the precinct but that might have a cognitive proximity to certain firms and activities (e.g. an university lab specialised in aviation maintenance). The dynamism of the precinct could indeed be measured by the frequency and quality of these activities and the professionals performing them. These activities also constitute an indication of the extent of a functional economy existing in airports not just as institutional linkages or organisational alliances. These 'activities' can be identified as the best indicator of knowledge interchange, transfer and adaptation across the precinct, and improve the connectivity between knowledge precincts.

#### **4 AIRPORT REGIONS: MAGNETS FOR KNOWLEDGE-INTENSIVE INDUSTRIES**

In many countries there has been a major policy focus for the KBUD of cities through investing in knowledge production; developing knowledge precincts; building human capital; and providing quality of life and place for knowledge workers (Yigitcanlar et al., 2007; Yigitcanlar & Martinez-Fernandez, 2007). 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. Particularly, international hub airports provide an ideal location for knowledge precincts because of their national and international connections, strong infrastructure support, and importance as logistics hubs (Button et al., 1999). However, very little is known on the conditions for the emergence of AKPs.

##### **4.1 Airport metropolis: airport-driven development of city-regions**

Although the list of airport-related effects beyond airport boundaries has grown through time, treatments of particular impacts have remained highly specialised and contained within disciplinary paradigms. Airports are increasingly recognised as general urban activity centres; that is, key assets for cities and regions as economic generators and catalysts of investment, in addition to being critical components of efficient city infrastructure. The entrepreneurial idea of the modern airport goes beyond the movement of aircraft towards providing a variety of commercial and industrial opportunities. Three generic models of airports as activity centres have been conceptualised. The 'aviapolis' is the marketing and development of aviation orientated and airport-centred business hubs (Finavia, 2004). The 'airfront' is the collection of aviation related industries and services attracted to, and located within, an airport hinterland (Blanton, 2004). The identification of the airport as a focus for logistics, and as a function of transport-based urban development, has been recognised as an 'aerotropolis' (Kasarda, 1991a). The 'aviapolis' is the development of strategic opportunity to revitalise a city region and adjacent airport. It is intended to function as a mixed use commercial, industrial and residential centre capitalising on the advantages that an international airport may bring. Through cooperative agreement the Finnish government and industry stakeholders were able to establish cooperative administrative arrangements: a district wide comprehensive plan; an economic development and marketing strategy; and a governance framework built around this shared goal (Finavia, 2004). The development of the 'aviapolis' is the strategic re-organisation of an existing urban area into an aviation orientated business hub, utilising the anchors which exist within the region and maximising their potential. A perceived limitation may be the continued requirements of investment and international marketing, yet the 'aviapolis' still provides a model of the integrated planning and development of an airport and its hinterland, functioning as an international activity centre. Blanton (2004) conceptualises the 'myriad of commercial, industrial, and transportation facilities and services intrinsically tied to the airport' as the 'airfront'. Highlighting regional economic integration, the aim is to understand 'how planners can shape emerging airfront districts to achieve regional and local objectives' through a scenario planning approach. The airfront is not part of the airport, but of the region and recognised as a location of potential and unrealised opportunity. It supports the airport with an array of services based on industrial clustering. The better coordinated planning and development of this airfront provides for economic strengthening and revitalisation of the region for mutual benefit. However, little attention has been given to commercial districts surrounding airports, and few planning authorities understand how to plan development to best leverage this economic resource, let alone how it may best fit into broader transportation and regional land use planning (Blanton, 2004). Kasarda champions the development of the 'aerotropolis', a logistics based model of 'airport city' development (Kasarda, 1991a; 1996; 2000; 2001; Kasarda & Green, 2005). The aerotropolis is an urban form, centred on multimodal logistics, with an aviation focus, where low weight and

high value goods can be moved quickly and efficiently. Companies are able to maintain zero inventories: take customer orders, fly in raw materials, assemble them and fly them out again, at the one airport location (Kasarda, 1991b). This 'industrial/aviation complex' is intended as an actual metropolis (airport metropolis), where the airport and surrounding hotels, retail, distribution centres, light industrial parks, and even some residential zones all serve as a central business district. It is imagined as a 'centre' with excellent highway transport links, 'aerolanes', to the regional hinterland to ensure the unimpeded flow of goods, services and people (Kasarda, 2001). The 'aerotropolis', as a freight and logistics model, is based on the notion of 'survival of the fastest' (Kasarda, 2000). It may well be considered this paradigm presents limitations for tangible implementation where the notions of sustainability and equity in local access are significant.

All three descriptive models portray the modern airport as a dynamic new economic engine requiring the need for new and appropriate planning responses to better seize this potential. However, they are mostly descriptive economic conceptualisations and lack explicit acknowledgement of the wider urban system, and particularly, knowledge precincts. Several airports have recognised the linkage between KBUD and the airport and have facilitated knowledge precinct development either in, or near the airport. For example, Brisbane airport is developing the Da Vinci knowledge precinct within its boundaries as an education and high-tech research park. However, the opportunities for development within airport boundaries are limited world-wide, as most of the larger airports are presently meeting capacity within their boundaries for development projects. So, within this context, the more significant issue becomes how to set up linkages to other knowledge nodes within the urban core – thus, the types of development within the airport boundaries, the types of linkages, and the types of nodes within the urban fabric need to be understood and facilitated.

Airport-driven development and knowledge precincts can be understood in a geographical framework that radiates from the airport property. Airport lands are being developed, and in many cases redeveloped, around themes – which is clear in Kasarda's concept of the aerotropolis. With respect to knowledge precincts, the first construct of a framework requires an evaluation of what has been developed on airport lands as KBUD, and how is this unique to airports? Secondly, development near and around airports needs to be identified and classified. How knowledge precincts have clustered around airports? And thirdly, how are clusters and nodes, away from the airport, linked to the airport? In this case 'connectivity' is the primary consideration. A combination of the three geographic classifications provides a framework to evaluate the relationship of the airport metropolis to knowledge precincts.

## **4.2 Airport metropolis as a magnet for knowledge precincts: insights from global practices**

A high-performance airport is an essential factor in competitiveness, and a tool at the service of local and regional economic development. Having an international hub airport has become one of the key global command functions in the hierarchy of knowledge-based cities of the world (Smith & Timberlake, 2001). As Dvir and Pasher (2004) suggest the airport symbolises the opportunity for free flows of knowledge, ideas, different perspectives, expertise and innovation from and into the city. It is a central element of the innovation infrastructure of any modern city. In this regard, airport is a landmark and magnet in the new urban landscape of global knowledge-based cities. A hub airport is an increasingly important place to live, work and play, in other words, city within a city that boosts a city-region's economic competitiveness and global position. Many major international hub airports have diversified their property portfolio to attract knowledge-intensive industries to cluster around, and their land to support variety of KISA – i.e. Singapore's free-trade zones, Seoul Incheon's knowledge precincts. The diversification of the airport's activities reflect airports' evolution into central business districts (CBDs), particularly, Frankfurt's hospital, Denver's art gallery and McCarran's museum are among the examples of the transformation of an airport into a polycentric CBD (Kasarda, 2006). The trend of deconcentration that is long observed in the US is now appearing in Europe in developments around London Heathrow, Paris Charles de Gaulle, and Amsterdam Schiphol. Global knowledge economy puts large airport regions at the heart of clustering of business, R&D and knowledge spill-over (i.e. Denver International, Hong Kong International, Seoul Incheon, Paris Charles de Gaulle, Memphis International) (Kasarda, 2000). In the knowledge era, airports are in fierce competition with each other to attract knowledge-intensive industries, and to constitute key global conditions in the development of AKPs. These conditions include airport alliances and hub and spoke networks of airports, deregulation levels, global image, reputation, international immigration and science policies, and investment on AKP development.

An AKP is home to different industrial and business sectors which exploits airport's global connectivity and specialised services, world class hard and soft infrastructure – i.e. business and logistic parks. As a social 'milieu', an AKP can be regarded as synergetic and creative networks between stakeholders (i.e. industrial, business, and real estate initiatives) within an airport-linked geographical area (Camagni, 1995). An airport metropolis is a good example of innovation engine that provides the element of both 'accessibility and connectivity' which are among the key foundation stones of knowledge-based city formation (Dvir & Pasher, 2004). Airport metropolis is the latest obsession of global knowledge-based cities that is a home for knowledge workers, knowledge precincts and KISA. In this perspective, among a number of airport metropolises two international cases have significant KBUD:

Amsterdam Schiphol International Airport is the fourth busiest European passenger and cargo airport. Schiphol is the Netherlands' main airport and located 20 minutes (17.5 km) south-west of Amsterdam part of the Randstad city-region. Schiphol's development is a result of national development policy of the Netherlands based on a polycentric urban development strategy (Figure 1). As an integral part of the Dutch 'mainport policy' a large variety of industrial and commercial services are located in and around the airport, mainly because of its strategic position. The airport city, which has been created by the airport corporation, Schiphol Group, has become a magnet for knowledge-intensive industries and commercial services. This turned the airport into a one of the major activity centres of Amsterdam. The aviation operating income of the Schiphol Group is only less than a quarter of its all operating incomes. The remaining, over \$400M annually, came from consumers, real estate, industry, and alliances. 'Brainport' is another national level spatial policy that aims to connect knowledge networks with other global networks like aviation (Priemus, 2001). The Brainport, a giant knowledge community precinct, in Eindhoven/South Brabant is constituted from the region of 21 municipalities, with around 725,000 residents and 355,000 workplaces. A large number of high-tech and technology companies, educational institutions and knowledge-intensive organisations are clustered together. In this regard, Eindhoven International Airport, partially owned by Schiphol Group, is contributing to the Brainport process by bringing the exchange of know-how and wider mobility for travelling for business and investment.

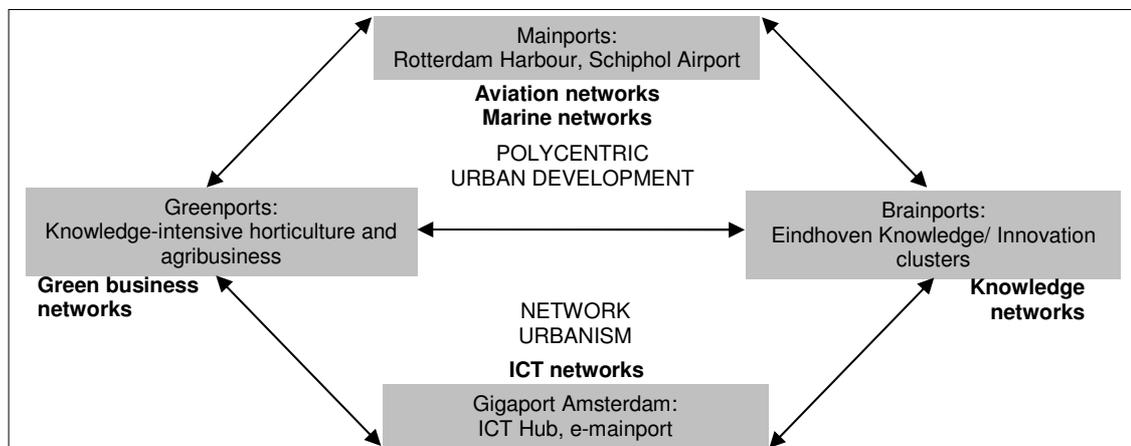


Fig. 1: Position of Schiphol Airport within Dutch national spatial policy

Seoul Incheon International Airport is the world's fourth busiest airport by cargo traffic and tenth busiest airport by international passenger traffic. Incheon like other Asian competitors (i.e. Hong Kong International Airport and SkyCity, Beijing Capital International Airport and Capital Airport City, Kuala Lumpur International Airport and Putrajaya and Cyberjaya in Malaysia's Multimedia Super Corridor) Incheon has an ambitious KBUD strategy. This airport-linked real estate and state-powered mega project undertakes airport-driven urban development at the metropolitan level. Incheon International Airport is one of the mobility nodes of South Korea's 'Pentaport' concept (a combined airport, seaport, business port, teleport and leisure port) that designed to be a hub airport of Asia by locating Media Valley, Korea's version of Silicon Valley, as the centrepiece of development with a large knowledge precinct and a university research centre (Browning, 2006) (Figure 2).

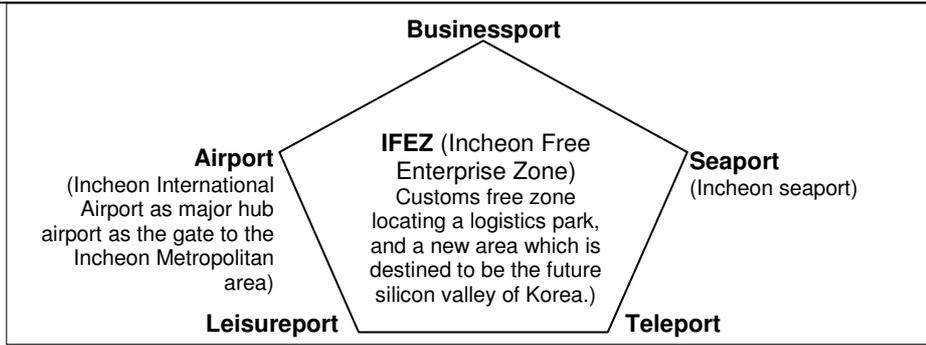


Fig. 2: Seoul Incheon Airport as the mobility node of Pentaport concept

Recent global practices address remarkable progress towards KBUD of international hub airports. In European cases (i.e. Schiphol) provide evidence that aviation networks as integrators of passenger, freight and information networks clearly linked with other continental and regional sub-networks (Priemus, 2001). A characteristically continental network is that of high-speed trains currently in development. Stations in this network are located in big cities, large employment centres, and airports. Polycentric urban development, convergence of networks (based on strong links and nodes), national and state powered economic and spatial policies (i.e. Asian cases), and large-scale real estate investments (i.e. Dubai World Central International) has leitmotifs of current airport-linked global KBUD practices.

### 5 CONCLUSION: A FRAMEWORK FOR RESEARCH

This paper raises a number of questions related to the development of AKPs. To investigate these questions and the conditions for the emergence of AKPs, this study develops a research framework based on an effective policy analysis model. As a policy analysis model ‘Pentagon Analysis’ offers an in-depth scrutiny on the drivers of a successful policy and has been implemented in examining success factors of airports (see Nijkamp & Yim, 2001). Nevertheless, because of the multi-dimensional nature of the subject under study this research develops a ‘Multi-level Pentagon Prism Analysis’ model to investigate the AKP phenomenon. The analysis considers five distinct, broad factors (tangible, intangible, organisational, financial, and ecological structures) in four geographical levels: macro (global and national), regional (aerotropolis), local (airport city), and micro (knowledge precinct) levels for a multi-dimensional perspective scrutiny of AKP (Figure 3).

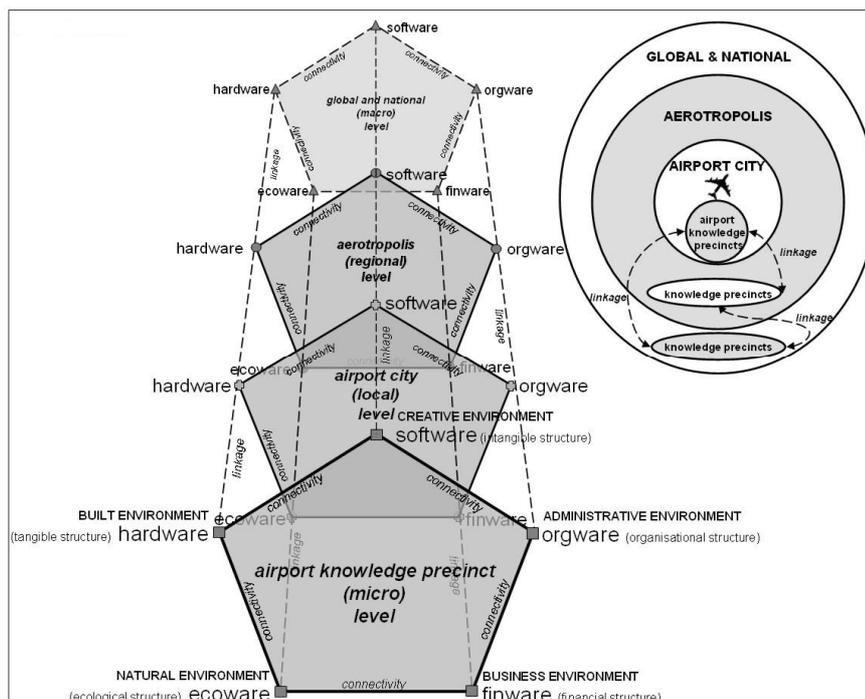


Fig. 3: Multi level pentagon prism analysis for investigating AKP phenomenon

The starting point for widening the prism to five spatial levels is recognition that knowledge generation and exchange can occur within or across all these levels. Thus the central research question of the extent to which geographical concentrations of knowledge sector industries in cities result from Marshallian industrial district-type input-output linkages that minimise transaction costs (including those of tacit knowledge) on the one hand, and from general urban agglomeration economies on the other, is separated into two or three distinct spaces that frame knowledge-based activity: the precinct, local and regional (metropolitan) levels. In turn, the distinction between the precinct and the local spaces enables the importance of walkable facilities and contacts at the precinct level to be distinguished from other less proximate, but still local, advantages for clustered knowledge development. In particular, the precinct level can incorporate understanding of the dynamics of knowledge-based activity situated within or immediately adjacent to the airport itself. Beyond these levels, the multiple prism framework recognises the way in which knowledge flows across space in the contemporary global economy. Knowledge generated by industry leaders or knowledge precincts in one country, for example, can be transmitted across national boundaries and combined with local tacit knowledge in another precinct. While such transmission typically involves electronic transmission, airport precincts can be critical for the transmission of knowledge embodying a significant tacit element, for which face-to-face meetings are preferable.

The multiple prism framework can therefore enable the role of airports in the generation of knowledge over space and time to be more subtly conceptualised. The framework is particularly rich in being able to account for the complexity of global chains of knowledge and their operation. Thus tacit knowledge generated in a global centre might need to be explained face-to-face to a potential customer, alliance partner or branch operation in another country. Or even where codified knowledge is involved, an initial face-to-face meeting might be needed to establish a sufficient level of trust if the value of the knowledge is high and restricted. These situations might involve meeting at an airport hotel or airline lounge in the second country – a combination of the precinct level (airport hotel) and the regional level (metropolitan area size and structure determining airport attractiveness and hence likelihood of use in exchanging knowledge). The tacit knowledge may or may not then be used in an establishment in the airport locality: the distance of the establishment from the airport might depend to a significant extent on the frequency of such airport meetings. The prism framework recognises the different time-space nodes of such knowledge chains.

This highlights the research utility of the five dimensions of each prism. The various factors need to be identified at each spatial level as their nature changes according to spatial scale, involving different layers of determinants. The hardware/tangible dimension, for example, will be realised in a variety of forms dependent on spatial level, ranging from suitable buildings and meeting spaces at the precinct level; through to connecting highways at the local level; airport capacity and customer base at the regional level; and telecommunication networks at higher levels. Intangible factors will vary from residential attractiveness and the right image at more local levels to education levels at higher levels, for example. Similarly, financial factors will include some such as public location incentives that will vary according to level, and others such as venture capital availability that operate mainly at higher levels. Scalar variations in organisational factors recognise basic characteristics of global economy operation such as global chains of production, the structure of multinational enterprises, and the spatial organisation of global or national alliances. Ecological (natural) structures will be most apparent at the local level, such as in constraints on physical expansion of precincts because of sea or mountain barriers or valued natural environments such as greenbelt areas. However, even at higher spatial scales, natural factors may come into play, such as via attractive or unattractive climates for knowledge elites.

In an age of ever-increasing electronically-based communication, the emergence of AKPs as significant locations for KBUD is, at a certain level, paradoxical. One challenge for research on such precincts is to understand whether airport locales mean that the enhanced face-to-face communication thus enabled represents a substitution of e-communication, or whether it builds on e-communication to yield even greater knowledge generation benefits. A related research challenge is to understand whether AKP development displaces similar development elsewhere, and if so, from where and under what conditions? Or more generally, using the above prism framework, how can we understand airport knowledge development and the exchange of knowledge at airports as part of the generation of global knowledge chains and their time-space embeddedness? Our research framework enables the ‘glocal’ conceptualisation that has come to be used to suggest the joint operation of global and local dimensions in economic development to be extended to a more

nuanced interrogation of the operation of AKPs within knowledge chains that have multiple nodes at different spatial scales, in which airports are a central facilitator.

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