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Spatial relationships and movement patterns of the air cargo industry in airport regions

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Background: During the past few years, with the increase in air traffic and the expansion of airports, very few industries had such a large spatial development and movement impact as that of airport-related clusters or airport regions. Although much research was done on the various impacts of the airport industry, very little research was done on the air cargo industry in airport regions.

Objectives: This article specifically explored the unique spatial relationships, impacts, trends and movement patterns of the air cargo industry within a typical airport region.

Method: The article focused on the OR Tambo International Airport in Gauteng, South Africa, as a case study and was informed by an extensive quantitative spatial and land use analysis and modelling of the study area.

Results: The article presented findings and insights on the movement patterns and relationships between (1) the airport facility and (2) the spatial configuration of air cargo industries in the particular airport region. These findings also provided some framework for a possible spatial model and guideline that could assist in steering and managing development and movement patterns in airport regions.

Conclusion: The article provided new insights and understanding on the spatial dynamics of airport regions and the air cargo industry, ultimately addressing some gaps in this knowledge field. The article in the end highlighted the need for a different and novel approach to the planning and management of the air cargo industry in airport regions and a basis for further research.

Introduction

Background overview of the problem and challenges

Development in airport regions, with specific reference to the air cargo industry, and the increase in air traffic in recent years, has resulted in many new challenges for airports and the air cargo industry and a new role for airports in the way in which they deliver services (Boloukian & Siegmann 2016; Merkert, Van de Voorde & De Wit 2017). It has become increasingly important, specifically within the context of the air cargo industry and the related logistical challenges, to effectively plan and manage air cargo at airports and to look afresh at the challenges of the air cargo industry in airport regions (Boloukian & Siegmann 2016; Janic 2016).

Based on the limited literature available dealing with airport regions in Africa, it is argued that the planning and development of airport regions on the African continent has not been receiving the attention that it deserves. Compared to international standards, air transport infrastructure in Africa (excluding South Africa) is of a relative low density and a poor quality (Pedersen 2001:86). However, African air transport increased rapidly since the mid-90s, especially to and from South Africa with OR Tambo International Airport developing into the most important African hub (Pedersen 2001:90–91; Pirie 2006:12). Although Africa has relatively low levels of high-value trade, the continent's locality, together with international air transport technology, is making trade with the rest of the world very attractive. Approximately 25% of all export products from Africa (measured in monetary value) are already transported by air with a high likelihood of this increasing because of the economic and demographic growth of India and China (Naude 2009:7). In stark contrast, air transport between African cities (excluding South Africa) is weakly developed (Njoh 2006:24).

Although the aerotropolis concept mainly emerged in the 1900s internationally (see Kasarda & Appold 2010; Kasarda & Lindsey 2011), the concept only recently (2011) started receiving wide

coverage at the OR Tambo International Airport. More recently, efforts were also made to explore the aerotropolis concept at Cape Town International Airport, Durban's King Shaka International Airport and Johannesburg's Lanseria International Airport (see also Mokhele 2016).

The function and character of airports, airport hubs or airport regions the world over have changed significantly and have become centres for urban growth and major drivers in the local and global economy (Callanan 2016). These airport regions increasingly contribute to wealth creation, trade, tourism, direct and indirect gross domestic product and employment (Luke & Walters 2010).

In recent years, much research was done on the economic impact of airport regions and related economies and various methods were explored to actually measure and monitor such impacts (see Luke & Walters 2010; May et al. 2014). As experienced internationally, various academic discourses and research also focus on the social and environmental impacts (within the context of airport regions), and with specific reference to, for example, noise and safety (Freestone & Baker 2010a:264; Knippenberger 2010:101; Li & Loo 2016). Various attempts are being made to also study, measure and analyse the movement patterns and economic trends relating to the air cargo industry (see Boloukian & Siegmann 2016; Janic 2016; May et al. 2014; Merkert et al. 2017; Walcott & Zhang 2017).

Irrespective of these efforts, however, it is argued in this article that the specific spatial dynamics, movement patterns and relationships between the various air cargo sectors in an airport region have not been fully understood in airport regions (see also corresponding views from Boloukian & Siegmann 2016; Walcott & Zhang 2017).

Stevens, Baker and Freestone (2010:279) specifically point out that there is a need to better understand the catalysts for, and catchment areas of, industrial and commercial development in airport regions. According to Alkaabi and Debbage (2011:1518), a better understanding of the conceptual base of the aerotropolis will create an understanding of why some cities are more successful than others at developing spatial agglomeration and clustering of air cargo–related businesses. Schlaack (2010:114) points out that there is an urgent need for closer scientific attention to the often uncontrolled process of airport-related growth.

Appold and Kasarda (2010) argue for a relook at the economic impact of airports and airport cities. They hold the view that the impact of airports and airport cities are currently underestimated, *inter alia* because of the fact that there is an inadequate link between airport studies and urban and rural development theory (Appold & Kasarda 2010:16). Spatial planners and transport planners thus need to acknowledge the role that their airports can work in any country or city that wishes to grow its economy (Appold & Kasarda 2010; Boloukian & Siegmann 2016; Conventz 2010; Freestone & Baker 2010a; Stevens et al. 2010; Yuan, Low & Tang 2010).

Airports have a range of transport, economic, social and environmental impacts and dynamics (Halpern & Brathen 2011:1154; Merkert et al. 2017), and a myriad of possible research areas. The study that informed this article, however, focuses primarily on the air cargo component, related logistics businesses, freight forwarders and related land uses in the OR Tambo International Airport's region, which is described by Wang and Hong (2011) as being of the 'dependant industry' category. Whilst it is not argued (at this stage) that the air cargo industry is the most important sector in this particular airport region, the reason for choosing this component as the main focus for this study was largely influenced by the fact that this industry has such a visible footprint in, and relationship with, typical airport regions. To this end, the study that informed this article primarily focused on the dynamics, relationships and movement patterns and trends between airport-related cargo industries and the airport core. In order to focus the scope of this study, passenger-related land uses were excluded from the study.

Literature review

Air cargo and logistics

It is very obvious from various readings that the general international trend is towards an increased use of air cargo and an expansion of the global logistics industry (see Alkaabi & Debbage 2011; Appold & Kasarda 2011; Bhat 2010; Charles et al. 2007; Feldhoff 2002; Kesselring 2010; Lee & Yang 2003; May et al. 2014; McKinnon 2009; Merkert et al. 2017; O'Connor 2010; Rivera, Sheffi & Knoppen 2016; Stevens et al. 2010; Wang et al. 2011; Yuan et al. 2010).

The growth in air cargo as a transport mode is leading to an increased importance for airports in the global movement network and may be giving rise to increased pressure for land required for cargo-related businesses in airport areas. The increase in cargo is also expected to increase the geographic area of influence of airports. Additionally, the logistics industry is becoming more specialised, resulting in specific land use and transport requirements in airport surrounding regions (Merkert et al. 2017). In planning terms, this equates to an opportunity for more refined and integrated land use/transportation planning in airport regions. Specialisation in the logistics industry is giving rise to a number of third-party logistics providers who render logistic services on behalf of any number of clients. Logistics as an industry in its own right is thereby becoming more established.

According to Insight Media (2010:79–81, 85–93, 106–107, 119–124, 135–138), the major typical international 'cargo airports' are Memphis International Airport (also America's first aerotropolis and used to be the largest cargo airport in the world for 18 consecutive years), Hong Kong (the world's number 1 in 2010), Incheon International Airport in South Korea, Frankfurt Airport, Beijing Capital International Airport, Taoyuan International Airport in Taiwan, Luxembourg-Findel Airport, Dallas/Fort Worth International Airport, Denver International Airport and Athens International Airport.

The major so-called cargo airports in the world are all planning for airport expansion to allow for an anticipated growth in cargo volumes and related industries. The occurrence of specialised, planned and designed land developments such as logistics parks, free-trade zones, cargo villages, logistics hubs, business centres, cargo cities and other real estate creations have become a trend at major cargo airports around the world.

Manuel Castells also explains that information technology–induced communication networks on which the network society is based transcend boundaries making it global (Castells 2005:4–5). Castells argues that technology supports globalisation through Information Communication Technology (ICT) networks that '… generate, process and distribute information on the basis of the knowledge accumulated in the nodes of the network' (Castells 2005:7). From studying Fuller and Harley (2004), Scholl (2010), Kesselring (2010), Uber (2012) and Boloukian and Siegmann (2016), it is clear that airports are becoming important nodes in these spaces and networks.

Looking at the global nature of international airports and airport industries and their role in the global knowledge movement network, it is expected that land uses such as ICT industries, research centres, universities, trait centres, technical colleges and related uses may become spatially more prominent in or close to airport regions. Walcott and Zhang (2017) also refer to the influence of low-weight air cargo, medical goods, perishables and time-sensitive items such as biological items.

Clustering and the spatial configuration of land uses and cargo industries in typical airport regions

Michael Porter, as cited in The Hill Group, Inc (2012:2), defines a cluster as a '… geographic concentration of inter-connected companies and institutions working in a common industry'. Porter further states that '… clusters encompass an array of collaborating and competing services and providers that create a specialised infrastructure, which supports the cluster's industry'. A cluster is said to start for a variety of reasons, *inter alia* a desirable location and supportive business infrastructure. The presence of an international hub airport can be considered as a desirable location for airport-related businesses – and a typical airport cluster. Boloukian and Siegmann (2016) also compare such clusters with a magnet that draws a particular business and specifically those businesses who want to compete in such a cluster – also in terms of the advantages that such cluster present (see also Appold & Kasarda 2010; Bhat 2010; Kesselring 2010; Schaafsma 2010). Likewise, the airport can also be considered as a component of supportive business infrastructure that enhances the airport region as a suitable cluster area for airport-related businesses (Boloukian & Siegmann 2016). Callanan (2016) also refers to airport regions as the multiuse precincts and the increase of a variety of land uses related to the airport industry. Rivera et al. (2016) highlight the benefits of clustering logistics and related air cargo industries with specific reference to agglomeration benefits, collaboration, training and the business advantages.

The form and function of the cluster will vary according to the specific characteristics of the airport. In a cluster, related businesses, land uses, activities and infrastructure typically tend to gravitate towards the magnet (the airport). These different activities would typically compete for location – closest (in terms of distance and time) to the core or magnet.

These typical airport clusters and clustering of activities in and around airports in recent years have taken many different shapes and forms – resulting in various different types of airport clusters or regions, each with its own characteristics and branding. In many cases these clusters grow to such an extent where it becomes prominent and major urban nodes are functionally integrated within metropolitan areas (see also Schaafsma 2010:174; Schlaack 2010:113).

Some examples and terms coined for such clusters are the Airport City (see Betz 2010:155; Schaafsma 2010:174; Schlaack 2010:115; Wang et al. 2011:809); the Aerotropolis (see DeSantis 1939; Kasarda & Appold 2010:51; Kasarda & Lindsey 2011:419); the Airport Corridor, Airport region and Airea (see Schlaack 2010:116); The AeroSCAPE (see Kraffczyk 2011); the Aviopolis (see Fuller & Harley 2004:9); the Airfront (and airfront development) (see Feldhoff 2002:170); and the Airport Metropolis (see Stevens et al. 2010:276).

What has emerged from the above analysis of airport-type cities is the formation of a new and unique kind of 'airport-oriented city' (see also Kasarda & Lindsay 2011:6) or a new type of urban form, spatial form and geography around airports. It is also evident that such a city is or will in future be characterised by new, different and unique economies, dynamics, relationships, connections and movement patterns. It is further evident that these emerging cities will require a new way of thinking and planning (Kasarda 2012:36), as well as a different kind of institutional and logistical arrangement (see Merkert et al. 2017; Schlaack 2010:116).

It is also clear from the readings that such airport regions will have major impacts on the larger regional economies and spaces (Callanan 2016; Walcott & Zhang 2017). Merkert et al. (2017) refer to the major evolutions in the air freight market and the heterogeneous environment in which air cargo services are performed.

Research methodology and design

The paper focused on the OR Tambo International Airport in Gauteng, South Africa, as a case study and was informed by a literature review on the subject matter, as well as an extensive quantitative spatial modelling and analysis of the study area.

The research that informed this article amongst others drew on 'correlation research' as it studied the extent to which differences in one characteristic are related to differences in another characteristic (see also Lanthier 2002;

Leedy & Ormrod 2010:183–184). The study assessed airport land use patterns in terms of the land use context descibed by Kasarda (2012), Wang et al. (2011), Stevens et al. (2010), Schalk and Ward (2010), Halpern and Brathen (2011), Freestone and Baker (2010b) and Schlaack (2010).

The literature study largely focused on studies and readings related to contemporary airport planning, air cargo and logistics industries in airport regions, clustering theories, examples of typical airport regions, spatial concepts and transport and movement systems in airport regions. The discourse culminated in a number of dispositions, which then formed the basis for the empirical fieldwork undertaken.

The empirical fieldwork part of the study entailed two main components: (1) an analysis of air cargo–related business location as sourced from a national business directory and (2) an extensive spatial and land-use survey of 596 properties conducted in five industrial areas in the Gauteng airport region.

The Yellow Pages is a well-known South African business directory and is the flagship brand of Trudon. Trudon, formerly known as Telkom Directory Services, provides advertising and marketing to more than 127 000 companies from the small, micro and medium enterprises (SMMEs) and corporate market (Trudon 2012). For the purpose of component 1, the Yellow Pages was accessed on http://www.yellowpages.co.za. Data searches were conducted on 17 August 2012 (Yellow Pages 2012). A number of searches were conducted using air cargo–related business categories as search phrases, namely Air Cargo, Freight Forwarding, Couriers, Distribution, Logistics, Transport Consultant Services, Shipping, Warehouses, Container Services, Import Agents and Export Agents. Searches were run with OR Tambo International Airport selected as a central point for the search. The website allows for searches of the selected business categories within the following radii: 2 km, 5 km, 10 km, 15 km, 20 km, 30 km, 50 km and 100 km from the selected central point. The search for each business category shows the number of businesses within the selected radius. In determining the number of businesses per distance band, the number of each smaller radius was deducted from the number of businesses within the larger radius. The result was the number of businesses per distance band. The following distance bands were used: 0 km – 2 km, 2 km – 5 km, 5 km – 10 km, 10 km – 15 km, 15 km – 20 km, 20 km – 30 km, 30 km – 50 km and 50 km – 100 km.

With regard to component 2, the study was conducted in five industrial areas within the Ekurhuleni municipal area, at varying distances from OR Tambo International Airport. The following industrial areas have been sampled for the study: Isando, Pomona, Aeroport, Anderbolt and New Era. These areas were sampled as representative of industrial areas in the Ekurhuleni municipal area, located at varying distances from OR Tambo International Airport.

Fuller and Harley (2004), Freestone and Baker (2010a), Appold and Kasarda (2010), Schlaack (2010), Knippenberger (2010), Le Tourmeur (2010), Kasarda (2012) and Insight Media (2010) also indicate that the spatial impact of an airport can generally be measured as a distance impact, measured in kilometres or miles (e.g. 25 km) and as a time–distance impact measuring travel time in minutes (e.g. 20 min travel time).

Research results

The relationship between the airport and surrounding industrial areas in terms of *distance* and *travel time*

With regard to *distance*, the findings of this study show a strong negative correlation between distance from the airport and percentage of air cargo properties (Figure 1). The prevalence of air cargo–related properties clearly drops sharply as distance from the airport increases. A relatively high percentage of air cargo–related properties still occurs at about 6 km from the cargo terminal (26%). At a distance of 15 km away from the cargo terminal, the percentage of air cargo–related properties is very low (6%). It can be deducted that the occurrence of air cargo–related properties becomes diminutive beyond 9 km from the cargo terminal, when it declines to below 20% of the properties per area.

With regard to *travel time*, the findings of this study show a strong negative correlation between travel time from the airport and percentage of air cargo properties (Figure 2). The prevalence of air cargo–related properties clearly

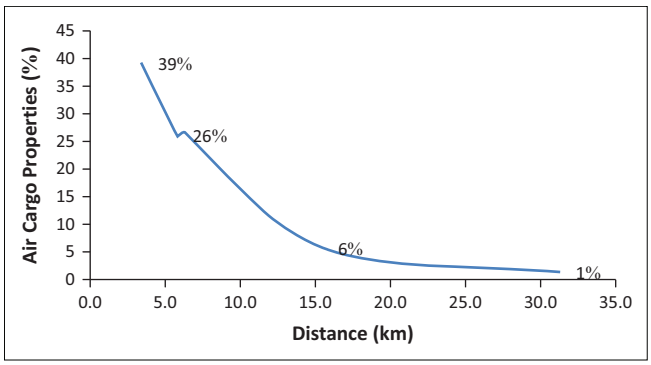

FIGURE 1: Relationship between distance and percentage of air cargo properties.

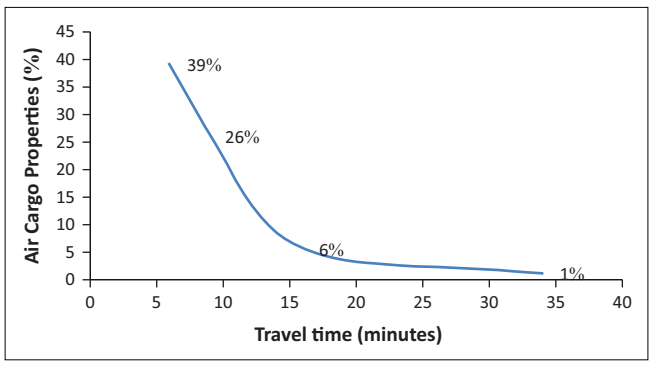

FIGURE 2: Relationship between travel time and percentage of air cargo properties.

drops sharply as travel time from the airport increases. A relatively high percentage of air cargo–related properties still occurs at 9-min travel time. The occurrence then drops rapidly to as low as 6% at 16 min away from the cargo terminal. It can be deducted that the occurrence of air cargo–related properties becomes miniscule beyond 10 min travel time from the air cargo terminal as it then declines to below 20%.

Based on the above, it can be stated that there is a strong relationship between access to the airport and the prevalence of air cargo–related development in the surrounding industrial areas. As access to the airport increases through shorter distances and shorter travel time, so too does the prevalence of air cargo–related development increase.

Number and density of air cargo businesses per distance band

The search for air cargo–related business in the study area as described in paragraph 3 rendered a total of 6471 records. This, however, does not imply a total of 6471 businesses as some businesses render more than one service type thus appearing in more than one business category. A single business may thus account for more than one record. The search was very useful in determining the number of businesses per business category and per distance band (distance measured from the core of the airport). See also description of business categories and distance bands in paragraph 3.

The data obtained were analysed to determine the number of businesses per distance band, for example, 2 km – 5 km and 5 km – 10 km. This was used as a basis to calculate the density of businesses per distance band. The research results were mapped to graphically indicate the spatial distribution of business densities relative to OR Tambo International Airport. This was done by mapping the results of each type of business in a three-dimensional map format where the 'height' of the urban footprint reflects the density of businesses per 100-km² per distance band. Figure 3 presents an example of the typical spatial mapping conducted for each business category.

In order to quantify the degree to which the airport impacts on the locality of businesses, the author devised an airport inclination factor. The airport inclination factor is the business density in the 2-km – 5-km distance band divided by the average business density for that specific business category. The 2-km – 5-km distance band was selected rather than the 0-km – 2-km band. This was done because of the fact that distance bands were plotted from the geographic centre of the airport, thus a point between the two runways. The 0-km – 2-km distance band thus includes a large part of vacant land on the airport property where no business development can take place. The results for the 0-km – 2-km distance band are thus slightly distorted and were not deemed representative enough in determining an airport inclination factor.

A calculated airport inclination factor of 1 is neutral as it reflects a business density equal to the provincial average for

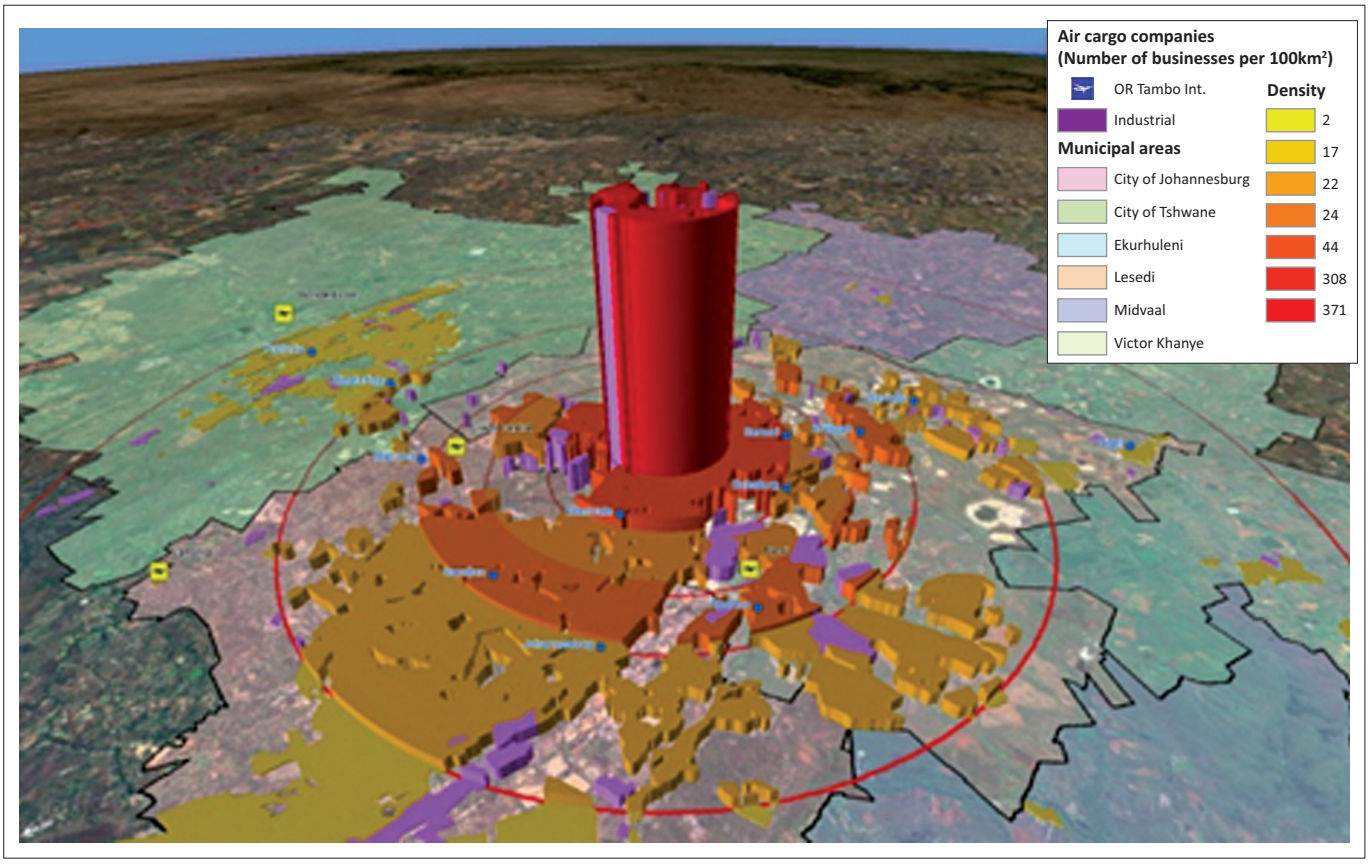

FIGURE 3: Density of air cargo companies.

that business category. An airport inclination factor of less than 1 reflects a business density lower than the provincial average for that business category and may be interpreted as a 'push' factor from the airport. A factor of less than 1 may thus be interpreted as if the airport 'pushes' that business category away. The higher the airport inclination factor, the higher and more positive is the impact of the airport on the locality of such businesses. For the purpose of this analysis, the results of the survey of the business directory information are considered to be representative of the Gauteng provincial area.

Density of logistics businesses around OR Tambo

Logistics businesses show the highest density within the 2-km – 5-km distance band with a density of 590 businesses per 100 km^2. This is the highest density of all business categories investigated across any distance band. The 0-km – 2-km band and the 5-km – 10-km band have the second highest densities. Densities outside the 2-km – 5-km band drop substantially. Logistics businesses are highly concentrated in the 2-km – 5-km distance band around the airport with a relatively high airport inclination factor of 12.1.

Density of air cargo businesses around OR Tambo

The highest density of air cargo businesses are within the 2-km – 5-km distance band with a density of 371 businesses per 100 km^2. The 0-km – 2-km band has the second highest density at 308 businesses per 100 km^2. Densities in the 5-km – 10-km band and beyond drop substantially. Air Cargo businesses are clearly concentrated in the first 5 km from the airport with a massive airport inclination factor of 23.2, which is substantially higher than any of the other business categories searched.

Density of freight forwarding businesses around OR Tambo

Freight forwarding businesses shows the highest density within the 2-km – 5-km distance band with a density of 460 businesses per 100 km^2. The 0-km – 2-km band has the second highest density at 308 businesses per 100 km^2. Densities in the 5-km – 10-km band and beyond drop substantially. Air Cargo businesses are clearly concentrated in the first 5 km from the airport with a relatively high airport inclination factor of 14.2, which is the third highest of all the business categories searched.

Density of courier businesses around OR Tambo

The highest density of courier businesses is within the 2-km – 5-km distance band with a density of 230 businesses per 100 km^2. The 5-km – 10-km band has the second highest density at 34 businesses per 100 km^2. Densities outside the 2-km – 5-km band drop substantially, both closer to and further from the airport. Courier businesses are concentrated in the 2-km – 5-km band with an airport inclination factor of 15.2. This is the second highest of all the business categories searched.

Density of distribution businesses around OR Tambo

Distribution businesses have its highest density in the 2-km – 5-km distance band at 172 businesses per 100 km^2. The 15 km – 20-km band has the second highest density at 62 businesses per 100 km^2. Densities outside the 2-km – 5-km band drop substantially. Although the highest density of Distribution businesses is in the 2-km – 5-km distance band around the airport, it has an airport inclination factor of only 4.9, lowest of all the air cargo–related business categories.

Density of transport consultant businesses around OR Tambo

The highest density of transport consultant businesses is within the 2-km – 5-km distance band with a density of 150 businesses per 100 km^2. The 5-km – 10-km band has the second highest density at 59 businesses per 100 km^2. Densities outside the 2-km – 5-km band drop significantly, both closer to and further from the airport. Transport consultants have an airport inclination factor of only 5.8 in the 2-km – 5-km distance band. This is substantially lower than most of the air cargo–related business categories searched.

Density of shipping businesses around OR Tambo

Shipping businesses show the highest densities within the 2-km – 5-km distance band with respective densities of 44 and 42 businesses per 100 km^2. The 15-km – 20-km band has the third highest density at 62 businesses per 100 km^2. Densities outside the 0-km – 5-km band drop slightly, with a second peak seen in the 15-km – 20-km distance band with a density of 32 businesses per 100 km^2. The density of shipping businesses is at an airport inclination factor of only 5 in the 0-km – 2-km band.

Density of warehouse businesses around OR Tambo

The highest density of warehouse businesses is within the 2-km – 5-km and 5-km – 10-km distance bands with a respective density of 58 and 52 businesses per 100 km^2. The 5-km – 10-km band has the second highest density at 59 businesses per 100 km^2. Densities further from the airport do however not decline substantially. Warehouse Businesses are relatively equally distributed throughout the province (region) with above average densities of 39 businesses per 100 km^2 in the 20-km – 30-km distance band. The highest density zone is only marginally higher than the average. Warehouse businesses show the lowest airport inclination factor of all the air cargo–related business categories searched with a factor of only 2.5. For the purpose of this analysis, identified warehouse businesses were surveyed and categorised according to the actual land use.

Density of container service businesses around OR Tambo

Container service businesses show the highest densities within the 2-km – 5-km distance band with a density of 161 businesses per 100 km^2. Container service businesses have a relatively high airport inclination factor of 12.9 in the 2-km – 5-km band. Container service businesses are the second smallest of all the business categories surveyed with only 289 records searched. For the purpose of this analysis, identified container service businesses were surveyed and categorised according to the actual land use.

Density of import agents around OR Tambo

The highest density of import businesses is within the 2-km – 5-km distance band with a density of 133 businesses per 100 km^2. The 15-km – 20-km band has the second highest density at 78 businesses per 100 km^2 indicating a second peak in density removed from the airport. Densities further from the airport do generally decline, but not as rapidly as for other business categories surveyed. The density of import agents is at an airport inclination factor of only 4.4 in the 2-km – 5-km distance band.

Density of export agents around OR Tambo

The density distribution of export agents shows broadly the same trend as for import agents but with less intensity. The highest density is within the 2-km – 5-km distance band with a density of 97 businesses per 100 km^2. A second peak appears in the 20-km – 30-km distance band, albeit at a lower density of 61 businesses per 100 km^2. The density of export agents is only three times as high in its most dense zone as compared to the regional average of 31 businesses per 100 km^2. Of the searched air cargo–related business categories, export agents show the second lowest airport inclination at 3.1 in the 2-km – 5-km distance band.

It should be noted that although other non-freight–related land uses such as hotels, conference venues, guest houses as well as bed and breakfast establishments were also mapped, these land uses do not form part of the focus of this particular article.

Although the concentration of airport-related businesses around the airport is to be expected, the intensity of this concentration for certain business such as air cargo, logistics, freight forwarding and courier businesses were not expected.

Measuring the actual impact of OR Tambo on the locality of different categories of businesses in the surrounding region

The above analysis clearly indicates that OR Tambo International Airport impacts strongly on the locality of air cargo–related businesses to various degrees.

Businesses classified as air cargo businesses show the highest inclination towards the airport with an airport inclination factor of 23.25 in the 2-km – 5-km distance band. This is an extremely high airport inclination, which confirms the point that OR Tambo International Airport has an extremely high impact on the locality of air cargo businesses.

Couriers, freight forwarding, container services and logistics businesses also show a very high inclination towards the airport. These uses have an airport inclination factor of between 15.22 and 12.06 in the 2-km – 5-km distance band. This, for example, means that couriers are about 15 times as likely to establish in the 2-km – 5-km distance band as at any other locality in the regions (province). Logistics businesses are about 12 times as likely to establish in the 2-km – 5-km distance band as in any other locality in the region (province). OR Tambo International Airport thus also has a very high impact on the locality of couriers, freight forwarding, and container services and logistics businesses.

Transport consultants, distribution businesses and import agent businesses in the 2-km – 5-km distance band show an airport inclination factor of between 5.83 and 4.36. Shipping businesses show the same degree of inclination with an airport inclination factor of 5.02, but in the 0-km – 2-km distance band. These businesses are thus four to five times as likely to establish in the 2-km – 5-km distance band as in any other locality in the region (province). Shipping businesses are about five times as likely to establish in the 0-km – 2-km distance band as in any other locality in the region (province). OR Tambo therefore also has a very high impact on the locality of transport consultants, distribution businesses, import agents and shipping businesses.

Export agents and warehouse business showed the least airport inclination of all the air cargo–related business categories with respective airport inclination factors of only 3.08 and 2.51, despite the fact that ample land is available for such uses. Although these airport inclination factors are relatively low, it is still considered to reflect a medium impact of the airport as these uses are two to three times as likely to establish in the 2-km – 5-km distance band as in any other locality in the region (province). OR Tambo therefore has a moderate impact on the locality of export and warehouse businesses.

Summarising the findings

Based on the foregoing discussions, a number of pertinent findings and lessons are derived, in respect of (1) the land development impact of OR Tambo International Airport on surrounding areas and land uses and (2) the unique spatial dynamics, forces and relationships within a typical airport region. Within the context of the study and based on the spatial analysis and land use surveys (in terms of distance, time and density of land uses), the following main findings were made:

- It is clear that OR Tambo International Airport has a very high impact on the location of the various airport-related businesses in the surrounding area – specifically within the 2-km – 5-km distance band.
- It was also found that the arrangement of cargo-related land uses and the density thereof vary according to distance and travel time from the airport cargo terminal.
- In general, the level of interaction with cargo increases as it nears the airport from the land side. Correspondingly, the intensity of specialised cargo land uses increase in close proximity to the airport to accommodate the increase of cargo interaction.
- There is a strong negative correlation between distance from the airport and the percentage of air cargo properties in industrial areas, and the air cargo impact of the airport greatly reduces beyond 9 km from the cargo terminal.
- There is a strong negative correlation between travel time from the airport and percentage of air cargo properties in

industrial areas and the air cargo impact of the airport is greatly reduced beyond 10-min travel time from the air cargo terminal.

- OR Tambo International Airport has a very high impact on the locality of couriers, freight forwarding, container services, logistics businesses, transport consultants, distribution businesses, import agents and shipping businesses and a somewhat lesser and moderate impact on the locality of export and warehouse businesses.
- The results of the business density calculation show a high density of air cargo, freight forwarding and logistics businesses in specifically the 0-km – 2.5-km distance band. Lower densities are found across most business categories in increasing distance bands.
- The increase in air cargo and the land requirements thereof are expected to radically increase the geographic area of influence of airports and the so-called footprint of airport regions.
- The spatial impact of an airport can generally be measured as a distance impact measured in kilometres or miles or as a travel time impact measured in minutes. The size and shape of an airport's impact footprint is dependent on a number of factors, including the condition and locality of land transport infrastructure in the area; the locality of other airports in the area; the function of other airports located in the area; the relative importance of air cargo as opposed to land and sea cargo; the locality of urban nodes in the airport area; natural features; current land uses and the planning policy of the land use authority.

Based on the literature review that informed this study – a study of the international concepts, trends and spatial configurations of airport regions or clusters – and combined with the spatial analysis and land use study that was done for the OR Tambo International Airport region, the following diagram (Figure 4) was constructed to schematically indicate

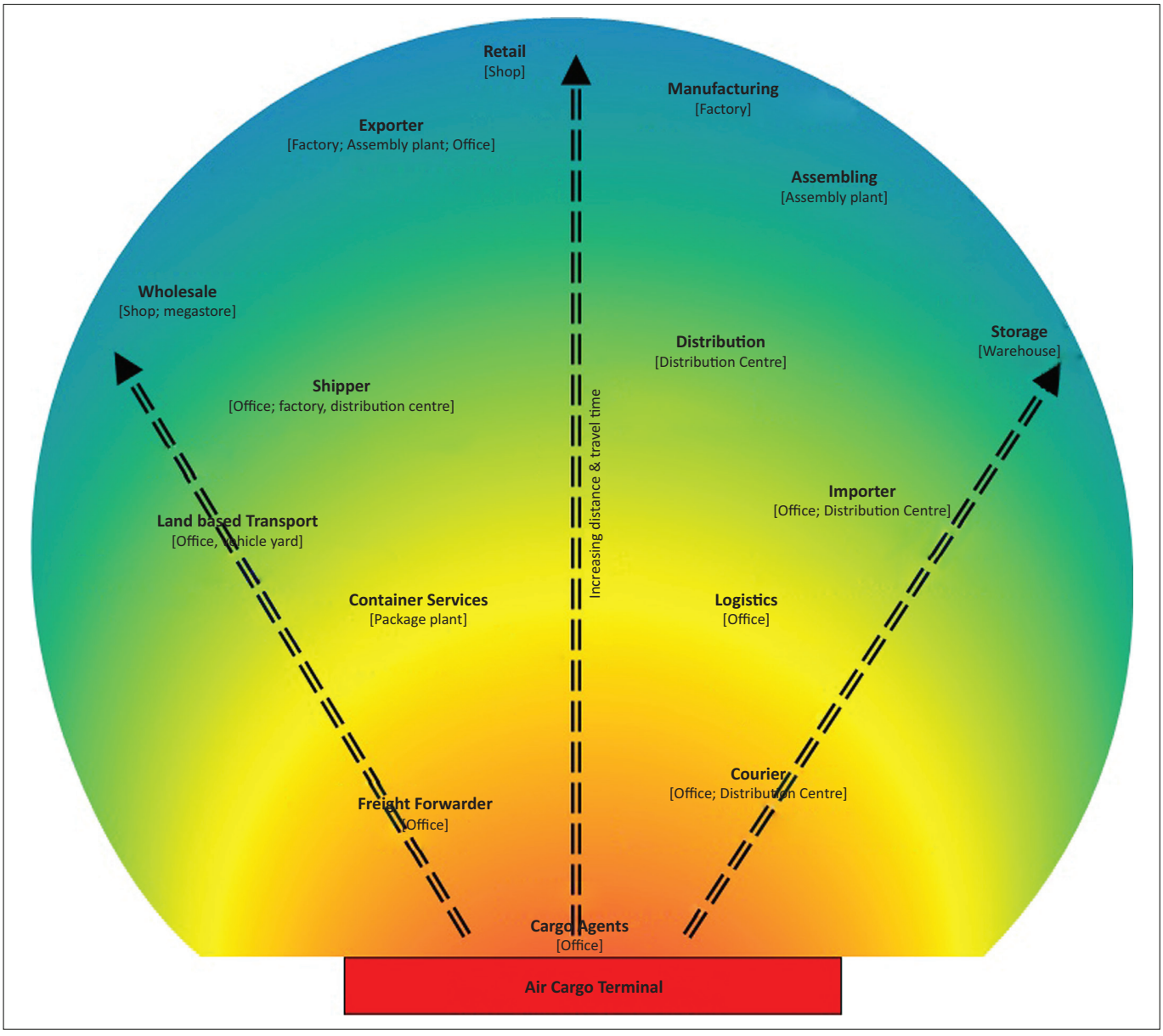

FIGURE 4: Relationship between the cargo terminal and cargo-related land uses.

(1) the specific cargo-related business types (land uses and building type) in a typical international airport region or aerotropolis and (2) the most likely locality of typical cargo-related business types (land uses and building type) in relation to distance and travel time, to and from the cargo terminal.

Figure 4 is not an attempt to describe a further airport-centred planning concept, but rather aims to reflect the typical, expected or desired spatial distribution of cargo-related land uses. It is believed that this diagram can be used as an important guideline in the spatial and transport planning of typical airport regions or aerotropoli – not only in Gauteng, but also in the planning of other similar airport regions as a whole. This diagram furthermore can be used as a guideline for airport owners and operators, for example, The Airports Company South Africa, as well as airport area real estate owners and potential investors seeking the optimum location for a specific business.

Janic (2016) also highlighted the challenges such as incompatibility of land use within an airport region, and the need for a model or land use plan that could guide the challenge and future development and organisation of the unique land uses within the airport region. Boloukian and Siegmann (2016) refers to airport-centred developments and the need for a logical arrangement of related air cargo land uses. To this end, Boloukian and Siegmann (2016) strongly emphasises the need for proper urban planning in complicated regions such as an airport region. Walcott and Zhang (2017) refer to the need for a strategic, integrative approach to the land development on the aerotropolis and the need for freighter operators to be innovative in their approach.

Conclusion

Already at this stage it is evident that this study is beginning to fill a major gap in African and South African research on the impacts of airports and airport logistics on land use development. For the Ekurhuleni Metropolitan Municipality, the research contributes to a better understanding of the aerotropolis concepts and its application to OR Tambo International Airport. It is further believed that this article can evenly contribute to improving the understanding of the dynamics, relationships and movement patterns within not only airport regions in general but also in Africa and other parts of the world.

It is imperative to emphasise the need for planners, development professionals, decision makers and developers to realise and improve the understanding of the rapid and ever-changing dynamics of the airport industry and its changing relationships with the surrounding, regional and global space economies.

To this end, it is argued that the future planning and development of airport regions will have to require a total new 'aerial' and global way of thinking (see also Coetzee, Lazarevski & Schumacher 2012), or as stated by Coetzee and Retief (2013), a novel and different 'Bluesky-thinking' approach that moves away from the lethargic, ordinary, archaic and rigid way of land use planning.

This again emphasises the need for strong and appropriate leadership, sufficient capacity and skills levels, a developmental and entrepreneurial mindset, and appropriate embedded governments that are in close contact with its people (see Coetzee 2010:22–26) … and perhaps a 'shared political planning vision' as described by Schlaack (2010:116) in his Airport Region.

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Competing interests

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Authors' contributions

P.J.v.V.C. is a senior lecturer at the Department of Town and Regional Planning, University of Pretoria, and was the supervisor for P.A.S. for his Master's dissertation, who was primarily responsible for the research. Both authors contributed to the writing of the manuscript.

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