

## Article

# Impact of Airports on Landside Industrial Development: A Case Study of Brisbane Airport

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**Abstract:** Numerous studies have established strong connections between air traffic and economic growth at the regional level. However, without consideration of individual airports' immediate vicinities, this aggregate view can lead to an overly simplistic conclusion about the role of airports in their urban environment. The impact of airports on local economic development is evaluated through a case study of Brisbane Airport by using primary data sourced from semi-structured interviews and a survey. The results demonstrate that the role of airports as transport hubs is not the dominant mechanism that drives industries to locate in airport areas. Rather, the local urban context is a dominant driver for development in and around airports. Based on the survey and interview results, urbanization economies have the highest significance on the landside industrial location decision, with a mean of 3.53 in terms of importance level. The findings provide a reference for policymakers regarding investment in airport expansion or construction, as well as a refinement of the understanding of the local economic impact of airports.

**Keywords:** agglomeration economies; airport city; Brisbane Airport; mechanisms



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## 1. Introduction

Airports have become significant economic centres, anchoring a wide range of industries, including aeronautical, non-aeronautical, and freight-based providers. In addition, the emergence of commercial and industrial development on airport lands over the past decade to supplement revenue has led to a variety of land uses in and around airports internationally. This phenomenon has been described by various airport-centred urban development models, especially the airport city and aerotropolis. In these models, airports are recognised as economic engines that are credited with having a substantial impact on regional employment growth. A large body of empirical studies confirms that a strong connection exists between airports and regional economies [1,2]. This link is often used to justify airport investment and expansion based on the assumed subsequent regional benefits [3].

However, recent scholars are starting to question the role of airports as economic engines, which is the foundation of the airport city model. They argue that conditions around the airport can limit further economic growth due to negative external effects, such as noise emissions, environmental pollution, and traffic congestion [4–6]. The costs caused by the negative effects around airports are clearly localised, which raises the question of whether the subsequent benefits brought by airports are also localised [5]. In other words: Is the landside industrial growth around airports primarily driven by airports? Little research has explored the relationships between airports and economic growth within the airport immediate vicinity.

Previous studies have examined this connection at the regional scale, most commonly around metropolitan areas [7–9]. These studies often adopted an aggregate view to examine

the link by building statistical models using census data [7,10]. The aggregate view can lead to an overly general conclusion about the economic impact of airports without considering the local history and surrounding urban morphology [5]. For example, Bilotkach applied a longitudinal technique by using a 17-year dynamic panel dataset [11]; Appold implemented a cross-sectional study in which the data covered 51 large US metropolitan areas in 2000 [12]; Baker et al. conducted a combination study which analysed 88 regional airports in Australia over a period of 1985–86 to 2010–11 [7]. The variables most widely used for the econometric models include employment, usually covering different years to represent economic growth, and air traffic data, mostly airport passenger numbers and air cargo volume [7,11,12]. The geographic scale of analysis in the airport studies has a wide range from a country or metropolitan area to a 50 km radius of an airport [7], among which the metropolitan area is most commonly applied [7]. Only a few studies have explored the local effects of airports on surrounding urban economies. Cidell calculated the employment within 2.5, 5, and 10 miles of the largest 25 US airports and compared it with other significant centres (the CBD, the shopping mall, and the wastewater treatment plant) within the same radii [5]. Sonnenburg and Braun evaluated the spatial patterns of employment in four Australian airports by aggregating the values for each Statistical Area Level 2 (SA2) to four areas: the airport land, 5 km terminal buffer zone, 5 km CBD buffer zone, and job centres located farther than 5 km from the CBD and airport [13]. Appold analysed the employment within 1 mile of three types of anchors: the CBD, the airport fence, and non-CBD subcenters [12]. However, these studies featured little consideration of the locational differences of distinct industrial sectors [5,13–15]. The requirements for airport access vary among different sectors. As a result, it is essential to identify the differences among sectors for an in-depth understanding of the impact of an airport. Current studies are not sufficient to explain the mechanisms underlying industrial clusters around airports and whether airports play the dominant role in their landside development.

Different from the above studies, this research conducts a case study on Brisbane Airport to explore the airport impact more deeply across industrial sectors. Data in this paper are primarily sourced from semi-structured interviews and a survey with industries, which are clients rather than management or planning authorities. The interviews with land users are different from the study of Sonnenburg and Braun [13], which was based on the perspective of airport experts; this view enables the researcher to directly inquire about the motivation of moving to the airport landside from the industries themselves. Furthermore, an interview with the real estate company is also included in this study to investigate the attractiveness of airports to the industries from a management perspective. Consequently, a combination of the perspectives of both the clients and management facilitates a better understanding of the influence of airports on the landside industries.

Cluster theory has been used as a dominant approach for decades in analysing the processes and mechanisms of economic development in regions [16,17]. This paper uses clusters or agglomerations interchangeably and defines ‘industrial cluster’ as an airport agglomeration in which the industries of various sectors concentrate in the airport landside caused by different impacts of airports, including the direct, indirect, induced, and catalytic effects. This means that the airport agglomeration in this study is place-specific and sector-mixed, aligning with the definition of a regional cluster [18]. Agglomeration economies and social networks are the main drivers underlying a wide range of cluster models [19–21]. Geographical proximity is emphasised in the cluster models in both the economic and network perspectives of drivers. This perspective allows the establishment of a location factor framework, including both economic and non-economic, to explore the drivers that motivate industries to cluster in the airport landside. Therefore, this research applies cluster theory to evaluate the role of airports in the economic development at a local scale using a case study of Brisbane Airport. The purpose of this study is not to deny the existence of the airport city or aerotropolis model, but rather to investigate the validity of the claim that airports are an economic engine of a region within the Australian context. This case study

provides a comprehensive assessment of the airport's impact on the local economies and contributes to the cluster and airport studies by adding empirical knowledge to both fields.

The remainder of this article begins with Section 2, which outlines the literature evaluating airports and industrial agglomeration. The following section introduces the research design and methods applied in this study, and the fourth section provides the results of the case. The discussion provides an analysis of the empirical results on the impact of airports in landside industrial development and frames them in the current literature. Finally, the article provides a summary of key findings and implications for land use planning and economic development policy.

## 2. Airports and Industrial Agglomeration

Airports have experienced a dramatic change in the global economy, which emphasises speed and flexibility in the supply chain. One key advance in the supply system is that mass production with standardized goods has been replaced by flexible, customized production, just-in-time production, and rapid delivery. Air travel and air freight have become a preferred mode of transport adopted by an increasing number of businesses, as they can be well fitted to the needs of fast, long-distance shipping. More businesses benefit from the fast delivery provided by air logistics, which provides a competitive advantage for these businesses in the global markets. In addition, airports have become attractions for corporate headquarters, regional offices, and service sectors, which require frequent inter-city travel for face-to-face contact [22–24]. As a result, airport areas have become valued locations for growing business and industries sectors. At the same time, trends in the aviation sector, such as privatisation and commercialisation [25–27], further promote non-aviation development at and around airports, resulting in a spatial agglomeration of a variety of activities in the airport vicinity. Various terms have been applied to describe this phenomenon of airport-driven development, notably the “airport city” and “aerotropolis”.

### 2.1. Classifications of Industries around Airports

Activities or industries are found at different distances from the airport due to a spatial gradient reflecting cost, time, and frequency of contact with the airport [28]. Table 1 summarises the main industry types based on their relationship with airports by a review of classifications of industries around airports.

**Table 1.** Summary of industry classifications around airports based on the literature review.

Classification Basis	Relation to Air Traffic [28]	Relation to Air Traffic [29]	Requirement of Airport Access [30]	Location Relative to Airport [31]	Relation to Air Transportation [14]
1	Core industry	Core aeronautical activities	N/A	At airport	Transportation providers
2	Dependent industry	Airport-related activities	Airport-support activities <ul style="list-style-type: none"> <li>• Services directly support operations</li> <li>• Airport-related freight services</li> <li>• Services for airline employees and passengers</li> </ul>	Adjacent to the airport	Transportation-supporting activities, e.g., <ul style="list-style-type: none"> <li>• Hotels and retail for air travellers</li> <li>• Suppliers for air shippers</li> </ul>
3	Airport-related industry	Airport-related activities	Time-sensitive activities; Business with high travel demands	Vicinity of the airport	Transportation-using activities <ul style="list-style-type: none"> <li>• Advanced producer services</li> <li>• Manufacturing for goods transport</li> </ul>
4	N/A	Airport-oriented industry	Non-aeronautical development	Vicinity of the airport or beyond this area	N/A

Seven industry sectors for this study are identified based on the above review and the definitions in the Australian and New Zealand Standard Industrial Classification (ANZSIC).

They include airport-support services, logistics, commercial, knowledge-intensive services, manufacturing and construction, agricultural and mining, and other services sectors. The four-digit codes of the industries that each sector covers are in line with the ANZSIC codes.

Four sectors are evaluated in this study: logistics, commercial, knowledge-intensive, and manufacturing/construction. The logistics sector consists of transport operators (such as air cargo, trucking, and sea transport companies), freight forwarders, couriers, postal services, storage facilities, and transport support services. The commercial sector comprises Divisions F (Wholesale Trade) and G (Retail Trade) in the ANZSIC classifications. The knowledge-intensive sector includes information media and telecommunications, financial and insurance, property, professional, science and technical services, administrative and support services, education and training, and health care and social assistance [5,30]. Manufacturing and construction sectors are consistent with Divisions C (manufacturing) and E (construction) in the ANZSIC classifications.

## 2.2. Factors That Drive Industries to the Airport City

The cluster models provide a theoretical basis to build a framework of agglomeration factors which explores the critical factors that attract industries to locate around airports (see Table 2). Currently, there are two main dimensions in cluster studies when analysing the mechanisms of industrial clusters: agglomeration economies and social and institutional dimensions. Agglomeration economies refer to the external economic benefits accruing to firms or industries as a result of their geographic proximity. Hoover [32,33] distinguished them into localisation economies and urbanisation economies, depending on the economic benefits derived from a similar industry or from a variety of industries. Localisation economies are the benefits arising in an industrial or business specialisation, where firms producing similar products are in proximity. Marshall [34] argued that firms in the same industry can gain three advantages by clustering in the same location, including labour market pooling, intermediate goods supply and demand linkages (or forward–backward linkages), and technological/knowledge spillovers [35]. Urbanisation economies are defined as the advantages generated by the proximity of all local firms, irrespective of the sector [36]. They include (a) the availability of a range of infrastructures (such as public utilities, transportation, and communication facilities); (b) the existence of various business and commercial services; and (c) the complementarity of the labour supply [37,38]. Models of agglomeration economies indicate that firms tend to concentrate in an area mainly due to economic motivation, either minimizing the input costs or increasing productivity [20,35,39]. On the other hand, social and institutional models emphasize that non-economic factors are essential drivers to promote clustering [40–42]. There are three main models in the analysis of industrial agglomeration and the role of regions from the social and institutional perspectives [41]: the flexible specialisation model, the linkage–transaction cost model, and untraded interdependencies. The former two models provide a theoretical basis to facilitate the understanding of the forming of the airport agglomeration; just-in-time production, customized production, and rapid delivery built on the flexible specialisation model are important factors that drive the airport role transformation from the city infrastructure to an economic centre [43–45]. Untraded interdependencies constructed by Storper [41], referring to ‘conventions’, common languages, and rules for developing, communicating, and interpreting knowledge, promoted the understanding of the processes behind spatial clusters, especially for knowledge-based industries.

The dominant factors that drive airport agglomeration, whether economic or non-economic, vary across different industrial sectors. Minimizing the costs can motivate cost-sensitive industries to locate in the airport areas. Airport agglomeration depends largely on the airport’s strong logistics function. Airports act as a magnet to attract aviation-related freight companies, including air freight companies and third-party logistic providers. The air traffic volumes provide for a wide range of services to be based around the airport. For example, Rust et al. [46] provided an account of the negative impact of COVID-19 on the business clusters around Duluth Airport due to the reduction of air traffic volumes in

2020. Air freight firms, as heavy consumers of air services, have a very strong motivation to be located near airports to satisfy the customer demand for fast delivery and to save on transport time and costs. Other logistics firms may not be so strongly attracted by airport proximity, such as air freight firms. The influence of airports on their location choices is primarily determined by the goods they ship. The higher the proportion of time-sensitive goods, the stronger the need for them to be close to airports [13,24,47]. Firms that ship goods mostly by road are drawn to the airport vicinity mainly because of agglomeration economies, such as excellent ground connectivity and proximity to other logistic firms.

**Table 2.** Factors for industrial agglomeration based on cluster theory.

Mechanisms		Factors	Citation
Localisation economies	1	Access to specialist workers	[34]
	2	Proximity to airport-related suppliers or customers	
	3	Proximity to distributors	
	4	Being located near competitors	
	5	Coordination with related and supporting industries	
Urbanisation economies	6	Availability of warehouse space/land	[32,33]
	7	Access to ground transportation	
	8	Airport accessibility	
	9	Proximity to air freight companies	
	10	Proximity to third-party logistics service providers/freight forwarders	
Government impact	11	Financial incentive (provision of venture capital or subsidies)	[19]
	12	Tax reduction or exempt	
	13	Strategy for the area as presented in the Brisbane Airport Master Plan	
	14	Other policies for airport area/trade coast region produced by local, state, or federal government	
Institutional and cultural factors	15	Access to universities, research institutions, and training and technological centres	[19]
	16	Access to local industrial body representatives	
	17	Interpersonal/professional networks	
	18	Prestige of a location near Brisbane Airport	

Recently, retail and wholesale firms have been attracted to Australian airports, competing for space with transport and warehousing facilities [13]. The tendency to be near airports for this sector is attributed to the benefit from the patronage of a growing number of airport-based firms, airport employees, and passengers (including layovers and people who pick-up or drop-off air travellers) [13]. Another strength of airport proximity for this sector stems from the airport-related transport infrastructure, which facilitates the expansion of their services across the metropolitan area [13,47]. Customers from other regions in the city are partly drawn to the airport area due to the convenient and excellent ground transportation. The growth of commercial firms is positively affected by the increasing number of flights and the expansion of airports. However, there are other types of retail and wholesale establishments, whose customers are sourced mainly from the metropolitan areas instead of relying on airports. They are attracted to the airport landside because of various factors, including land availability, good ground transportation, and affordable property [13,48].

For knowledge-intensive firms that require a high frequency of face-to-face contact for knowledge exchange, untraded interdependencies [41] are indispensable factors that drive the sector to the airport area. In contrast to other locations, the strength of the airport as a magnetic location for this type of firm is the global accessibility created by the infrastructure, which satisfies their needs for long-distance, face-to-face information exchange. A growing number of knowledge-intensive firms agglomerate in high-end commercial office spaces at international hub airports due to the decline in air travel costs and the frequent services to various destinations that airports provide. Airports also create a favourable environment as places of “meetingness” to facilitate the transactional economy [30,49,50]. Regional corporate headquarters and offices are also attracted to the office space in the airport corridors [30].



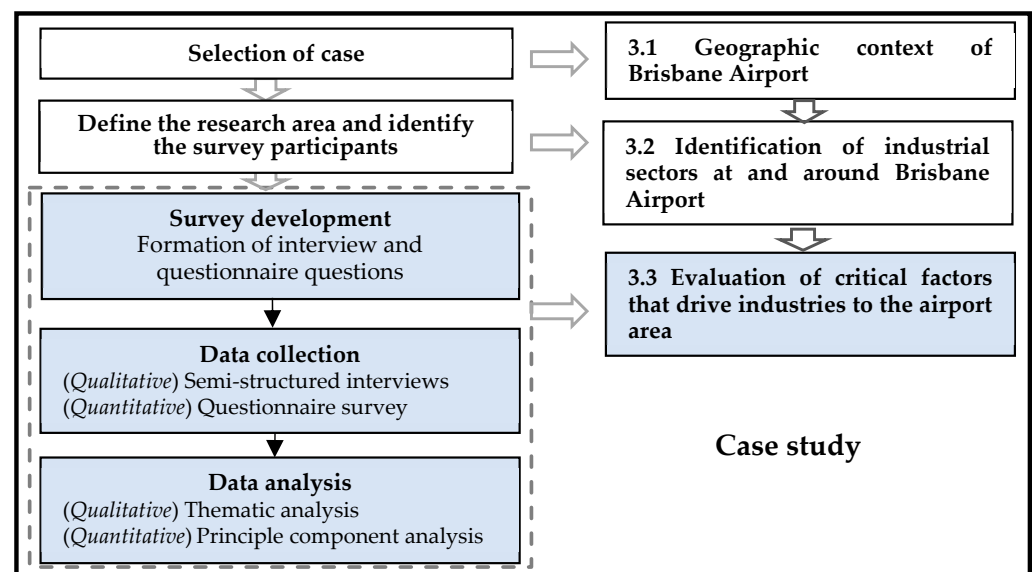
However, empirical studies have shown that clusters of knowledge-intensive firms tend to be concentrated in a limited number of international hub airports with a strong knowledge economy base [5,13,51]. Beyond a few international hub airports, knowledge-intensive companies might be drawn to metropolitan areas other than the vicinity of airports because of the negative impacts of aircraft noise [5]. Knowledge-intensive firms may have higher demands for other decisive location factors, such as property values and quality of life.

Manufacturing and construction companies find that airport areas provide the best possible combination of access to land, labour, and high-quality transport infrastructure [14]. Empirical evidence from the US suggests that manufacturing is less tied to airports compared with employment as a whole [24].

Above all, a variety of industries with varying location requirements are emerging around airports and are adding more complexity to airport landside development. Few studies have evaluated the dominant factors that attract industries across the different sectors to the airport landside. To fill this gap, this study aims to explore the influence of an airport on the industries that locate in its vicinity and to evaluate the essential location factors across different industrial sectors.

### 3. Research Design

A case study was developed to explore the impact of airports on land uses within and adjacent to the airport boundary using primary data sourced from semi-structured interviews (qualitative data) and a questionnaire survey (quantitative data). Figure 1 presents the research design steps of this study.



**Figure 1.** Flow chart of research design.

#### 3.1. Geographic Context of Brisbane Airport

Brisbane Airport was selected as the case in this study (Figure 2) because it is characterised by intense and diversified landside development and shares a similar industrial structure with other major Australian airports (see Section 3.2). The airport identifies itself as an airport city [45], with the largest available airport land area among the Australian airports, which provides more potential for landside development. As a result, Brisbane Airport has been frequently employed as a case or context in many Australia-based studies to explore airport land use planning and the impact of air traffic on urban economies due to the extensive properties developed on and outside the airport [13,45,52].



**Figure 2.** Geographic context of Brisbane Airport.

Since its privatisation in 1997, Brisbane Airport has rapidly grown in both air passenger numbers and international air freight volume, respectively increased by 53.2% and 82% in two decades. Now, it is the third largest airport in Australia in terms of passenger numbers. The airport has two major terminals, accommodating 33 airlines flying to 84 domestic and international destinations (BAC, 2020). Table 3 provides an overview of the economic activities in terms of total income, business numbers, and number of employee jobs in the three regions: Brisbane Airport (SA2), airport surroundings, and greater Brisbane.

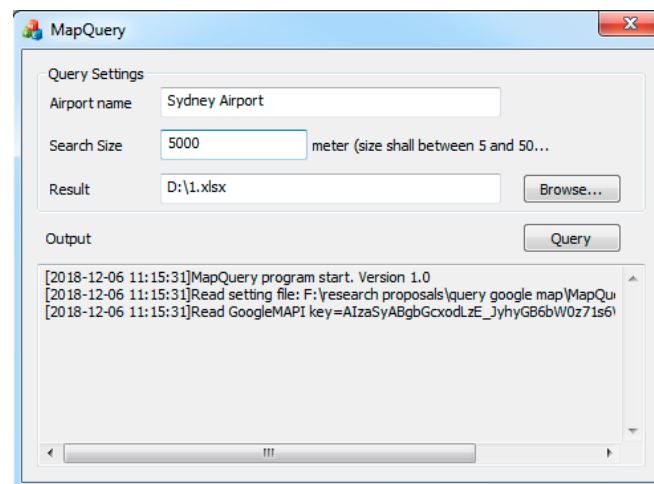
**Table 3.** Overview of economic activities in the three regions (Brisbane Airport, airport surroundings, and greater Brisbane).

	Year	Brisbane Airport (SA2)	Airport Surroundings	Greater Brisbane
Mean total income (excl. government pensions and allowances) (AUD)	2018	76,242	65,598	64,104
Total income, in millions (excl. government pensions and allowances) (AUD)	2018	7.2	2122.2	89,251.4
Total number of businesses	2020	253	5575	215,855
Number of jobs	2018	130	38759	1,943,363
Land areas (ha)	2020	4548.6	3595.6	1,584,196

Note: The data are sourced from Australian Bureau of Statistics (ABS); airport surroundings include six geographical areas around Brisbane Airport in the Statistical Area 2 (SA2) level, which are Eagle Farm, Northgate–Virginia, Nudgee–Banyo, Nundah, Hendra, and Ascot.

### 3.2. Identification of Industrial Sectors at and around Brisbane Airport

This study developed a program, called MapQuery (Figure 3), to download the information of firms around nine major Australian Airports (including Brisbane Airport) from Google Maps [53]. The search radius was set at 5000 m, and the searching output was saved as an Excel file, which included the data about each firm's name, latitude, longitude, address, and type.



**Figure 3.** Interface of MapQuery.

The information of the firms around Brisbane Airport in the generated Excel file was converted into shapefiles by ArcGIS and displayed spatially as a GIS map based on each firm's latitude and longitude. The scope for this study included only the firms within and near the airport boundary, as shown in Figure 4.



**Figure 4.** Firms of different industrial sectors around Brisbane Airport (Google Map, 2018).

The firms in the research area were classified by their four-digit industry code according to the Australian and New Zealand Standard Industrial Classification (ANZSIC), 2006 (Revision 2.0), and they were further divided into different sectors (Figure 4). Four hundred and forty-five firms in the four industrial sectors, including commercial, logistics, knowledge-intensive services, and manufacturing and construction sectors, were selected as the potential participants for the semi-structured interviews and questionnaire survey in this study (Table 4).



**Table 4.** Number of firms around Brisbane Airport by sector compared with other Australian major airports.

No.	Industrial Sectors	ADL	BNE	CNS	CBR	DRW	OOL	HBR	PER	SYD	Sum	Av.
1	Airport-support services	87	189	94	60	64	88	64	204	235	1085	121
2	Commercial	186	194	47	49	68	41	51	144	211	991	110
3	Logistics	39	60	17	4	10	8	13	116	99	366	41
4	Knowledge-intensive services	74	105	77	78	53	64	23	98	274	846	94
5	Manufacturing and construction	71	86	15	2	19	14	22	73	66	368	41
6	Agriculture and mining	0	2	2	109	0	0	0	10	0	123	14
7	Other services	36	47	21	16	26	34	11	44	69	304	34
Total		493	683	273	318	240	249	184	689	954	4083	

Note: The 4-digit codes of the industrial sectors are provided in the Supplementary Materials.

### 3.3. Evaluation of Critical Factors That Drive Industries to the Airport Area

This research employed semi-structured interviews and a questionnaire survey to explore the factors that motivate firms to the airport area, including qualitative and quantitative data. Interviews were conducted to complement the survey data. The research was approved by the QUT Research Ethics Committee, with Research Ethics Approval Number 1800001163.

#### 3.3.1. Qualitative Data Collection and Analysis

The qualitative data were collected in thirty-one interviews from participants in 30 industrial firms as property clients and 1 real estate firm as property managers (Table 5). The interview questions were developed to explore the significance of different location factors from a combination of perspectives of both the clients and management. Several techniques were adopted to recruit interview participants, including phone calls, email, snowballing, and face-to-face door knocking. None of the strategies worked particularly well other than face-to-face contact and going directly to the firms on location.

**Table 5.** An overview of interview participants.

No.	Sector	Participants' Position	No.	Sector	Participants' Position
1	Commercial sector	Manager	17	Logistics	Supervisor
2	Airport-support services sector	Salesperson	18	Manufacturing and construction	Executive assistance
3	Knowledge-intensive sector	Manager	19	Manufacturing and construction	Customer service
4	Commercial sector	Manager	20	Manufacturing and construction	CFO
5	Commercial sector	Owner	21	Commercial sector	Owner
6	Manufacturing and construction	Manager	22	Knowledge-intensive sector	Project administration and purchasing
7	Manufacturing and construction	Engineer	23	Commercial sector	Manager
8	Manufacturing and construction	Production manager	24	Commercial sector	Customer service
9	Knowledge-intensive sector	Manager	25	Commercial sector	Customer service
10	Commercial sector	Salesperson	26	Commercial sector	Manager
11	Commercial sector	Director	27	Commercial sector	Customer service
12	Commercial sector	Customer service manager	28	Commercial sector	Manager
13	Logistics	Customer service	29	Commercial sector	Customer service
14	Commercial sector	Manager	30	Commercial sector	Manager
15	Commercial sector	Casual employee	31	Knowledge-intensive sector	Manager
16	Logistics	Manager			

The raw qualitative data, including transcripts and notes, were coded and developed into different themes based on a thematic analysis using Nvivo. The results and analysis of the interview data are provided in Sections 4 and 5.

#### 3.3.2. Quantitative Data Collection and Analysis

A survey questionnaire was developed to collect quantitative data, and the participants were requested to rate the importance of 18 factors that affected their location decision by a 5-point Likert scale. The 18 location factors in the framework of Table 6 were established based on the review of mechanisms of industrial clusters and revised according to the feedback from several experts in the related field. The actual level of importance of each factor is represented by the mean of the ratings of every factor (Table 6). Initially, a pilot survey was conducted online, with questionnaires distributed to airport experts; minor amendments were made based on the pilot survey responses. A total of

103 surveys were collected in this study by a combination of techniques, consisting of 4 on-line, 21 postal mail, and 78 face-to-face. The collected quantitative data were then analysed by principal component analysis (PCA). The 103 survey respondents included 45 commercial, 15 logistics, 19 knowledge-intensive services, 19 manufacturing and construction, and 5 airport-support services firms. The five respondents in the airport-support services sector, collected randomly during the survey, were included to add more samples for the principal component analysis.

**Table 6.** Descriptive statistics of agglomeration factors.

Mechanisms		Factors	Citation	Mean	Std. Deviation	N
Localisation economies	1	Access to specialist workers		2.53	1.371	103
	2	Proximity to airport-related suppliers or customers		3.34	1.563	103
	3	Proximity to distributors	[34]	2.92	1.398	103
	4	Being located near competitors		2.29	1.340	103
	5	Coordination with related and supporting industries		3.27	1.402	103
Urbanisation economies	6	Availability of warehouse space/land		3.73	1.373	103
	7	Access to ground transportation		3.55	1.289	103
	8	Airport accessibility	[32,33]	3.30	1.454	103
	9	Proximity to air freight companies		3.13	1.513	103
	10	Proximity to third-party logistics service providers/freight forwarders		3.30	1.297	103
Government impact	11	Financial incentive (provision of venture capital or subsidies)		1.96	1.275	103
	12	Tax reduction or exempt		1.76	1.116	103
	13	Strategy for the area as presented in the Brisbane Airport Master Plan	[19]	2.15	1.279	103
	14	Other policies for airport area/trade coast region produced by local, state, or federal government		2.08	1.281	103
Institutional and cultural factors	15	Access to universities, research institutions, and training and technological centres		1.83	1.043	103
	16	Access to local industrial body representatives	[19]	2.01	1.142	103
	17	Interpersonal/professional networks		2.53	1.399	103
	18	Prestige of a location near Brisbane Airport		2.44	1.499	103

Notes: The importance level of each factor is represented by the mean of every factor's ratings using a 5-point Likert scale by survey respondents.

- **Principal Component Analysis (PCA)**

Principal component analysis has been widely used as a default method to reduce a large number of correlated variables to a smaller set of linearly uncorrelated components/factors [54]. These principal components capture the primary information conveyed by the variables with the minimum loss of information [55]. "Each component is independent and is a linear weighted combination of the original variables" (p. 41) [55]. Principal component analysis was adopted in this study to define the essential components extracted from the eighteen correlated variables (referring to the location factors).

Bartlett's test of sphericity (BTS) and the Kaiser–Meyer–Olkin (KMO) test were used mainly for testing the sampling adequacy and factorability of the matrix [55]. It is feasible to carry out a principal component analysis if the significance level of Bartlett's test of sphericity is less than 0.05 and KMO is greater than 0.7 [54]. The results from these two tests using SPSS showed a BTS value of 1011.678 and a level of significance of  $p = 0.000$  (Table 7), indicating that the data were suitable for the principal component analysis. The result of the KMO measure of sampling adequacy was 0.837, revealing that this study had sufficient items for each factor.

**Table 7.** KMO and Bartlett's Tests.

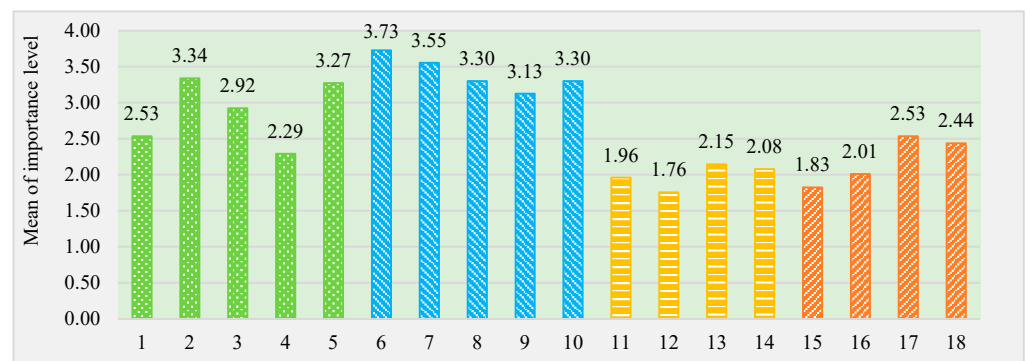
<b>Kaiser–Meyer–Olkin Measure of Sampling Adequacy</b>		<b>0.837</b>
Bartlett's Test of Sphericity (BTS)	Approx. Chi-Square	1011.678
	df	153
	Sig.	0.000

Varimax was implemented for the factor rotation after the initial set of factors were extracted based on the PCA. The Kaiser criterion (eigenvalue-one criterion) and variance accounted for criterion were employed to determine the number of factors to retain. If a factor's eigenvalue was greater than 1, then this factor was extracted as a component. In addition, the sum of the variance accounted for more than 60% of the total. Based on both criteria, there were four principal components extracted by the PCA. The results are presented in Section 4.

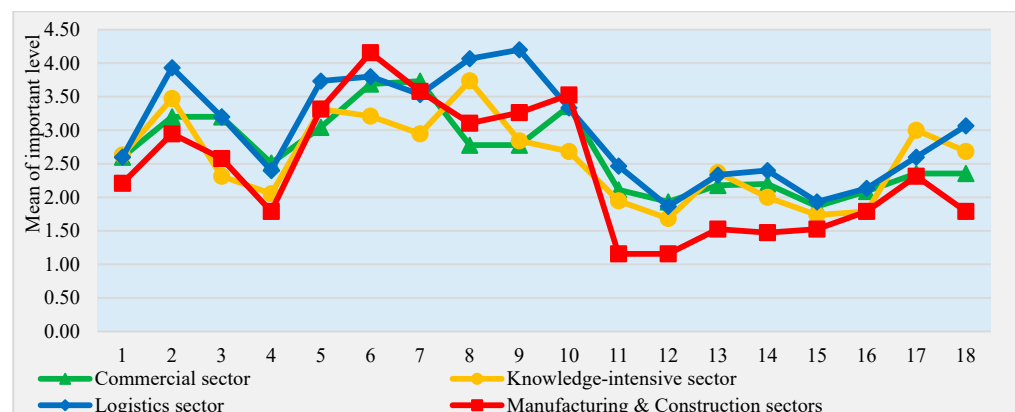
#### 4. Results for Critical Factors That Drive the Growth of Airport Agglomeration

The major themes and their factors generated from the interview data are listed in Table 8.

Based on the questionnaire survey results, the relative importance of the 18 factors is presented in Figure 5. The significance of these factors varies across different industrial sectors (see Figure 6).



**Figure 5.** Significance of the 18 agglomeration factors rated by the surveyed respondents using a 5-point Likert scale. (Factors 1 to 5 indicate localisation economies, factors 6 to 10 represent urbanisation economies, factors 11 to 14 indicate government impact, and factors 15 to 18 denote institutional factors).



**Figure 6.** Significance of agglomeration factors by sector.

**Table 8.** Analysis of the interview data.

Themes	Factors	Numbers of Respondents	The statements of Views or Quotes from the Respondents about the Main Advantages Brought by the Factor
Urbanisation economies	Airport accessibility	7 firms	Views from the property clients: Being convenient for the external managers or directors to frequently visit the company (No. 1) Reducing a lot of time to deliver goods by air (Nos. 13, 16, and 17) Views from the property managers: Large cost savings (No. 31)
	Ground transportation connectivity	11 firms	Views from the property clients: Being convenient for their customers to visit the stores (No. 5) Bring large traffic flows to them (No. 29) Views from the property managers: Attract their clients (No. 31)
	Availability of property	28 firms	Views from the property clients: Lower property price to maintain the lower price of their products to keep their old customers (No. 5, 15, 16) Larger size and space of the property, including warehouse and parking space (Nos. 4, 5, 14, 16, 25, and 27) Suitable building layout (Nos. 11 and 16) Views from the property managers: The cheaper land was one of the strengths of the airport (No. 31)
	Complement-ary services	10 firms	Views from the property clients: Benefit from nearby these freight companies, as they can save a lot of cost and time for goods transportation (Nos. 1, 3, 4, 5, 10, and 17) Views from the property managers: Greatly benefited from the convenience within the airport precinct, such as banking service, café or food services, and hotel services (No. 31)
	Big catchment for customer flows	15 firms	Views from the property clients: Connecting to both domestic and international markets (Nos. 24 and 29) Customer flows consist of air passengers (Nos. 14, 15, 21, 26, 27, 29, and 30), employees working at airports or airport-based companies (Nos. 5, 23, and 28), and people from other metropolitan areas (Nos. 23, 24, and 27) Views from the property managers: An essential advantage of the airport to attract commercial businesses (No. 31)
Localisation economies	Other factors	-	Views from the property clients: The improved infrastructure, such as the reliability of the electricity network (No. 16) Proximity to the CBD (Nos. 3, 14, and 22) Proximity to the Brisbane Port (Nos. 6 and 16) Views from the property managers: Security within the airport precinct (No. 31)
	Proximity to customers or clients	7 firms	Views from the property clients: “The proximity is the most important thing for us. Being close to them allows us quick access” (No. 8) Many of the businesses that they interacted with were from around the airport (No. 9) Most of its customers (approximately 70% or 80%) were located around the airport area (No. 6)
	Proximity to suppliers	7 firms	Views from the property clients: “It’s close to one of our major suppliers” (No. 11) “We prefer to go as shorter distance as possible for the right product” (No. 7)
	Coordination with or benefit from related companies	4 firms	Views from the property clients: “Having them (related companies) here, a lot of tradesmen and stuff come to them. So, we being in close proximity to them also gets more people in here” (No. 14)
	Access to skilled workers	No interview respondents	-



Table 8. *Cont.*

Themes	Factors	Numbers of Respondents	The statements of Views or Quotes from the Respondents about the Main Advantages Brought by the Factor
Social and institutional factors	Zoning and land uses	6 firms	Views from the property clients: Being in the Eagle Farm industrial area, “we’ve got a much bigger block of land, compared to what we used to” (No. 14) “It’s because of the manufacturing industrial area. That’s why we are here” (No. 20) “It’s just the fact that Eagle Farm is one of the most desirable places in Brisbane for our type of business” (No. 8) The store was rezoned to a residential area so they were forced to move out (No. 15) They are land-intensive businesses that require large land occupation
	Prestige of being at or near the airport	7 firms	Views from the property managers: Profit from the opportunities of promoting their airport brand awareness that is not available off-airport (No. 31) Views from the property clients: Being near the airport “does make our brand noticeable” (No. 14) The success of those stores was partially attributed to the branding of the DFO (Nos. 1, 26, 29, and 30)
	24/7 operations	Property manager	Views from the property managers: The Auto Mall that can be operated on Sundays, which “completely changes the dynamic of the automotive retailing industry in this region well” (No. 31)
	Other factors	-	Views from the property clients: Industrial inertia due to the immobility of the capital plant and government regulations around the production process: They did not have a plan to move out because “it would cost a lot of money to move this sort of facility” (No. 20) Demand for the quality of life: “we wouldn’t come here, and it was very close to my house too. It’s a nicer area, because it was amongst residential houses” (No. 16) Government policy had no impact on their location decision (Nos. 2, 3, 4, 6, 9, 11, 12, 14, 15, 16, 17, 21, 22, 23, 25, and 26) Strategies for the airport area (Nos. 3, 9, 22, and 25) Professional networks (Nos. 3 and 22)

Note: The “No.” is used to identify the participants (see Table 5).

In the logistics sector, there were 11 factors that were given the highest scores of importance across all the sectors, involving all the airport-related factors (factors 2, 8, 9, and 18). This explains that the logistics sector was most strongly impacted by these factors, especially those that were airport-related, because this sector relies more on air freight services than the other sectors. Of these 11 factors, factor 9 (proximity to air freight companies) was the most critical factor with the highest score, seconded by factor 8 (airport accessibility).

In the commercial sector, factor 7 (access to ground transportation) was considered the most crucial factor because it determined the scale of the catchment, which was often a major concern for commercial firms. This sector was ranked as second in factor 10 (proximity to third-party logistics service providers), which means that the services provided by the logistics companies were very important to the commercial firms.

In contrast to other sectors, factor 13 (strategy for the airport area) and factor 17 (interpersonal or professional networks) were rated the highest in the knowledge-intensive sector. This is because knowledge-intensive firms can benefit from projects around the area, such as airport expansion or hotel construction, which draw more clients. Interpersonal or professional networks were also very important for this sector because networks facilitate the transmission of knowledge or information. Factor 8 (airport accessibility) was considered the most important for knowledge-intensive firms of the 18 location factors because these firms have a high demand for long distance face-to-face contacts.

### Principal Component Analysis (PCA) of Dominant Agglomeration Factors

There were four components identified by the PCA. The total variance, including both the initial extracted factors and the rotated factors, is presented in Table 9. Based on this table, the four components explained 65.771% of the total variance, indicating that these components captured the most essential information, i.e., 65.771% of all variance contained in the 18 variables. The larger the proportion of variance in each component indicates the more information that the component captured from the variables and the higher amount of shared common variance within the four components of the PCA model.

**Table 9.** Total variance of the four components identified from the 18 agglomeration factors by principal component analysis.

Components	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.374	40.965	40.965	3.665	20.360	20.360
2	2.005	11.141	52.106	3.170	17.610	37.970
3	1.437	7.981	60.087	2.881	16.005	53.975
4	1.023	5.684	65.771	2.123	11.796	65.771

Table 10 presents the rotated component matrix, demonstrating the correlation of the 18 factors with each rotated component. To make the data easier to read, only the correlation coefficients greater than 0.6 are displayed in the table, while those below 0.6 are omitted. This is because a Pearson correlation coefficient greater than 0.6 is regarded as a strong positive correlation [56,57]. Table 10 shows that the first component is highly correlated with factors 11, 12, 15, and 16. These four factors are associated with the institutional support system. Consequently, this component is labelled the “Institutional Support System”. The second component is composed of factors 1, 4, and 5, representing “Localisation Economies”. The third component can be explained by factors 2, 8, and 9. These factors are all related to the airport. As a result, this third component is called the “Airport Impact”. The last component is tied to factors 6, 7, and 10, reflecting “Urbanisation Economies”.

**Table 10.** Rotated component matrix indicating the correlation of agglomeration factors with each rotated component.

Location Factors		Component			
		1	2	3	4
Factor 1	Access to specialist workers		0.716		
Factor 2	Proximity to airport-related suppliers or customers			0.665	
Factor 3	Proximity to distributors				
Factor 4	Being located near competitors		0.614		
Factor 5	Coordination with related and supporting industries		0.715		
Factor 6	Availability of warehouse space/land				0.777
Factor 7	Access to ground transportation				0.740
Factor 8	Airport accessibility			0.820	
Factor 9	Proximity to air freight companies			0.807	
Factor 10	Proximity to third-party logistics service providers/freight forwarders				0.682
Factor 11	Financial incentive (provision of venture capital or subsidies)	0.865			
Factor 12	Tax reduction or exempt	0.846			
Factor 13	Strategy for the area as presented in the Brisbane Airport Master Plan				
Factor 14	Other policies for airport area/trade coast region produced by local, state, or federal government				
Factor 15	Access to universities, research institutions, and training and technological centres	0.693			
Factor 16	Access to local industrial body representatives	0.626			
Factor 17	Interpersonal/professional networks				
Factor 18	Prestige of a location near Brisbane Airport				

Extraction Method: Principal Component Analysis  
 Rotation Method: Varimax with Kaiser Normalization  
 a. Rotation converged in 6 iterations

Therefore, this study identified four types of agglomeration mechanisms of industrial clusters around the airport by PCA. Table 11 lists the summary statistics of these mechanisms in terms of percentage of variance and mean. Here, the mean is the average scores of importance of the factors corresponding to each component (see Table 6). The institutional support system

had the highest ratio of variance, indicating that it explained the highest amount of the shared common variance within the four components (20.360%), followed by localisation economies (17.610%), the airport impact (16.005%), and urbanisation economies (11.796%).

**Table 11.** Summary statistics of four mechanisms (components) identified by principal component analysis.

Component	Factors		% of Variance	Mean
1. Institutional Support System	11	Financial incentive (provision of venture capital or subsidies)	20.360	1.89
	12	Tax reduction or exempt		
	15	Access to universities, research institutions, and training and technological centres		
	16	Access to local industrial body representatives		
2. Localisation Economies	1	Access to specialist workers	17.610	2.70
	4	Being located near competitors		
	5	Coordination with related and supporting industries		
3. Airport Impact	2	Proximity to airport-related suppliers or customers	16.005	3.26
	8	Airport accessibility		
	9	Proximity to air freight companies		
4. Urbanisation Economies	6	Availability of warehouse space/land	11.796	3.53
	7	Access to ground transportation		
	10	Proximity to third-party logistics service providers/freight forwarders		

The four components had a different significance in influencing the location of industries based on the views of the survey respondents, indicated by the mean in Table 11. The institutional support system had the lowest mean among all the mechanisms, revealing that this mechanism had the smallest impact on the location decision of all the sectors. This was followed by localisation economies and the airport impact. Urbanisation economies had the largest mean, reflecting that they were the most critical driver to draw industries to the airport environs. The quantitative findings were aligned with the findings from the interviews.

## 5. Analysis and Discussion of Mechanisms That Drive Airport Agglomeration

This section brings together analyses of both the qualitative and quantitative data to reveal that the airport city model of airport dynamics was not the dominant driver for the urban development around the airport in the Brisbane case study context. Cidell [5] argued that the influence of airports is overstated in the airport city model. This study confirmed Cidell's argument by finding that airport agglomeration was a result of multiple drivers, in which the direct airport proximity was not the most critical factor for agglomeration.

Cidell [5] did not deny the existence of the airport city; she found in her research that some firms were attracted to the region by the growth of air services and deliberately located around the airport. This means that airport-related firms had a high demand for the space in the airport immediate vicinity. Two major themes related to the airport's impact were identified based on the interviews: airport accessibility and large catchment of customer flows (Table 8). Airport accessibility was a primary concern for the industries with a high demand for air services to transport people or goods [14,58–60]. The large catchment of customer flows, created by the airport infrastructure, enabled the commercial sector to access easily both domestic and international consumers. This advantage significantly contributed to the performance of the commercial sector in the airport environs.

The survey results of agglomeration factors across the sectors (Figure 6) supported and complemented the above themes on airport impact; these results indicated that proximity to air freight (factor 9) was the most significant driver to motivate the logistics sector to locate in airport areas, followed by airport accessibility, while the knowledge-intensive sector considered airport accessibility (factor 8) to be the most important. Both the logistics and knowledge-intensive sectors were most strongly influenced by the airport-related

factors, especially airport accessibility. This confirmed Appold's [14] finding that airport access was responsible for the presence of transportation-providing employment, primarily for the logistics service providers.

However, airports anchor not only airport-related but also non-airport-related industries, as Appold [14] emphasised—employment in the airport environs may or may not be related to aviation or to the airport. Accordingly, the impact of airports was only one mechanism that drove the growth of airport agglomeration. This was further confirmed by Sonnenburg and Braun [13] that the position size and the accessibility of motorways and labour force were regarded as more significant determinants for the growth of suburban employment centres than airport accessibility. Appold [14] drew a similar conclusion that major highways and proximity to the CBD had larger impacts on the size of airport cities than air-intensity. Cidell [5] also confirmed that ground transport access was more important than air access in attracting firms to locate near the airport. Consistent with the previous studies, this research found that urbanisation economies were the most critical mechanism to drive the growth of airport landside industries (Tables 8 and 11).

Three primary factors associated with urbanisation economies were identified by the thematic analysis, including the availability of property (including price, size, and layout), ground transportation connectivity, and complementary services (especially logistics) (Table 8). The low price and large size of properties is an advantage of Brisbane Airport and its environs to attract industries from the areas in the city centre or fringe. Almost all interviewees noted that inexpensive and large-size property was one of the most important factors to motivate them to locate in the airport area (Table 8). This is an effect of spatial filtering based on urban land-rent, which demonstrates that airport cities are partially driven by urban spatial expansion. Evidence of airport cities as a by-product of urban sprawl was also found in the Appold's study [14]. Particularly, land-intensive industries that require large properties, such as manufacturing and wholesalers, were strongly influenced by this effect. Sonnenburg and Braun [13] supported the significant impact of the availability of property on industrial location, as they found that low prices for land, floor space, and car parking, as well as sufficient land, were more attractive to non-airport-related industries than air transport accessibility. In this study, sixteen interviewees considered the availability of space (parking and warehousing) as important. The survey results also indicated that the availability of warehouse space and land (factor 6) had the most significant impact on the firms' location (Figure 5); in particular, manufacturing and construction sectors were most strongly attracted by this factor (Figure 6).

Ground transportation connectivity was a second strength of the urbanisation economies that enabled the airport to attract industries, particularly non-airport related businesses. As discussed, previous studies confirm that land access connections, such as access to highways and motorways, had a more significant impact on the growth of airport cities than did air transport accessibility [5,13,14]. In this study, eleven interviewees regarded this factor as important (Table 8). The survey results indicated that access to ground transportation (factor 7) was the second most important factor that impacted the firms' location decision among the 18 factors (Figure 5); the commercial sector was most strongly influenced by this factor across the four sectors (Figure 6).

Complementary services were the third major benefit related to urbanisation economies. A large number of logistics companies were attracted to the airport vicinity, as airports are a multi-mode transport node and have excellent ground access. Accordingly, industries that require frequent logistics services were also drawn to airport areas for cost and time savings. In this research, ten interviewees considered being proximate to logistics service providers as important for their location choice (Table 8); the survey results also supported this evidence, as the significance of the proximity to third-party logistics service providers (factor 10) was ranked fourth among the 18 location factors (Figure 5).

Other urbanisation economies were derived from the factors, such as infrastructure, security, and proximity to the CBD and the port. Seven participants (including two interviewees and three survey respondents) viewed proximity to the CBD as an important factor



to their location decision; while two interviewees (including one logistics firm and one electrical service provider) noted that proximity to the Brisbane Port significantly impacted their location choice. This factor strongly impacted the logistics firms that rely on sea freight. This evidence demonstrated that the growth of airport cities was partially driven by the impact of other significant centres, such as the CBD and the port. The impact of other significant centres needs to be considered when the airport “as a job generator” is evaluated, otherwise it can lead to an overly optimistic conclusion about the airport’s importance; for example, industries concentrated in the Bulwer Island precinct (an industrial area adjacent to the Brisbane Airport) were strongly impacted by the Brisbane Port rather than the airport, as this area is designated for general/heavy industries, particularly those with high demand for port access.

Evidence of the above agglomeration mechanisms demonstrated that airport cities are a product of a combination of drivers rather than simple proximity to the airport. This was supported by Appold [14], who argued that airport cities are a mixed result of both the airport influence and urban spatial expansion, rather than a simple product of one or the other. Surprisingly, airport impact was only one driver, most significantly influencing the airport-related industries, while urbanisation economies were identified as the most critical driver in this study, being particularly important for non-airport-related industries. Airport cities have developed under the interplay of multiple drivers. Consequently, the dominant driver responsible for the growth of airport cities varies across airports based on the individual histories and geographies of regions. Undeniably, the impact of airports outperforms other factors in the major freight and logistics airport hubs, where spin-off effects in the airport vicinity are substantial; examples include the Louisville and Memphis airports [5]. However, these effects can be quite limited in most of the airports, where mechanisms other than the airport impact are dominant.

Within the Australian context, the spillover effects of Sydney Airport, the largest airport in terms of passengers and freight, are limited. This is primarily due to the physical constraints imposed by the surrounding metropolitan area and the limited land base of the airport. This is one of the few international airports that has noise curfews. Freestone and Tice [61] noted that Sydney Airport has not been developed at the scale as anticipated compared with airports of a similar size. Consequently, the construction of a second airport (Nancy Bird Walton Airport) in Western Sydney has been underway, as the metropolitan area in greater Western Sydney has continued to expand. This second Sydney airport, which is presently under construction, is being developed around the aerotropolis model and is expected to be an economic centre in Western Sydney, attracting both airport-related and non-airport-related activities. Much of the development in local councils, such as Liverpool, is centered on the airport as a potential freight hub. The scale of development is documented in the Western Sydney Aerotropolis Land Use and Infrastructure Implementation Plan (2018) around an 11,200 hectare site contributing to “200,000 jobs for Western Sydney” (p. 15). The airport impact is only one driver in the large-scale development of Western Sydney. However, the delivery of the vision of the aerotropolis is firmly based on the precept that the airport will be an economic driver within its own right, and “a once-in-a-generation economic boom” will be created by the airport (p. 9). The findings from our study suggest that much of the synergies of the airport’s landside will be generated by the surrounding city, rather than the airport itself.

## 6. Conclusions

This research finds that airport agglomeration is driven by a combination of drivers, with urbanisation economies as the dominant factor. The significance of the agglomeration factors varies by sector. The airport impact is only one of the drivers responsible for landside development, most significantly influencing the airport-related industries. Urbanisation economies, rather just the airport, are the dominant mechanism that attracts industries to the airport areas; this is particularly important for non-airport-related industries. The findings support the studies of Cidell [5] and Sonnenburg and Braun [13] on the limits of

the role of airports in the airport city model. The airport is not the engine that drives the land development, but rather, the airport is part of a much larger urbanized economy.

This research fills a gap in airport studies by exploring the airport's impact at the local level and its differences across industrial sectors using the case study approach. The findings refute the role of airports as a dominant economic engine, as claimed in the airport city model in the Australian context, which is in line with Cidell's [5] arguments. Specifically, this research validates Cidell's [5] findings within a different context, which indicates that her argument is applicable internationally. However, this study was limited in that MapQuery was unable to identify airports with similar names to others. Melbourne Airport had to be discarded in the analysis of Table 4 due to its similarity to Orlando Melbourne International Airport in the USA. This study focused on only one airport case. Further research can apply the methods applied in this study to other similar contexts, such as ports or railways, to compare the impact of the infrastructure on the local economies with other significant transport hubs. Additionally, further case study research on why firms are attracted to airport environs can be extended to other international airports to enrich the empirical findings in this substantive area.

Our research demonstrates a different picture of the connection between airports and economic development than that which has been promulgated by the airport city model. For those with an investment in airport location and development, the complexities of the economic geographies of airports and their surrounding industries need to be understood and factored into the planning [62]. In the movie *Field of Dreams*, the main character exclaims "if you build it, they will come" in reference to a sporting infrastructure. This belief underpins the airport city model. However, as this research demonstrates, the economic geographies of airports are shaped by a dense complexity of factors, among which the actual airport is only one driver.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land12071327/s1>, Supplementary Materials: Industrial classification based on 4-digit ANZSIC codes.

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## Note

- <sup>1</sup> In this research, "airport impact" refers to the influence of air traffic on the location choice of firms, which includes factors such as airport accessibility, proximity to air freight companies, proximity to airport-related suppliers or customers, and customer flows brought by air traffic.

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