buildings

MDPI

Article

Innovation District Typology Classification via Performance Framework: Insights from Sydney, Melbourne, and Brisbane

Rosemary Adu-McVie [1], Tan Yigitcanlar [1,*], Bo Xia [1] and Isil Erol [2]

[1] City 4.0 Lab, Faculty of Engineering, Queensland University of Technology, 2 George Street, Brisbane, QLD 4000, Australia
[2] Department of Real Estate & Planning, Henley Business School, University of Reading, Whiteknights Rd, Reading RG6 6UD, UK
* Correspondence: tan.yigitcanlar@qut.edu.au; Tel.: +61-7-3138-2418

Abstract: As a new land use type, innovation districts are taking prominence in the urban development policies and plans of many cities across the globe. This new urban land use comes in many shapes and forms and offers various features and functions to the users. Despite its increasing popularity, there exist only limited approaches to classify innovation districts, and there are no holistic typologies developed so far. This study focuses on this understudied, but important area of research. The paper aims to develop an innovation district typology matrix and evaluates its practicality with real innovation district data. The methodological approach is three-fold. First, the multidimensional innovation district classification framework is adopted as a performance framework. Second, data from three eminent Australian innovation districts—i.e., Macquarie Park Innovation District (Sydney), Monash Technology Precinct (Melbourne), and Kelvin Grove Urban Village (Brisbane)—are collected. Third, both qualitative and quantitative analysis methods are employed for data analysis. The study finds that innovation district performances can be measured, and typologies can be developed though a novel approach. These, in return, inform property developers and managers, city administrators, and urban planners in their efforts to plan, design, develop, and manage competitive innovation districts.

Keywords: innovation district; innovation district classification; typology matrix; Macquarie Park Innovation District; Monash Technology Precinct; Kelvin Grove Urban Village; Australia

Citation: Adu-McVie, R.; Yigitcanlar, T.; Xia, B.; Erol, I. Innovation District Typology Classification via Performance Framework: Insights from Sydney, Melbourne, and Brisbane. *Buildings* **2022**, *12*, 1398. https://doi.org/10.3390/buildings12091398

Academic Editors: Nikolai Vatin, Mohammed Hamza Momade and Saurav Dixit

Received: 17 August 2022
Accepted: 2 September 2022
Published: 6 September 2022

1. Introduction

During the last several decades, urban locations have started to heavily dominate the hosting of innovation activities [1,2]. In line with such domination, the concept of innovation districts has globally been recognized and accepted as the new urban land use type by many cities for the economic, social, and spatial benefits they offer to the host city [3–6]. However, developing innovation districts is a risky investment with a high cost; hence, there is a need for the holistic assessment of their performance to inform relevant stakeholders involved in the planning, development, and management of these districts [7–10]. Such an assessment will identify areas with the most-needed interventions as well as policy and investment decisions on developing innovation district types with characteristics that are most suitable for the specific locations [11–13], and, consequently, contributing to the success of innovation districts. This calls for the employment of a holistic assessment framework, which the literature confirms is lacking [14].

Typologies are analytical tools that are employed by diverse disciplines including urban planning and development and related fields for classification analysis, which involves the process of performance assessment and the creation of typologies. So far, there are limited studies on the classification of innovation districts, including [15], who identified four typologies and [16] five typologies.

However, these classification studies only focus on partial dimensions—e.g., 'firm configuration' and 'industry type' [15,16]—and exclude other important spatial attributes; hence, they do not holistically classify their case study innovation districts. A notable reason is due to the lack of suitable performance frameworks. To date, and to the best of our knowledge, only one multidimensional performance framework has been designed by the authors in their previous study [14] to holistically classify innovation districts.

The study aims to contribute to the body of knowledge by adopting the multidimensional innovation district performance framework and testing its practicality through a three-step process [12], as illustrated in Figure 1, on three selected innovation districts representing Australia's largest cities, i.e., Sydney, Melbourne, and Brisbane. This study focuses on producing: (a) a ranking of innovation districts based on their performances; (b) a performance matrix that categorizes innovation districts into clusters; (c) a typology matrix that describes the character of innovation districts, and (d) subsequently a better understanding on the holistic assessment of innovation district performances.

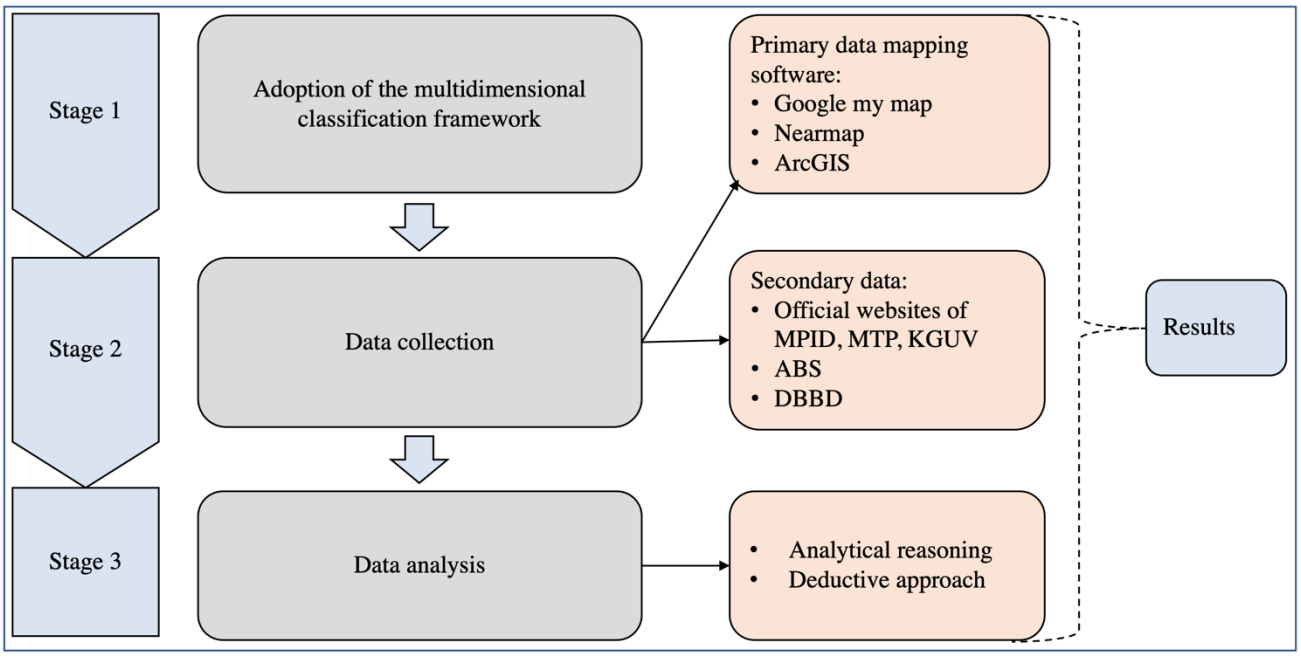

Figure 1. Stages of the research.

This paper is structured as follows. Section 2 presents the literature review concerning the various name tags for innovation districts; typology as an analytical tool and its use not only in social science, but by diverse disciplines including urban planning and development; the evolution of innovation district classification; and the multidimensional innovation district performance framework. Section 3 presents the research design, introduces the case study, and then discusses the methods the study utilized in the data collection and analysis. Section 4 presents the study's findings. Section 5 discusses the findings. Section 6 highlights the implications and concludes the paper.

2. Literature Background

The term 'innovation district' is described by [14] as an expansive term that includes similar developments such as high technology districts (Forsyth, 2014), science and technology parks [17], innovation and cultural districts [18], innovation precincts [19], knowledge and innovation spaces [12], and knowledge community precincts [20]. Some of the world's most renowned innovation districts include the United States' (US's) Silicone Valley, France's Sophia Antipolis, Spain's 22@Barcelona, Singapore's One North, and Australia's Macquarie Park Innovation District. Despite the fact that these districts come in various

sizes, forms, and characteristics, they all have a common purpose, i.e., to achieve agglomeration benefits in terms of economic, technological, sociocultural, and environmental outcomes for their host cities [14].

The term 'typology' is defined as organized system of types and is a well-established analytical tool in the social sciences. Typologies facilitate 'diverse analytical tasks forming and refining concepts, drawing out underlying dimensions, creating categories for classification and measurement, and sorting cases' [21]. The use of typologies as analytical tools dates to the early 1970s and includes [22] analysis and identification of 'polyarchies', 'competitive oligarchies', 'inclusive hegemonies', and 'closed hegemonies'. To date, typologies are still employed for classification analysis by diverse disciplines including climatology [23], architectural and building sciences [24,25], urban studies [26,27], and ecosystems studies [28]. Typology outcomes are typically illustrated in a matrix form, an approach seen as a method that uses a system of different criteria for classifying elements [24].

Attempts to classify industrial districts and clusters, which are accepted as the predecessors of innovation districts, date back to 1996 [15,29–31]. From the start of the millennium, most of these industrial clusters were transformed into innovation districts [32–34], and in recent years, there has been an increasing interest in classifying innovation districts or the new 'innovation spaces' [35–38]. These attempts have resulted in the emergence of some famous innovation district typologies including the anchor plus, re-imagined urban areas and urbanized science parks [39,40], corridors, clumps, cores, and comprehensive campuses [41]. Whilst these studies identified some typologies, none of them holistically classified innovation districts due to the lack of a comprehensive performance framework [14].

Despite the urgent call for a suitable innovation district performance framework, so far, to our best knowledge, there is only one of such frameworks in the current body of knowledge, which was developed recently by [14]: the multidimensional innovation district performance framework (see Table 1). The framework was validated by 32 international experts through a two-round Delphi survey in 2020. The multidimensional performance framework comprises four key dimensions of context, feature, function, and form, with 16 indicators including social amenity, industry type, and land-use mix and 48 measures comprising three tiers (e.g., strong, moderate, weak). It uses multidisciplinary objective methods for measuring indicators. The framework's main purpose is to classify the typologies of innovation districts based on their characteristics and performance. Hence, the multidimensional framework serves a dual purpose: first, as a performance framework and second, as a classification framework.

Table 1. Multidimensional innovation district performance framework.

Dimension	Indicator	Description	Measure
Context	Spatial system	City-wide spatial layout and architecture qualities including physical environment	Strong
			Moderate
			Weak
	Societal system	Societal progress of the city including diversity and age structure	Strong
			Moderate
			Weak
	Governance system	Political progress of the city including political institution effectiveness, transparency, and accountability	Strong
			Moderate
			Weak
	Economic system	Macroeconomic progress of the city including monetary and fiscal performance	Strong
			Moderate
			Weak

Table 1. *Cont.*

Dimension	Indicator	Description	Measure
Feature	Social amenity	Presence/availability of social amenities for public use within the innovation district	Strong
			Moderate
			Weak
	Human capital	Inventory of skilled people	Strong
			Moderate
			Weak
	Skilled labor	Skilled employment outcome of the innovation districts activities	Strong
			Weak
			Moderate
	Locality setting	Location of the district within the metropolitan area	Inner city
			Suburban
			Regional
Function	Company size	Relative size of the firms within the innovation district	Multinational enterprises (MNE) anchored
			Large national enterprises (LNE) dominated
			Small and medium enterprises (SME) dominated
	Industry type	Dominant business activity operating within the innovation district	Creativity-intensive businesses
			Technology-intensive businesses
			Business support services
	Investment type	Principle support and funding body for the development of the innovation district	Public–private–community partnership
			Public–private partnership
			Public or private sector driven
	Property management	Management model of the innovation districts' properties and activities	District-wide body corporate
			Building-based body corporate
			None
Form	Green–blue infrastructure	Aesthetic qualities of urban green and blue	Strong
			Moderate
			Weak
	Land-use mix	Main land use types within the innovation district	Complex mix
			Mixed-use
			Single use
	Built environment	Architectural design of built forms and functions encouraging open innovation systems, connectivity, and mobility within the innovation district	Strong
			Moderate
			Weak
	Space design	Spatial layout design encouraging open innovation system within the innovation district	Open layout
			Semi-open layout
			Closed layout

3. Materials and Methods

This study applied a case study method to test the abovementioned multidimensional performance framework on three internationally recognized Australian innovation districts and classify these districts based on their performance. The case study method is used by diverse disciplines as a 'robust research method particularly when a holistic, in-depth investigation is required' [42,43]. The case studies are identified as a qualitative form of research design. Their subjects for analysis usually include persons, social communities, and organizations [44]. The present study's aim falls within the above-stated requirement; hence, a case study approach is suitable. Information on the case study is provided in Section 3.1. To apply the framework, the study followed [12] three-step process (Figure 1), which is briefly discussed in Section 3.2.

3.1. Case Studies

The following three leading Australian innovation districts are selected for the study: Macquarie Park Innovation District (MPID) in Sydney, Monash Technology Precinct (MTP) in Melbourne, and Kelvin Grove Urban Village (KGUV) in Brisbane. From these three cases, MPID is recognized as the largest and most mature innovation district in Australia, MTP is seen as the leading non-central business district hub for employment, economic growth, and innovation in Victoria [45,46], and KGUV is one of the best known 'new urbanism' projects in Australia formed as a mixed-use master planned community [47]. Figures 2–4 show the location of the case study innovation districts—licensed Nearmap software was used to create these figures.

Figure 2. Location of Macquarie Park Innovation District.

MPID is an 'industry-led initiative' that was reestablished in 2015 (as an extension of Macquarie Park that was established in 1999) by key stakeholders to strengthen 'their competitive advantage in life sciences, health and pharmaceuticals, digital and biotechnology' [48]. MTP was established in 1984 based on a public–university–private initiative. It hosts leading institutions in education, health, research, and innovation business activities. Compared to the other two case study innovation districts, KGUV is a medium-size district in terms of land area and was established in 2003 under a public–private–university–community investment partnership. Additionally, KGUV is Australia's first mixed-used master planned urban village and university precinct [49,50]. It is also one of Brisbane's eight global precincts [51–53], which hosts health and education research, creativity, residential housing, and retail activities.

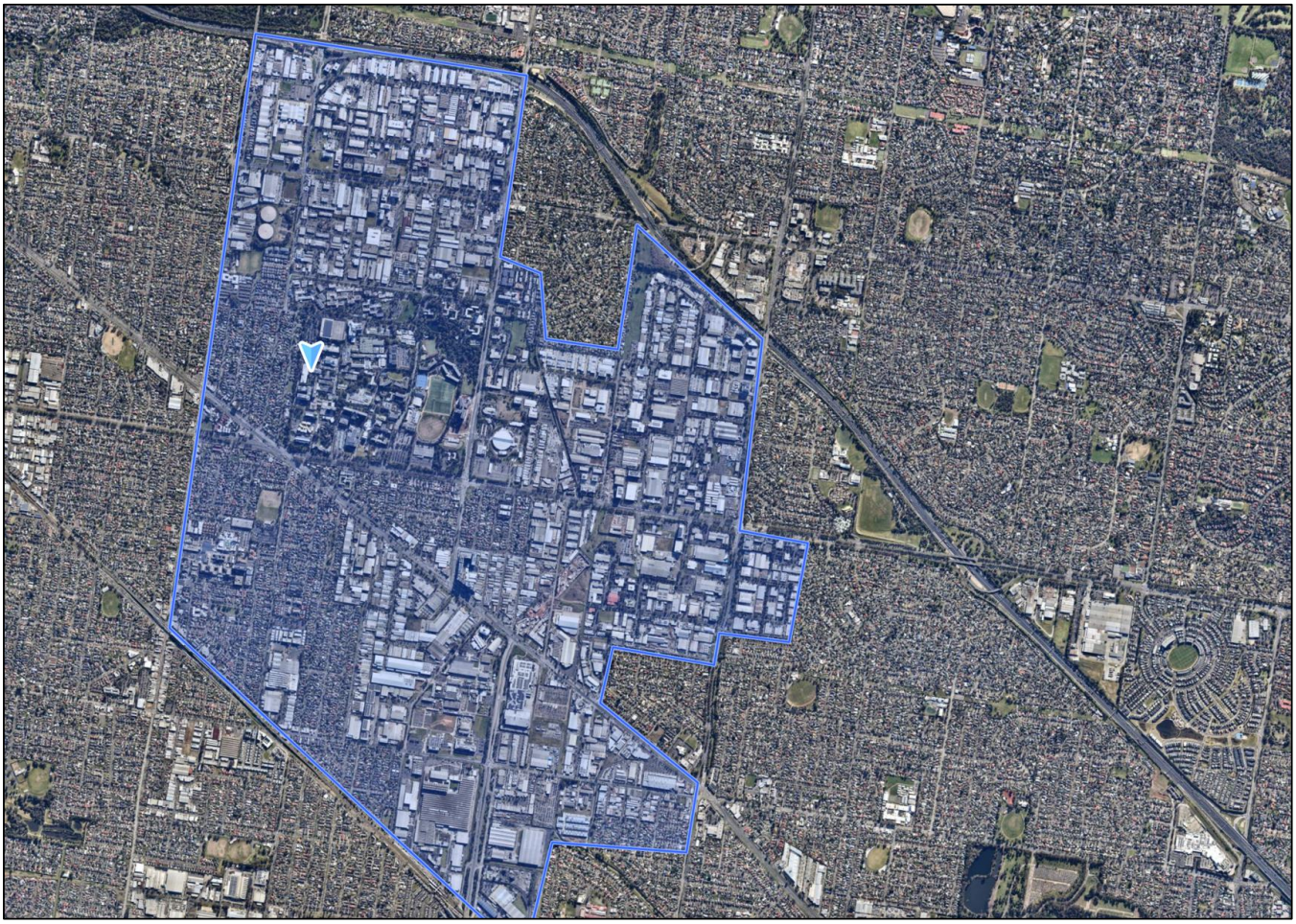

Figure 3. Location of Monash Technology Precinct.

Each of the selected innovation districts is strategically located in their respective state's economic corridors, which obviously contributed to their rapid and successful growth. Located in Sydney's northern district and along the 'Global Economic Corridor of Sydney', MPID's suburban area is approximately 12 km from the CBD and is adjacent to Lane Cove National Park that provides green and blue spaces for leisure and physical exercise activities [12]. Likewise, MTP is also a suburban area in Clayton (Melbourne's southeast), which is 23 km from the Melbourne's CBD. It sits at the crossroads of Clayton, Wellington, Blackburn, and Dandenong roads, and the Monash Freeway. On the other hand, KGUV is an inner-city suburb located less than 3 km from Brisbane's CBD. It sits amidst the Kelvin Grove and Victoria Park roads and is surrounded by major arterial roads to the north and south and is accessible from the Inner-City Bypass, Airport Link, CLEM7 and Legacy Way tunnels [54]. Regarding the size, MTP and MPID have larger land areas of 6.9 km^2 and 6.8 km^2, respectively, whilst KGUV is only 0.37 km^2 [55].

All three case districts contain top universities such as the Macquarie University, Monash University, and Queensland University of Technology, as well as research and training hospitals, e.g., the Macquarie University Hospital (MPID), Monash Medical Trial Centre at Monash Health (MTP), and Kelvin Grove Medical Centre as the main anchors. In terms of the workforce and number of existing businesses, MPID has more than 380 businesses employing over 45,000 people and has some of Australia's top 100 companies including Cochlear, Sony Australia, Foxtel, Microsoft, and Johnson & Johnson, with their head offices located within the district [56]. MTP, on the other hand, is referred to as an ecosystem because it hosts 13,000 businesses employing over 94,000 employees [46]. The top organizations and companies located in this district include CSIRO, ANSTO Synchrotron, Agilent, Bosch, and

Johnson & Johnson. In contrast, KGUV only has around 50 businesses employing approximately 4000 people. Besides its anchors and the Queensland Academy of Creative Industries, the other existing businesses are mainly in the health care (e.g., medical centers), retail, and food service (e.g., restaurants) sectors.

Figure 4. Location of Kelvin Grove Urban Village.

In terms of economic growth, MPID and MTP contribute approximately AUD 9 billion to their state's economic output. Whilst there are no publicly available data on KGUV's economic contribution, it is believed that KGUV (as one of Brisbane's eight global precincts) has contributed significantly to the Brisbane region's AUD 181 billion gross regional product for 2020–2021 [57]. Demographically, all three districts have a large proportion of their populations with high education degrees—i.e., in MPID, 78% of the district population has a minimum of a bachelor or higher degree (BA+) qualification, and this ratio is 93% for KGUV and 61% for MTP. Considering the potential labor force, 67% of MTP's, 70% of MPID's, and 68% of KGUV's respective Statistical Area 2 (SA2) population falls into the age category of 15 to 44 years with a graduate certificate and bachelor or further qualifications [55], thus indicating the strong presence of a young workforce.

3.2. Data Collection

The present study employed [12] three-step process (Figure 1) to test the application of the multidimensional framework on three selected innovation districts. Firstly, it involved the adoption of the framework to guide the remaining two stages of data collection and analysis, respectively. Secondly, the study applied desktop audits using mapping and GIS software, specifically Google My Map, Nearmap, and ArcGIS, to collect the primary data,

whereas the secondary data were collected from the official websites of the case innovation districts, the Australian Bureau of Statistics (ABS), and the Dun & Bradstreet Business Directory (DBBD). Thirdly, the study employed analytical reasoning method and the deductive approach for the data analysis. The validated multidimensional framework was employed in the deductive approach to test each of the indicators for the three innovation districts.

Primary and secondary data were collected and used to assess the performance of the selected case districts. The primary data included spatial data such as land-use mix and space design and descriptive data of social amenities, and the secondary data included demographic statistics on human capital and skilled labor, financial data on tenant companies' annual income, and descriptive information on types of investment. The audits on MPID, MTP, and KGUV were all conducted remotely on a desktop utilizing the mapping software. The legal boundaries of each of the case districts were first identified and marked to ensure the audits were done within the boundary of the case innovation districts. These layout maps also acted as the base maps for further spatial and descriptive analysis.

The three main types of activity that typically exist in any innovation district are: 'technology-intensive businesses' that are composed of firms involved in information communications and technology services, biotechnology, or use high technology and knowledge for the production of goods and services, and carry out research to generate knowledge and innovation [41,58]; 'business support services', composed of firms that provide services such as marketing, auditing, and insurance [59,60] to tenants within the innovation districts; and; 'creativity-intensive businesses' that are mainly involved in music, films, and gaming industries to generate cultural knowledge [61–63].

To determine an accurate estimate of the total business population of the case districts, the study adopted [64] definition of 'technology-intensive businesses', 'creativity-intensive business categories' and 'business support services', wherein the first one is expanded to include other healthcare facilities besides hospitals (e.g., private surgeries and dentistry services), all manufacturing activities, and mechanical and engineering workshops. The second contains businesses involved in music, film, entertainment, cultural, and gaming industries. The last category is composed of services, except for retail, that do not fall into either of the technology-intensive businesses and creativity-intensive business categories, including real estate, wholesalers, consultancy services in the built environment, engineering and financial services, and community services (i.e., senior and childcare services).

The next section discusses the various audit tools employed and describes the process followed to collect the required data. The discussion is presented under the subsections of 'context', 'form', 'feature', and 'function'. It is noteworthy that previous related studies recommended excluding the "context" dimension when assessing the performance of innovation districts, due to its broadness and suitability for regional or city-level assessments [14,19]. However, the present study includes it for the following two reasons. First, three case innovation districts are selected from three major capital cities (i.e., Sydney, Melbourne, and Brisbane) of Australia, respectively; hence, it is useful to identify the influence of cities on these case study districts. Second, it would be more proper to assess all four dimensions since this is a study to test the practicality of the newly validated 'multidimensional innovation district performance framework'.

3.2.1. Context

The secondary data for the indicators of context dimension, namely, 'economic', 'societal', 'spatial', and 'governance' systems, are sourced from the ABS, official websites of Sydney, Melbourne, and Brisbane City Councils, and other relevant reports and related studies. It should be noted that the investigation or audit referred to in this section focuses on the three hosting cities of the case innovation districts.

The audit of the economic system aims to investigate the macroeconomic progress of the case cities by considering their five-year (2016–2020) trend in terms of attributes: gross net debt (GND), gross state product (GSP) growth, inflation, and unemployment rates. The raw data obtained for each city are already in percentage points and therefore

need to be normalized. We opt to compute the median rather than mean scores specifically to avoid skewed results due to the extremely small and large values when calculating the mean [65]. The individual median score for each attribute over the five-year period is computed before calculating a composite median. Finally, we employ Excel's quartile function in the spreadsheet to run the three cities' composite median scores to determine the minimum, median, and maximum values. Note that the composite median scores include attributes GND, inflation and unemployment rate which have negative impact hence, the minimum, median, and maximum values are interpreted in reverse i.e., minimum = strong, medium= moderate, maximum= weak. These values inform the weighting value range, which defines the cities' overall economic performance.

For the societal system, the audit aims to investigate the societal progress of each city in terms of 'diversity', 'tolerance', 'equality', 'age structure', and 'participation in cultural and community activities'. However, due to the availability of data and lengthy processing time, the study only selects 'diversity' and employed Brookings Institute's audit guide to investigate each of the city's baseline measures of diversity, specifically 'workers by ethnicity and gender', 'graduate students by ethnicity and gender', and 'residents by race/gender and foreign-born status'. The raw data obtained are used to compute individual percentage scores for the population by place of birth (POB), and then the composite mean scores are used to determine the ratio of the dominant to minority population by POB. For this attribute, we opt for composite mean because it has a small disparity in percentage scores. Individual mean scores for each POB category per ABS classification are computed. The mean scores are then recategorized into two classes: a dominant class comprising Oceania/Antarctica (Australia included), and a minority class (i.e., all other POBs not included in the former class). The composite mean scores are converted into a minimum, medium, and maximum value, which defines the level of diversity of each city.

For the 'spatial system', the audit aims to investigate each city's spatial layout and architecture qualities in terms of the physical environment (i.e., public green space and playgrounds), unique natural conditions (i.e., waterfronts), unique man-made built environment (i.e., landmarks, heritage preservation, and 'image of the city'), and quality of physical patterns (i.e., characters of the public built environment including basic infrastructure, transportation, and mobility). The study employs the direct method of age standardization—rate per 1000 population [66]—to individually measure most of the spatial attributes except for the city image, where average scores are used, and for basic infrastructure and transportation, where composite scores are employed. To standardize the raw scores, weighting values are given to each attribute before computing the composite and mean scores. Then, quartile values of the mean scores are computed to determine the minimum, median, and maximum value, which defines each city's overall spatial system performance.

Finally, for the 'governance system', the audit aims to assess the city's political progress in terms of political institution effectiveness through public services, accountability and transparency, and participation. Using an audit checklist, the stated governance indicators are primarily assessed from descriptive reports of each city's official annual reports and plans. After the individual scores are given within the range of 0 = absent, 0.5 = limited, and 1 = unlimited, the composite scores and mean are calculated. Likewise, quartile values of the mean scores are then computed to determine the minimum to maximum value, which defines the overall performance level of each of the three cities' governance system.

3.2.2. Form

The three case districts are virtually visited through Google My Map and Nearmap to obtain primary data on the following indicators: 'land-use mix', 'space design', 'built environment', and 'urban green and blue infrastructure'. Audits on land-use mix aim to identify the type of existing land-use within the legal boundary of the case districts, such as a complex mixed-use (i.e., work–learn–live–play), mixed use (i.e., work–learn–live or play) or single use (work or learn). Descriptive and spatial analysis is done through an aerial view of each of the innovation districts. An innovation district with a clear aerial

image of complex mixed-use is rated 'strong', mixed use 'moderate', and single use 'weak'. Evidence of land-use types is captured by screenshots and recorded for reference.

The audit on space design is guided by [67] three-element cluster model to identify whether the case districts' spatial layout design encourages knowledge generation. The model is used to determine whether the innovation district is an open, semi-open, or closed layout innovation system. It regards three land-use zonings of R&D (university), house (market or consumer), and park/entertainment facilities (museum) based on three theories. First, an open innovation system in a three-factor cluster takes place when those from the 'house zone' must pass through the 'R&D (university) zone' to get to the 'park (museum) zone'. Second, a semi-open innovation system is when those from the 'house zone' can go directly to the 'park zone' without passing through the 'R&D zone'; however, the R&D is nearby to incite their interest to contact the R&D. Finally, a closed innovation system is when those from the house go directly to the park without passing the R&D and have minimal contact with the R&D. In sum, the measure is about people's permeability to the innovation district. Similar analysis performed on land-use mix is repeated here. An innovation district with a clear aerial image showing evidence of an open layout design is rated 'strong', a semi-open design is 'moderate', and a closed layout design is 'weak'. Evidence of space design for innovation districts is captured by screenshots and recorded for reference.

Furthermore, an audit on built environment features aims to investigate whether the case districts' architectural design, built form, and function encourage an open innovation system, connectivity, and mobility within its legal boundary.

The audit sheet employed was derived from the Healthy Build Environment Checklist [68] and an urban design for walking checklist [69], comprising seven themes including 'street connectivity and smaller block sizes' and 'number of local living destinations (e.g., transit stations, grocery shops, hospitals, education institutes etc.) within walking or cycling destinations within 1 km radius of the case district'. A similar analysis process employed for the above form indicators is followed for the built environment. The auditor uses aerial images to identify the presence of the attributes within a 1 km radius of the innovation districts. For instance, if there is at least one each of the living destinations within the 1 km radius, a score of 10 (unlimited) is given, and vice versa. In total, seven attributes are audited, and individual scores are given as 0 = No, 5 = Limited, and 10 = Unlimited. The composite scores derived from the audit are computed to mean scores to define the innovation districts' overall performance for the built environment.

The audits on urban green and blue infrastructure aim to investigate any presence of urban green and blue ecosystem services for aesthetic qualities both within (green) and without (blue) the legal boundary of the case districts. The audit sheet employed to obtain data is based on the design principles for green–blue infrastructure [70], which has two main parts. The first part concerns green ecosystem services at the innovation district or cluster level and has seven themes, including mitigating heat stress, noise reduction, and air quality regulation. The second part focuses on blue ecosystem services at the city level with eight themes, including green–blue corridors, places to meet, swimming, and playing.

Furthermore, the audit sheet has a guideline to assist the auditor(s) in their ratings between various innovation district sizes. For instance, a small innovation district that has fewer than two trees with large crowns for 'mitigating heat stress' is rated 'limited presence' (0.5 score) and those districts with more than two trees with large crowns are considered 'unlimited' (1 score). In terms of the blue ecosystem services, if the district's host city has fewer than 10 places to meet, e.g., restaurants/eateries along seashores and riverbanks, it is rated 'limited' and more than 10 is 'unlimited'. Scores are given as 0 = Absent, 0.5 = Limited, and 1 = Unlimited. Together, 23 attributes are audited for each case district.

Overall, the composite scores of green ecosystems and blue ecosystems are combined and computed to a percentage score to define the innovation district's performance—i.e., strong, moderate, or weak.

3.2.3. Feature

The indicators of 'human capital', 'skilled labor', and locality setting require secondary data, whilst 'social amenity' requires primary data. The audit on human capital aims to identify the number of potential workforces with BA+ qualifications in the surrounding suburbs of the case district, which are identified from the ABS Statistical Area 2 (SA2). First, we identify the suburbs in the same SA2 as the one that the case innovation district is in, and then we use the ABS table builder to generate a report on these suburbs' labor force status. Only data for the qualifications of bachelor's degree and above are extracted and a percentage score of the population is computed. The rating value for this attribute is >50% strong, <50% moderate, and <25% weak. On the other hand, an audit on skilled labor aims to identify the number people in the workforce or knowledge workers with BA+ qualifications within the case district. Like for human capital, a similar analysis process is carried out, except the data analyzed concern the number of employees within the innovation district.

Furthermore, the information on the estimated or actual number of employees is generated by running the tenant company names on the DBBD as well as from the tenant company's official website. In addition, these data sources provide other required information including the actual or estimated annual income of the companies, the company nationality status, and the nature of the business, which facilitates determining the 'company size' and 'industry type', respectively. These characteristics will be discussed further in the subsequent section for function dimension.

As for the locality setting, the audits aim to identify whether the case district is in an 'inner city', 'suburban', or 'regional' area. The localities are identified from the SA2 areas. In terms of the audit on 'social amenity', it aims to investigate any presence and availability of amenities for public use within the legal boundaries of the case district. The audit tool employed is derived from [71] 'public open space tool' (POST), which was used to assess the quality of public parks and open space in their study. The POST focuses on the following themes, namely, 'activities', 'centrality/locality', 'environment quality', 'amenity', and 'safety'. The present study not only adopts the POST, but also expands this measurement tool to include restaurants and cafes, cultural and entertainment facilities, public parks/open space, and playgrounds.

The audit sheet is designed with a key question (for each theme), which guides the auditor to answer either by checking options 'No', 'Yes', or 'N/A', and Likert scale scores ranging from 0 to 5. The auditor virtually performs the desktop assessment. For instance, under the theme 'environment quality', question 4 is 'Is there clear presence of outdoor dining and coffee shop? (Check an answer below)'. The auditor searches the aerial image of the restaurant or coffee shops for evidence of outdoor tables and chairs to confirm, and checks an answer (i.e., Yes = 1, No = 0, N/A= 2) accordingly. On the other hand, question 6(b) for the theme 'environment quality' is 'Is there shade along paths (check one only)'. This question is only relevant for parks, open spaces, and outdoor ground level social amenities; hence, indoor social amenities above ground level are checked as N/A. The auditor checks the selected Likert scale score ranging from 0 to 5 based on the aerial observation of the tree canopies, guided by the given parameters of 6(b): the scores given for 'Yes', 'No', or 'N/A' range from 0 to 2, where No = 0, Yes = 1, and N/A = 2, whilst the Likert scores range from 0 to 5 where 0 = Very poor (little or no shade), 1 = Poor (canopies of trees do not touch and trees are spread apart), 2 = Medium (canopies of trees do not touch, but trees are close together), 3 = Good (canopies of some trees touch), 4 = Very good (canopies of many trees touch), and 5 = Not applicable (as there are no paths).

The descriptive scores derived above are converted to values and transferred to an Excel spreadsheet to formulate a 'master scoresheet'. The overall composite score is then normalized to obtain a composite mean score, which defines the innovation district's performance—i.e., >50 strong, >40 moderate, <40 weak. Overall, 44 social amenity attributes are audited for each innovation district.

3.2.4. Function

The data obtained for the indicators of 'investment type', 'industry type', 'company size', and 'property management' are all from secondary sources such as DBBD and the official websites of tenant companies. The audit on investment type focused on identifying whether the principal support and funding body of the district is a 'multiple-sector' (public–university–private–community) investment, a 'two-sector' (public and private) investment, or a 'single-sector' (public or private) investment. The auditor identifies each case district's investment type from their history or background information sourced from their official websites. Multiple-sector investment is the most preferred type, hence it is rated as the top-tier measure for this attribute. Additionally, the audit on industry type aims to identify the dominant industry activity within the case district, i.e., 'technology-intensive business', 'creativity-intensive business', or 'business support services', where the industry type that has a score over 50% becomes the dominant one.

The auditor identifies existing tenants (at the time of audit) and the business type, and then categorizes them into three classes as per the business types mentioned above. Following this, the percentage of each class is computed to determine the most dominant industry. A similar process is followed in auditing the company size, wherein the audit aims to identify the relative size of the tenant companies. For example, a company is regarded as being multinational if it meets the condition-matching criteria (i.e., $\geq$AUD 1 million, $\geq$50 employees, Australia-based company with branches overseas or vice versa); a large national enterprise ($\geq$AUD 1 million, $\geq$50 employees, Australia-based), or small and medium enterprise (<AUD 1 million, <50 employees, Australia-based). After categorizing the companies into the three classes above, their percentage to total tenant companies within the innovation district is computed. A company size with more than 50% is the dominant one, but the most preferred company size is the multinational enterprise, which is rated as the top-tier measure for this attribute.

Finally, the audit on 'property management' assists in identifying the type of operations and asset management practices in the case district. While a 'district-wide management' has an organization body that supervises or manages the overall operation and assets of the district, a 'building level management' does not have an independent district management, having individual buildings managed separately. The third management type is defined as one in which there is no form of management. Each innovation district's property management type is identified from the official website's 'about' or 'who we are' information. The most preferred management type is 'district-wide management', which is rated as the top-tier measure for this attribute.

All raw data obtained are filtered and normalized to avoid any potential bias in the analysis stage [72,73]. For instance, those tenant companies within the districts that have missing values for 'number of employees' and 'annual income' are excluded from the data analysis. However, those with at least one value are retained, and average estimates are adopted to replace the missing values. The study opts for an average value instead of a minimum value [72], mainly to ensure that the concern variable is not unnecessarily replaced with a lower value, which may contribute negatively toward the performance of the studied case district. Finally, all of the standardized scores for each dimension above are converted to descriptive values, as illustrated in Table 2, which defines the innovation districts' overall performance.

Table 2. Case study results.

Dimension	Indicator	Description	Parameter	Measure	MPID (Sydney)	MTP (Melbourne)	KGUV (Brisbane)
Feature	Social amenity	Presence or availability of social amenities for public use	Strong presence of social amenities Moderate presence of social amenities Weak presence of social amenities	Mean composite score Strong > 50, Moderate > 40, Weak < 40	Moderate	Moderate	Moderate
	Human capital	Inventory of skilled people (i.e., information about education and skilled level of the population and potential stock of qualified people)	Strong human capital Moderate human capital Weak human capital	Percentage of knowledge workers with BA or higher qualification Strong > 50%, Moderate > 25%, Weak < 25%	Strong	Strong	Strong
	Skilled labor	Skilled employment outcome of the innovation district activities	Strong skilled employment Moderate skilled employment Weak skilled employment	Ratio of knowledge worker jobs to total innovation district jobs Strong > 50%, Moderate > 25%, Weak < 25%	Strong	Strong	Strong
	Locality setting	Location of the district metropolitan area	Inner city Suburban Regional	Location of the innovation district Inner city, Suburban, Regional	Suburban	Suburban	Inner city
Function	Company size	Relative size of the firms within the innovation district	MNE anchored LNE dominated SME dominated	Ratio of number of firm types to total firms within the innovation district MNE anchored if > 50%, LNE dominated > 50%, SME dominated if > 50%	MNE	LNE	SME
	Industry type	Dominant business activity operating within the innovation district	Technology-intensive business Creativity-intensive business Business support services	Dominant business activity of the district Technology-intensive if > 50%, Creativity-intensive if > 50%, Business support services if > 50%	Technology-intensive business	Technology-intensive business	Business support services
	Investment type	Principle support and funding body for the development of the innovation district	Public–private–community partnership Public–private partnership Public or private sector	Multiple sectors Two sectors Single sector	Multiple sector	Multiple sector	Multiple sector
	Property management	Management model of the innovation district's properties and activities	Managed by a district management Managed by a building management No form of management	District wide Building level None	District wide	District wide	District wide

Table 2. *Cont.*

Dimension	Indicator	Description	Parameter	Measure	MPID (Sydney)	MTP (Melbourne)	KGUV (Brisbane)
Form	Urban green and blue infrastructure	Aesthetic qualities of urban green and blue infrastructure within/out the innovation district (i.e., all natural and semi-natural landscape elements that form a green–blue network	Strong presence of ecosystem services Moderate presence of ecosystem services Weak presence of ecosystem services	Based on design principles of green–blue infrastructure innovation district level (green infrastructure), city level (blue infrastructure)Strong > 50%, Moderate > 25%, Weak, 25%	Strong	Strong	Strong
	Land-use mix	Main land-use types within the innovation districts	Complex mixed Mixed use Single use	Work–learn–live–play Work–learn, live or play Work or learn	Complex mixed	Complex mixed	Complex mixed
	Built environment	Architectural designs of built forms encouraging connectivity and mobility within the innovation districts	Strong internal connectivity Moderate internal connectivity Weak internal connectivity	Based on healthy built environment guidelines Composite scores Strong > 60, Moderate > 50, Weak < 50	Strong	Strong	Strong
	Space design	Spatial layout design encouraging open innovation system within the innovation districts	Open layout Semi-open layout Closed layout	Based on three element cluster model to determine whether the spatial design encourages knowledge generation within the innovation district Open layout, semi-open layout, closed layout	Semi-open layout	Semi-open layout	Open layout
Context	Spatial system	City-wide spatial layout and architectural qualities (i.e., physical environment, spatial conditions, and urban development)	Strong spatial design Moderate spatial design Weak spatial design	Composite index of quality of physical environment, unique natural environment, and physical patterns based on mean value Strong >1.8, Moderate <1.7, Weak < 1.7	Strong	Strong	Strong
	Societal system	Societal progress of the city (i.e., diversity, tolerance, equality, age structure, and participation in cultural/community activities)	Strong social assets Moderate social assets Weak social assets	Diversity and inclusiveness measured by composite scores based on Brookings's audit guide Strong > 70, Moderate >66, Weak < 66	Strong	Strong	Moderate
	Governance system	Political progress of the city (i.e., political institution effectiveness, accountability, transparency, and participation)	Strong governance effectivenessModerate governance effectiveness Weak governance effectiveness	Composite index of quality public services, civil services, quality of policy formulation and implementation, and credibility of the government's commitment to such policies of the city Strong >0.75, Moderate <0.75, Weak < 0.7	Strong	Strong	Strong
	Economy system	Macroeconomic progress of the city (i.e., monetary and fiscal performance to maintain stability of economic growth)	Strong economic performance Moderate economic performance Weak economic performance	Composite index of governance net debt, real GDP growth, inflation rate, and unemployment rate of the city based on composite median scores Strong<8.46, Moderate>8.46, Weak >9.22	Strong	Strong	Moderate

4. Analysis and Results

The results for each case innovation district are presented in Table 2 in a descriptive form. Both primary and secondary data obtained are analyzed using both qualitative and quantitative analysis methods, which are utilized to examine all secondary data and compute percentage scores by simple math calculation.

For ease of reference, the descriptive data from the preliminary findings in Table 2 are converted into a 'case study matrix', which provides a brief description of each case district. As illustrated in Table 3, the matrix comprises three vertical levels of A, B, and C representing the three tier measures (e.g., strong, moderate, weak, or inner city, suburban, regional) in the framework and 16 horizontal levels (i.e., o1-o4; e1-e4; u1-u4; c1-c4) representing 16 indicators under the four dimensions of feature, function, form, and context.

Table 3. An exemplar case study matrix of MTP.

Form				
		A	B	C
Land-use mix	o1	Complex mixed	Mixed use	Single use
Space design	o2	Open	Semi-open	Closed
Built environment	o3	Strong	Moderate	Weak
Urban green and blue infrastructure	o4	Strong	Moderate	Weak
Feature				
		A	B	C
Human capital	e1	Strong	Moderate	Weak
Skilled labor	e2	Strong	Moderate	Weak
Social amenity	e3	Strong	Moderate	Weak
Locality setting	e4	Inner city	Suburban	Regional
Function				
		A	B	C
Investment type	u1	Multiple sectors	Two sectors	Single sector
Industry type	u2	Technology-intensive	Creativity-intensive	Business support
Company size	u3	Multinational	Large national	Small and medium
Property management	u4	District wide	Building level	None
Context				
		A	B	C
Economic system	c1	Strong	Moderate	Weak
Societal system	c2	Strong	Moderate	Weak
Spatial system	c3	Strong	Moderate	Weak
Governance system	c4	Strong	Moderate	Weak

Table 3 is an example of the 'case study matrix' showing the audit results on Monash Technology Precinct (MTP), presented in the shaded area, which can be interpreted as per type (o1A, o2B, o3A, o4A) + (e1A, e2A, e3B, e4B) + (u1A, u2A, u3B, u4A) + (c1A, c2A, c3A, c4A) and described as a complex mixed-use semi-open design innovation district with strong features in the forms of built environment and urban green and blue infrastructure, located in a suburban area with moderate social amenity, strong human capital and skilled labor. It is funded by a multiple-sector investment partnership and is dominated by large national technology-intensive businesses under district-wide management. MTP is surrounded by strong systems of economic, societal, spatial, and governance.

To compute the overall performance scores, the descriptive measures, for example, Strong, Moderate, Weak, or Open, Semi-open, Closed, are assigned following the categorical values of Strong = A, Moderate = B, and Weak = C; Open = A, Semi-open = B, and Closed = C. Hence, converting MTP's descriptive measures in Table 3 results in the following categorical values (see Table 4): Land-use mix = A, Space design = B, Built environment = A, Urban green and blue infrastructure = A, Human capital = A, Skilled labor = A, Social amenity = B, Locality setting = B, Investment type = A, Industry type = A, Company size = B, Property management = A, Economic system = A, Societal system = A, Spatial system = A, and Governance

system = A. A similar conversion of descriptive measures to categorical values is repeated for the other two case districts. The categorical scores are further analyzed to compute the 'net scores', also known as 'net performance scores', using the following simple formula. The 'net scores' indicate each case district's overall performance.

$$\textit{Net score} = \textit{Percentage of A dimensions - Percentage of C dimensions} \quad (1)$$

Table 4. Case study categorical performance scores.

Dimension	Category	Indicator	MPID (Sydney)	MTP (Melbourne)	KGUV (Brisbane)
Form	Complexity and Layout	Land-use mix	A	A	A
		Space design	B	B	A
	Connectivity and Space Design	Built environment	A	A	A
		Urban green–blue infrastructure	A	A	A
Feature	Centrality and Amenity	Social amenity	B	B	B
		Locality setting	B	B	A
	Intelligence and Concentration	Human capital	A	A	A
		Skilled labor	A	A	A
Function	Specialization and Diversity	Investment type	A	A	A
		Industry type	A	A	C
	Scale and Support	Company size	A	B	C
		Property management	A	A	A
Context	Social and Economic	Economic system	A	A	B
		Societal system	A	A	B
	Spatial and Governance	Spatial system	A	A	A
		Governance system	A	A	A
	Total number of categorical values		16	16	16
	Percentage of 'A' dimensions	(n = 13, n = 12, n = 11)	81%	75%	69%
	Percentage of 'C' dimensions	(n = 0, n = 0, n = 2)	0	0	13%
	Net score		81	75	56

Note: Green color represents desirable performance, yellow = acceptable performance, and red = unsavory performance.

For example, MTP has 12 As, 0 Cs, and 4 Bs; therefore, the net score is 75. The maximum net score is achieved if a district receives all As, as the net score would be 100, whereas a district with all Cs will have a net score of −100. In other words, innovation districts with more As have more positive net scores than those with more Cs that will have negative scores. According to the rule of calculating net scores, the B scores are excluded because they are 'passive' scores [74]. Furthermore, the percentages of both As and Cs are expressed as a percentile score, whilst the net scores are expressed in metric. The analyzed performance scores for all case districts are presented in Table 4. For ease of reference, each indicator is color coded according to their performance.

The study considered two potential criteria rating systems, firstly, the Australia Green Star rating system—an internationally recognized Australian sustainability rating and certification system by the Green Building Council of Australia (GBCA). The Green Star rating system has four tools, of which the 'Green Star—Communities' and 'Green Star—Performance' are considered the most suitable for this study. 'Green Star—Communities' assesses the development stages of large-scale development projects of a precinct or community scale, and 'Green Star—Performance' assesses the operational performance of existing buildings, which covers broad environmental issues related with the building development process [75,76]. Green Star's ranking criteria range from 1 Star to 6 Star, where 1 Star = 10 points, indicating minimum practice, and 2–4 Star = 20–40 points, representing average to best practice, respectively. A 5 Star rating of 60 points or above represents Australia's best practice, and a 6 Star rating (75-point score or above) represents for world leadership.

Secondly, the 'net promoter score' (NPS) 'is a summary statistic commonly used in commercial survey research to estimate the propensity of business' customers to exhibit desirable behaviors' [77,78]. The NPS typically uses a marketing accountability metric known as a 'likelihood-to-recommend' (LTR) question to obtain responses from customers. A 0–10 Likert scale is presented in a single questionnaire for customer ratings [74]. The NPS ranking criteria range from −100 to 0 (Needs improvement), 0–30 (Good), 30–70 (Great),

and 70–100 (Excellent) [79]. Note that the criterion range can also be in decimal form (i.e., −1.0–0.00, 0–0.3, 0.3–0.7, 0.7–1.0).

The study adopts a combination of Green Star's ranking system and the NPS's operational method of analyzing the audit scores. The reason being that the Green Star rating system is most relevant to the study as it concerns the performance assessment of built environment and land development projects, unlike NPS, which concerns customer recommendations for businesses. However, whilst we chose not to use NPS's ranking system, its operational method of calculating the net scores is statistically sound for the analysis of the categorical variables hence adopted (see Table 4).

The study generally adopts the Green Star rating system with modified ranking criteria, as follows: scores from 0 to 30 are defined as unsavory (red color); scores from 30 to 60 are defined as acceptable (yellow color); and scores up to 60+ are defined as desired (green color).

5. Findings and Discussion

This section uses a comparison approach to present the key findings of applying the multidimensional innovation district performance framework to the MPID (Sydney), MTP (Melbourne), and KGUV (Brisbane). The findings for each of the case districts are presented separately through a 'performance matrix' (Figure 5), and a 'typology matrix' (Table 5). Our discussion on the findings is presented for the context, feature, function, and form.

	CONTEXT	FORM	FEATURE	FUNCTION	OVERALL
DESIRED	MPID, MTP	MPID, MTP, KGUV	MPID, MTP, KGUV	MPID, MTP	MPID, MTP
ACCEPTABLE	KGUV	-----	----	KGUV	KGUV
UNSAVOURY	-----	-----	-----	-----	-----

Figure 5. Performance matrix of the case innovation districts. Note: MPID = Macquarie Park Innovation District; MTP = Monash Technology Precinct; KGUV = Kelvin Grove Urban Village.

Regarding the 'context' dimension, the investigation into the capital cities that host each of the case districts reveals that both Sydney's and Melbourne's performance are at the 'desired' level, with 'A' scores for the social and economic category compared to Brisbane's acceptable performance with 'B' scores (Table 4). Meanwhile, all three cities scored 'A' for the spatial and governance category, indicating their strength in this category. The investigation into the three case districts' 'forms' dimension reveals that KGUV is leading the category of 'complexity and layout' with 'A' scores, followed by MPID and MTP with a mixture of 'A' and 'B' scores. Furthermore, all three case districts equally achieved 'A' scores for the 'connectivity and space design' category, indicating their strength in this category. The investigation into the case districts' 'feature' dimension reveals that KGUV performed better than MPID and MTP in the 'centrality and amenity' category. The former district scored a mixture of 'A' and 'B' scores, whilst the latter two districts attained 'B' scores. On the other hand, all three districts performed well, with equal 'A' scores for the 'intelligence and concentration' category, indicating their strength in this category.

Finally, the investigation into the 'function' dimension of the case districts reveals that MPID and MTP are equally leading in 'specialization and diversity' with 'A' scores, whilst KGUV scored a mixture of 'A' and 'C' scores. In terms of the 'scale and support' category, MPID outperformed MTP with 'A' scores, whilst MTP scored a mixture of 'A' and 'B' and KGUV scored a mixture of 'A' and 'C' scores.

Table 5. Typology matrix of the case innovation districts.

Type	Name	Context	Function	Form	Feature	Overall	District
Type 1	Diverse, complex, and centrally located in a highly favorable context	Highly favorable	Diverse	Complex	Central	Desired	MPID MTP
Type 2	Diverse, complex, and centrally located in a favorable context	Favorable	Diverse	Complex	Central	Acceptable	KGUV

Note: Diverse = diversified (more than two) partnership or portfolio, Dual = diversified (two) partnership or portfolio, Single = specialized (single anchor/sector) investment. Complex = complex mixed use (work–learn–play–live), Semi-complex = mixed use (work–learn–play or live), Simple = single use (work or learn). Central = inner city or suburban, Remote = regional. Highly favorable = strong performance of hosting cities' systems (economic, societal, spatial, governance), Favorable = moderate performance of hosting cities' systems (economy, societal, spatial, governance), Unfavorable = weak performance of hosting cities' systems (economy, societal, spatial, governance). Desired = net scores above 60+, Acceptable = net scores above 30, Unsavory = net scores below 30.

In sum, the discussion focuses on the 'A' and 'C' scores, as these are the subjects for calculating the net score. Based on the performance scores, MPID has consistent performance with 'A' scores (the desired level) for most of the indicators except for 'space design', 'social amenity', and 'locality setting', for which it scored 'B's (see Table 4). Note that it has no 'C' scores, hence, the 'A' score of 81% becomes an 81 net score. Likewise, MTP's performance is almost identical to MPID, except it has more 'B' scores than MPID. Its 'A' score of 75% becomes a 75 net score. KGUV, on the contrary, displays inconsistent performance as it exhibits 69% (n = 11) for 'A' scores, 19% (n = 3) 'B' scores, and 13% 'C' scores. The net score is calculated by subtracting 13% from 69%, resulting in a 56 net score. Hence, comparing the net scores, MPID's and MTP's performances are at the 'desired' level, whilst KGUV's performance falls into the 'acceptable' level.

The findings discussed above are summarized in the performance matrix presented in Figure 4.

Ranking of the case districts by performance scores shows that MPID is the top performer with net score of 81, edging out MTP on 75, both at the desired level, and Brisbane in third place with a net score of 56, which is an acceptable level.

Another important outcome of this study is to classify the case innovation districts into desired and acceptable typologies (see Table 5). Based on the final performance scores, MPID and MTP compose a typology named 'Type 1: Diverse, complex and centrally located in a highly favorable context' with the following characteristics.

Desired typologies: Suburban diversified (more than two) investment partnership dominated by multinational or large national firms. This type of innovation districts has:

- Complex mixed-use, semi-open space designs highly connected to external public spaces.
- Strong built environment and green and blue infrastructure.
- Strong human capital and skilled labor.
- Moderate social networking assets (social amenities).
- Technology-intensive firms.
- Macro (district-level) property management.

The second typology is named 'Type 2: Diverse, complex, and centrally located in a favorable context', which is represented by KGUV with following characteristics.

Acceptable typologies: Inner city diversified (more than two) investment partnership dominated by small and medium enterprises/firms (SMEs). This type of innovation districts has:

- Complex mixed-use, open designs highly connected to external public spaces.
- Strong built environment and green and blue infrastructure.
- Strong human capital and skilled labor.
- Moderate social networking assets (social amenities).
- Business support services.
- Macro (district-level) property management.

The results of the study show that both MPID's and MTP's performances are on par with each other at the 'desired' level, whilst KGUV has an 'acceptable' performance level. Comparing their performance by dimensions, MPID and MTP exhibit consistent performances by sharing the desired performance cluster with KGUV for both the form and feature dimensions. However, in terms of the context and function dimensions, MPID and MTP are the two only districts with the desired performances.

Based on the net scores, the study ranked Sydney's MPID in first place with a score of 81, followed by Melbourne's MTP in second place with a score of 75. Brisbane's KGUV came in third place with a score of 56. The difference of six points between the MPID and MTP net scores indicates very high competition between these two districts and their hosting cities. MPID is the top scorer due to having stronger performance in 13 out of 16 indicators, whilst MTP has 12 out of 16, and KGUV is not far behind with 11 out of 16 strong performances. The difference in the scores between MPID and MTP is due to MPID being anchored by multinational enterprise—first-tier measure compared to MTP dominated by large national enterprise—second-tier measure. Meanwhile, KGUV's relatively lower score is because the district hosts more smaller- and medium-sized 'business support service' firms than large-to-multinational technology-intensive businesses.

In addition, KGUV displayed 'acceptable' performance for its context because the host city of Brisbane is lagging behind the other two cities, Melbourne and Sydney, which points toward the need for intervention to improve the areas of concern. This finding is consistent with previous related studies on smart cities [2,80], official government/industry reports on the world's most innovative cities [81,82](JLL, 2019; Bateman, 2022), and knowledge cities [83] that have ranked the performance of Sydney and Melbourne interchangeably between first and second place, whilst Brisbane continues to trail them in third place [84]. Likewise, previous studies concerning MPID and MTP include Pancholi et al.'s [12] research, which ranked the two districts as the top best practice innovation districts in Australia. On the other hand, KGUV is said to be Queensland's leading and best practice innovation district [47,50].

In terms of context influence, the overall results of MPID, MTP, and KGUV is also influenced by the level of support from the respective states and city councils through their urban development policies and infrastructure development.

Based on the typology matrix developed in Table 5, two typologies are identified. MPID and MTP represent Type 1, namely 'Diverse, complex, and centrally located in a highly favorable context'. The main characteristics of the first typology include being initially developed and supported by more than two investment partners, having work–learn–play–live uses, designed as a semi-open space, and being in suburban areas. Innovation districts in this typology are dominated by multinational or large national firms in high-technology-intensive businesses with surrounding context (cities) having strong spatial, societal, economic, and governance systems. The second typology, Type 2, is 'Diverse, complex, and centrally located in a favorable context', represented by KGUV. Most of its characteristics are identical to typology 1's characteristics, except that they are designed as an open space, are in an inner-city area, and are dominated by small and medium business support service firms with surrounding context having moderate-to-strong spatial, societal, economic, and governance systems.

It is important to note that the present study identified the innovation district typologies using only three case studies from the three largest cities of Australia. Therefore, we opine that the typology characteristics identified are only partial and should be expanded by future similar studies with more innovation district case studies to obtain a more representative typology characteristic. Hence, our future prospective study will investigate the performance of more innovation districts.

6. Conclusions

This study develops an innovation district typology matrix and evaluates its practicality with real-life innovation district data. Adopting the multidimensional innovation district performance framework to assess the performance of three eminent Australian innovation districts—i.e., Macquarie Park Innovation District (MPID), Monash Technology Precinct (MTP), and Kelvin Grove Urban Village (KGUV)—across the dimensions of form, feature, function, and context, this study confirms the suitability of the multidimensional performance framework to develop an innovation district typology matrix.

Based on the overall performance scores of the case innovation districts, MPID and MTP are placed in the desired performance category, whereas KGUV takes its place in the acceptable performance category. It is noteworthy that the top performers are suburban innovation districts, whilst the acceptable performer is an inner-city innovation district, indicating that innovation districts outside of inner-city locations can perform better than those located in inner cities. Furthermore, the study ranked MPID as the top performer, followed by MTP in second place and KGUV in the third place. The six-point difference in the net scores between MPID and MTP indicates strong competition between them. Although KGUV has the potential to improve performance at the innovation district level, it will also rely on its host city of Brisbane to improve and boost its context and overall performance. The study also developed a typology matrix consisting of two distinctive typologies, where MPID and MTP represent Type 1: 'Diverse, complex, and centrally located in a highly favorable context' and KGUV represents Type 2: 'Diverse, complex, and centrally located in a favorable context'.

The findings of this study provide a number of practical implications. For example, identifying distinctive typologies for innovation districts is important for all stakeholders (i.e., urban planners, developers, managers, and local policymakers). Knowing and understanding the types and distinct characteristics of innovation districts can contribute to the decision making on where and what type of innovation district to develop, which industry type to invest in, and other areas that would most benefit from involvement. Consequently, these decisions and interventions can help innovation districts to be more successful.

Overall, the study sheds light on how to develop an innovation district typology matrix by carrying out a holistic assessment of the performance of innovation districts. The findings of this study inform our future research to implement the framework on existing innovation districts in South East Queensland (SEQ), Australia. They will also help in classifying the innovation districts into distinctive typologies for more precise assessment of their performances in their own typology groups.

The limitations of the study are as follows. First, the study took the context dimension as broad, and as it is not the primary focus of this study, not all of the context measures listed in Table 1 are assessed. Only measures with available data are selected—i.e., only diversity is audited and measured for the societal system. Furthermore, as the present study identified typologies using only three innovation districts, the typology characteristics identified are inevitably partial, meaning that future studies are needed to investigate a larger number of innovation districts to generate a deeper understanding into innovation district typologies. Addressing this issue will be the focus of our prospective research.

Author Contributions: R.A.-M.: data collection, processing, investigation, analysis, and writing—original draft; T.Y., B.X. and I.E.: supervision, conceptualization, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Human Research Ethics Committee of Queensland University of Technology UHREC # 2000000461 7 July 2020.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors thank the editor and anonymous referees for their invaluable comments on an earlier version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Yigitcanlar, T.; Inkinen, T. *Geographies of Disruption*; Springer International Publishing: Singapore, 2019.
2. Yigitcanlar, T.; Corchado, J.M.; Mehmood, R.; Li, R.Y.M.; Mossberger, K.; Desouza, K. Responsible Urban Innovation with Local Government Artificial Intelligence (AI): A Conceptual Framework and Research Agenda. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 71. [CrossRef]
3. Lawrence, S.; Hogan, M.; Brown, E.G. *Planning for An Innovation District*; RTI Press: London, UK, 2019.
4. Morawska, I.; Anielska, K.; Gądecki, J.; Afeltowicz, L. Changes in urban fabric–A cause or a result of an innovation district? *J. Urban. Int. Res. Placemaking Urban Sustain.* **2021**, 1–22. [CrossRef]
5. Cohendet, P.; Chenier, R.; Simon, L.; Stojak, L. Centech, a world-class business incubator based in the Montréal innovation district, inspired by Barcelona 22@. *J. Evol. Stud. Bus.* **2022**, *7*, 40–69. [CrossRef]
6. Kayanan, C.M. A critique of innovation districts: Entrepreneurial living and the burden of shouldering urban development. *Environ. Plan. A Econ. Space* **2022**, *54*, 50–66. [CrossRef]
7. Morisson, A.; Bevilacqua, C. Balancing gentrification in the knowledge economy: The case of Chattanooga's innovation district. *Urban Res. Pract.* **2019**, *12*, 472–492. [CrossRef]
8. Sisi, L. Streets place-making in Beijing's innovative districts: From the perspective of public assets and property rights. *China City Plan. Rev.* **2019**, *28*, 28–36.
9. Morisson, A. A framework for defining innovation districts: Case study from 22@ Barcelona. In *Urban and Transit Planning*; Springer: Cham, Switzerland, 2020; pp. 185–191.
10. Spirou, C. *Anchoring Innovation Districts: The Entrepreneurial University and Urban Change*; JHU Press: London, UK, 2021.
11. Borsi, K.; Schulte, C. Universities and the City: From islands of knowledge to districts of innovation. *J. Arch.* **2018**, *23*, 1143–1180. [CrossRef]
12. Pancholi, S.; Yigitcanlar, T.; Guaralda, M. Place making for innovation and knowledge-intensive activities: The Australian experience. *Technol. Forecast. Soc. Chang.* **2019**, *146*, 616–625. [CrossRef]
13. Wong, P.K. An Evolutionary Analysis of the Development of the One North Innovation District in Singapore. *J. Evol. Stud. Business-JESB* **2022**, *7*, 70–99. [CrossRef]
14. Adu-McVie, R.; Yigitcanlar, T.; Erol, I.; Xia, B. Classifying innovation districts. Delphi validation of a multidimen-sional framework. *Land Use Policy* **2021**, *111*, 105779. [CrossRef]
15. Markusen, A. Sticky Places in Slippery Space: A Typology of Industrial Districts. *Econ. Geogr.* **1996**, *72*, 293. [CrossRef]
16. SGS. *From Alleys to Valleys: Creating Innovation Precincts through Inclusive Policy*; SGS Economics & Planning: Sydney, Australia, 2020.
17. Díez-Vial, I.; Fern'andez-Olmos, M. Knowledge spill overs in science and technology parks: How can firms benefit most? *J. Technol. Transf.* **2015**, *40*, 70–84. [CrossRef]
18. Jones, A.L. Regenerating urban waterfronts-creating better futures- from commercial and leisure marketplaces to cul-tural quarters and innovation districts. *Plan. Pract. Res.* **2017**, *32*, 333–334.
19. Esmaeilpoorarabi, N.; Yigitcanlar, T.; Guaralda, M.; Kamruzzaman, M. Evaluating place quality in innovation dis-tricts: A Delphic hierarchy process approach. *Land Use Policy* **2018**, *76*, 471–486. [CrossRef]
20. Esmaeilpoorarabi, N.; Yigitcanlar, T.; Kamruzzaman, M.; Guaralda, M. How does the public engage with innovation districts? Societal impact assessment of Australian innovation districts. *Sustain. Cities Soc.* **2020**, *52*, 101813. [CrossRef]
21. Collier, D.; Laporte, J.; Seawright, J. Putting typologies to work concept formation, analysis, and rigor. *Political Res. Q.* **2012**, *65*, 217–232. [CrossRef]
22. Dahl, R.A. *Polyarchy: Participation and Opposition*; Yale University Press: New Haven, CT, USA, 1971.
23. Koc, C.B.; Osmond, P.; Peters, A. A Green Infrastructure Typology Matrix to Support Urban Microclimate Studies. *Procedia Eng.* **2016**, *169*, 183–190. [CrossRef]
24. Klein, R. How To Create A Building Typology? Typological matrix for mapping 19th century synagogues. *J. Fac. Civ. Eng.* **2014**, *30*, 57–68. [CrossRef]

25. Pozas, M.; Gonzalez, F.J. Housing building typology definition in a historical area based on a case study: The Valley, Spain. *Cities* **2018**, *72*, 1–7. [CrossRef]
26. Sarzynski, A.; Galster, G.; Stack, L. Typologies of sprawl: Investigating United States metropolitan land use patterns. *Urban Geogr.* **2013**, *35*, 48–70. [CrossRef]
27. Benefoh, D.T.; Villamor, G.B.; van Noordwijk, M.; Borgemeister, C.; Asante, W.A.; Asubonteng, K.O. Assessing land-use typologies and change intensities in a structurally complex Ghanaian cocoa landscape. *Appl. Geogr.* **2018**, *99*, 109–119. [CrossRef]
28. De Groot, R.S.; Wilson, M.A.; Boumans, R.M.J. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecol. Econ.* **2002**, *41*, 393–408. [CrossRef]
29. Roelandt, T.J.; Hertog, P.D. Assessing the knowledge distribution power of national innovation systems. In Proceedings of the OECD Conference on the New S&T Indicators for the Knowledge-Based Economy, Paris, France, 19–21 June 1996.
30. Boix, R.; Galletto, V. Innovation and Industrial Districts: A First Approach to the Measurement and Determinants of the I-District Effect. *Reg. Stud.* **2009**, *43*, 1117–1133. [CrossRef]
31. Metaxiotis, K.; Carrillo, F.; Yigitcanlar, T. (Eds.) *Knowledge-Based Development for Cities and Societies: Integrated Multi-Level Approaches. Premier Reference Source*; IGI Global: Hershey, PA, USA, 2010.
32. Leon, N. Attract and connect: The 22@ Barcelona innovation district and the internationalization of Barcelona business. *Innovation* **2008**, *10*, 235–246. [CrossRef]
33. Turkina, E.; Van Assche, A. Global connectedness and local innovation in industrial clusters. *J. Int. Bus. Stud.* **2018**, *49*, 706–728. [CrossRef]
34. Wu, Y.; Yang, Y.; Xu, W.; Chen, Q. The Influence of Innovation Resources in Higher Education Institutions on the Development of Sci-Tech Parks' Enterprises in the Urban Innovative Districts at the Stage of Urbanization Transformation. *Land* **2020**, *9*, 396. [CrossRef]
35. Lee, K.-R. From Fragmentation to Integration: Development Process of Innovation Clusters in Korea. *Sci. Technol. Soc.* **2001**, *6*, 305–327. [CrossRef]
36. Heaphy, L.; Wiig, A. The 21st century corporate town: The politics of planning innovation districts. *Telemat. Inform.* **2020**, *54*, 101459. [CrossRef]
37. Hansasooksin, S.T.; Tontisirin, N. Placemaking as an urban development strategy for making the Pattaya Innovation District. *Reg. Sci. Policy Pract.* **2021**, *13*, 1930–1950. [CrossRef]
38. Komninos, N.; Kakderi, C.; Mora, L.; Panori, A.; Sefertzi, E. Towards High Impact Smart Cities: A Universal Architecture Based on Connected Intelligence Spaces. *J. Knowl. Econ.* **2022**, *13*, 1169–1197. [CrossRef]
39. Katz, B.; Wagner, J. *The Rise of Innovation Districts: A New Geography of Innovation in America*; Brookings Institution: New York, NY, USA, 2014.
40. Yigitcanlar, T.; Sabatini-Marques, J.; da-Costa, E.; Kamruzzaman, M.; Ioppolo, G. Stimulating technological inno-vation through incentives: Perceptions of Australian and Brazilian firms. *Technol. Forecast. Soc. Change* **2019**, *146*, 403–412. [CrossRef]
41. Forsyth, A. Alternative Forms of the High-Technology District: Corridors, Clumps, Cores, Campuses, Subdivisions, and Sites. *Environ. Plan. C Gov. Policy* **2014**, *32*, 809–823. [CrossRef]
42. Zainal, Z. Case study as a research method. *J. Kemanus.* **2007**, *9*, 1–6.
43. Rashid, Y.; Rashid, A.; Warraich, M.A.; Sabir, S.S.; Waseem, A. Case Study Method: A Step-by-Step Guide for Business Researchers. *Int. J. Qual. Methods* **2019**, *18*, 1–13. [CrossRef]
44. Cacar, K.; Aykol, S. Case study as a research method in hospitality and tourism research: A systematic literature review (1974–2020). *Cornell Hosp. Q.* **2020**, *62*, 21–31. [CrossRef]
45. DIIS. *Stocktake of Australian Innovation Precincts*; Australian Government: Canberra, Australia, 2019.
46. Monash Technology Precinct. Available online: https://www.monashprecinct.com.au/about-us (accessed on 7 August 2022).
47. Wardner, P.; Hefferan, M. Kelvin Grove Urban Village, Brisbane post implementation: Lessons for new urbanism. *Australas. J. Reg. Stud.* **2015**, *21*, 373–395.
48. NSW-IPC. *NSW Innovation Precincts: Lessons from International Experience*; NSW Government: Sydney, Australia, 2018.
49. Pancholi, S.; Yigitcanlar, T.; Guaralda, M. Public space design of knowledge and innovation spaces: Learnings from Kelvin Grove Urban Village, Brisbane. *J. Open Innov. Technol. Mark. Complex.* **2015**, *1*, 1–17. [CrossRef]
50. Esmaeilpoorarabi, N.; Yigitcanlar, T.; Guaralda, M.; Kamruzzaman, M. Does place quality matter for innovation districts? *Determining the essential place characteristics from Brisbane's knowledge precincts. Land Use Policy* **2018**, *79*, 734–747. [CrossRef]
51. Business South Bank. Precinct. 2017. Available online: https://businesssouthbank.com.au/precinct (accessed on 7 August 2022).
52. BCC. Global Precincts. 2019. Available online: https://www.brisbane.qld.gov.au/about-council/governance-and-strategy/business-in-brisbane/growing-brisbanes-economy/opportunity-brisbane/opportunity-global-precincts (accessed on 7 August 2022).
53. Advance Queensland. Advancing Regional Innovation Program. 2021. Available online: https://advance.qld.gov.au/entrepreneurs-and-startups-industry-investors-small-business-universities-and-researchers/advancing-regional-innovation-program (accessed on 7 August 2022).
54. BCC. Opportunity: Kelvin Grove-Herston. 2020. Available online: https://www.brisbane.qld.gov.au/about-council/governance-and-strategy/business-in-brisbane/growing-brisbanes-economy/opportunity-brisbane/opportunity-inner-city/kelvin-grove-herston (accessed on 7 August 2022).

55. ABS. Australian Bureau of Statistics Data by Region. 2016. Available online: https://dbr.abs.gov.au/region.html?lyr=sa2&rgn=305031126 (accessed on 7 August 2022).
56. Macquarie Park Innovation District. Available online: https://www.connectmpid.com.au/about-us (accessed on 7 August 2022).
57. BCC. Brisbane's Key Economic Facts. 2022. Available online: https://www.brisbane.qld.gov.au/about-council/governance-and-strategy/business-in-brisbane/growing-brisbanes-economy/brisbanes-key-economic-facts (accessed on 7 August 2022).
58. Baum, S.; Yigitcanlar, T.; Horton, S.; Velibeyoglu, K.; Gleeson, B. *The Role of Community and Lifestyle in the Making of a Knowledge City*; Griffith University: Brisbane, Australia, 2007.
59. Yang, T.; Wang, N. The Cultivation of Cluster's Sustainable Competence Based on Knowledge Management. *Int. J. Bus. Manag.* **2008**, *3*, p83. [CrossRef]
60. Cravo, T.A.; Piza, C. The impact of business-support services on firm performance: A meta-analysis. *Small Bus. Econ.* **2019**, *53*, 753–770. [CrossRef]
61. Durmaz, B.; Platt, S.; Yigitcanlar, T. Creativity, culture tourism and place-making: Istanbul and London film in-dustries. *Int. J. Cult. Tour. Hosp. Res.* **2010**, *4*, 198–213. [CrossRef]
62. Zheng, J. Creative industry clusters and the entrepreneurial city of Shanghai. *Urban Stud.* **2011**, *48*, 3561–3582. [CrossRef]
63. Schmahmann, L. Industry clusters and knowledge spill-overs-a comparative study of creative industry clusters in Sydney. *Plan. News* **2019**, *45*, 10–12.
64. Yigitcanlar, T.; Adu-McVie, R.; Erol, I. How can contemporary innovation districts be classified? *A systematic review of the literature. Land Use Policy* **2020**, *95*, 104595. [CrossRef]
65. Watson, C. Difference between the Mean & the Average. 2020. Available online: https://sciencing.com/difference-between-mean-average-6461324.html (accessed on 31 August 2022).
66. Esmaeilpoorarabi, N.; Yigitcanlar, T.; Guaralda, M. Towards an urban quality framework: Determining critical measures for different geographical scales to attract and retain talent in cities. *Int. J. Knowledge-Based Dev.* **2016**, *7*, 290. [CrossRef]
67. Yun, J.J.; Zhao, X.; Yigitcanlar, T.; Lee, D.; Ahn, H. Architectural Design and Open Innovation Symbiosis: Insights from Research Campuses, Manufacturing Systems, and Innovation Districts. *Sustainability* **2018**, *10*, 4495. [CrossRef]
68. NSW Health. Healthy Built Environments. 2021. Available online: https://www.health.nsw.gov.au/urbanhealth/pages/default.aspx (accessed on 7 August 2022).
69. Victoria Walks. Urban Design for Walking. 2021. Available online: https://www.victoriawalks.org.au/urban_design (accessed on 7 August 2022).
70. Gehrels, H.; Meulen, S.; Schasfoort, F.; Bosch, P.; Brolsma, R.; Dinther, D.; Geerling, G.; Goossen, M.; Jacobs, C.; Jong, M.; et al. Designing Green and Blue Infrastructure to Support Healthy Urban Living. Utrecht. 2016. Available online: https://www.adaptivecircularcities.com/designing-green-and-blue-infrastructure-to-support-healthy-urban-living (accessed on 7 August 2022).
71. Taylor, B.T.; Fernando, P.; Bauman, A.E.; Williamson, A.; Craig, J.; Redman, S. Measuring the Quality of Public Open Space Using Google Earth. *Am. J. Prev. Med.* **2011**, *40*, 105–112. [CrossRef]
72. Morais, P.; Camanho, A. Evaluation of performance of European cities with the aim to promote quality of life improvements. *Omega* **2011**, *39*, 398–409. [CrossRef]
73. Audretsch, B.D.; Belitski, M. The limits to open innovation and its impact on innovation performance. *Technovation* **2022**, 102519. [CrossRef]
74. Baehre, S.; O'Dwyer, M.; O'Malley, L.; Story, V.M. Customer mindset metrics: A systematic evaluation of the net promoter score (NPS) vs. *alternative calculation methods. J. Bus. Res.* **2022**, *149*, 353–362. [CrossRef]
75. Zuo, J.; Xia, B.; Chen, Q.; Pullen, S.; Skimore, M. Green building rating for office building-lessons learnt. *J. Green Build.* **2016**, *11*, 131–146. [CrossRef]
76. Green Building Council Australia. Green Star Rating System. 2021. Available online: https://new.gbca.org.au/green-star/rating-system (accessed on 7 August 2022).
77. Reichheld, F.F. The one number you need to grow. *Harv. Bus. Rev.* **2003**, *81*, 46–54. [PubMed]
78. Rocks, B. Interval estimation for the "Net Promoter Score". *Am. Stat.* **2016**, *70*, 365–372. [CrossRef]
79. Retently. What Is a Good Net Promoter Score? 2022. Available online: https://www.retently.com/blog/good-net-promoter-score/ (accessed on 14 August 2022).
80. Tariq, M.A.U.R.; Faumatu, A.; Hussein, M.; Shahid, M.L.U.R.; Muttil, N. Smart City-Ranking of Major Australian Cities to Achieve a Smarter Future. *Sustainability* **2020**, *12*, 2797. [CrossRef]
81. JLL. Australia's Got Talent: JLL Ranks World's Most Innovative Cities. 2019. Available online: https://www.jll.com.au/en/newsroom/australias-got-talent-jll-ranks-worlds-most-innovative-cities (accessed on 7 August 2022).
82. Bateman, K. Cities and Urbanization. Which is the World's Most Innovative Cities in 2022? World Economic Forum. 2022. Available online: https://www.weforum.org/agenda/2022/02/innovative-global-cities-talent-property (accessed on 7 August 2022).

83. Pratchett, L.; Hu, R.; Walsh, M.; Tuli, S. The Knowledge City Index A Tale of 25 Cities in Australia. 2017. Available online: https://www.researchgate.net/publication/319472356_The_Knowledge_City_Index_A_tale_of_25_Cities_In_Australia_2017 (accessed on 7 August 2022).
84. BCC. Benchmarking Brisbane a Snapshot of Our Global Performance. 2018. Available online: https://www.brisbane.qld.gov.au/about-council/governance-and-strategy/business-inbris-bane/growing-brisbanes-economy/opportunity-brisbane/how-brisbane-compares (accessed on 7 August 2022).