Article

Development, Innovation, and Circular Stimulation for a Knowledge-Based City: Key Thoughts

Tai-Shan Hu [1],[*] , Ssu-Chi Pan [2] and Hai-Ping Lin [2]

1 Department of Urban Planning/Research and Development Foundation, National Cheng Kung University, No. 1, University Road, Tainan 701, Taiwan
2 Department of Urban Planning, National Cheng Kung University, No. 1, University Road, Tainan 701, Taiwan; asdvicky10000@gmail.com (S.-C.P.); s924418@gmail.com (H.-P.L.)
* Correspondence: taishan@mail.ncku.edu.tw

Abstract: Practitioners of economic geography recognize innovation as the key factor in sustainable economic development and urging a city to evolve. Urban development evolves from manufacturing-based development to knowledge-based development. Identifying the future benefits of urban development is a research issue. This work analyzes development performance based on quantitative indices of critical knowledge and innovation that enhance economic growth and influence society and competitiveness. The research further identifies the possibility of knowledge dissemination and innovation. This work investigates the key factors encouraging the development of a knowledge-based city for Helsinki, Melbourne, and Hsinchu in terms of economy, society, environment, and management, and observes that the progressive and positive circular stimulation for a city requires not only the cultivation of human capital, but also the construction of social environment and internal relations to form a high-density knowledge network. This work demonstrates that Hsinchu Science Park acts as a highly stimulated and highly interactive knowledge engine by building a dynamic innovation model based on circular stimulation of knowledge feedback to construct an urban environment and series of talent networks. The city, ultimately, reaches a virtuous cycle for innovation and achieves critical factors for the evolution of a knowledge-based city.

Keywords: knowledge-based city; establishing evaluation index; case study and analysis; development and innovation; knowledge-based development; circular stimulation

1. Introduction

Regional resilience has recently become a popular topic due to various unpredictable shocks; it has replaced long-term ability, which focused on reshaping the socio-economic structure using an evolutionary path [1,2]. From the perspectives of regional planning, spatial economy, and economic geography, researchers from different fields have acknowledged innovation to be the critical factor in improving resilience and achieving sustainable economic development for a region. The concept of knowledge-based urban development has been engaged to generate energy for regional research, development, and innovation as well as to further trigger regional economic development, which provides the best solution for the regional environment at the current stage of development.

A city is analogous to a living organism. In addition to information delivery, economic development, conservation of the natural environment, and cultural and social activities, measuring the level of development for a city also needs to consider the structural factors of a city, which include protection of the environment and different cultures, policy transparency, democracy, human capital enhancement, and management with vision [3,4]. A city that is oriented by knowledge becomes attractive when its evolution begins to focus on the integration of technology and socio-economic activities into regional development. Knowledge thus becomes a factor in urban development. The difference between a city's

features and development procedures affects the type of knowledge-based urban development. Accordingly, various factors should be considered when analyzing the development performance of a city. Furthermore, urban development depends on diverse factors, such as policy coherence, environmental safety, the completeness of public facilities and services, and changes in information, communication, and technology [5].

Knowledge is becoming increasingly important compared to other intangible assets [6]. Unlike tangible resources, intangible assets such as knowledge increase in value after use [7]. Although different cities take different development paths, cities are increasingly transforming from manufacturing-oriented, based on natural and physical sources, to service-oriented, based on knowledge [8,9]. Knowledge has always been a critical source to shape and maintain the economy, society, and cultural development. The development of the knowledge industry in a city attracts many related industries and supportive services. Participants in the knowledge industry enable the city to be competitive and unique. Urban development is an integrated and complex phenomenon. Regional development may take the form of knowledge-based urban development (KBUD), which promotes city competitiveness, attracts talents and investments, and provides good life quality to the residents [10–13]. However, current evaluation and definition of KBUD is based on the conceptual description and lacks clearly defined and quantitative indices to evaluate the development performance.

This work provides a basic understanding of KBUD, along with clarification and analysis that builds on previous KBUD evaluation [14]. Data are collected and statistically analyzed to generate quantitative indices for KBUD evaluation. Various KBUD evaluation indices are adopted for domestic case studies, which are compared with other cases worldwide. The goal of this work is to clarify the meaning of KBUD. We hypothesize that knowledge-based, human, environmental, and relational assets gradually form the power for continuous development and further lead a city into a virtuous cycle. Cities awarded the Most Admired Knowledge Cities by the World Capital Institute in the past 5 years are considered and incorporated into the case study in order to clarify and identify different types and characteristics of urban development.

This study has the following purposes: (1) proposing quantitative indices for the evaluation of knowledge-based cities; (2) verifying the quantitative index by performing a domestic and international case study; and (3) addressing possible strategies to improve and ameliorate urban development. Accordingly, this article first reviews literature related to knowledge-based cities, followed by hypothesizing quantitative indices. Case studies are conducted by analyzing proposed quantitative indices to verify the hypothesis. A discussion of the analysis follows. Finally, this work draws conclusions and provides suggestions for future research.

2. The Concept of Knowledge-Based Cities and the Critical Factors for Promoting the Development of a Knowledge-Based City

Previous works indicate that the major sources of competitive advantages for companies in the knowledge-based economy era are research, development, and innovation. Economic geographers are particularly concerned about spatial issues. Most researchers have concluded that knowledge is localized because its dissemination is limited by geographic boundaries and distancing. Gathering of the innovators in a certain space, e.g., inventors, high-tech companies, and research institutes, help in knowledge transfer, technical exchange, and learning, and further drive innovation and invention of the industries in the region [15,16]. That is, the innovative energy of a city is based on the connection of knowledge users. The establishment of innovative networks elevates research and development collaborations. Therefore, network proximity gradually changes the traditional knowledge exchange restricted by geographic locations, and the actual geographic space evolves accordingly.

2.1. Knowledge-Based Urban Development

In the late 20th century, cities aimed at improving life quality, culture and industries, believing in the importance of creating an attractive city and smart management. To construct a knowledge-based social structure, urban planning also needs to incorporate knowledge creation [17]. Knowledge has become critical to social and economic development, while promoting economic growth and increasing competitiveness. May and Perry [18] noted the challenge in the 21st century of how to solve problems using knowledge, as well as the importance of promoting interactions between tacit and explicit knowledge [19].

The characteristics of a city determine its development, as it evolves into a knowledge-based city. However, knowledge is the factor determining a city's value [20]. With globalization, cities are more than centers of political power, trade, banking, and finance, as they also attract and gather talented professionals and have high population density, expanding manufacturing industries and a core of information media. The transformation of a city to a global city requires certain features that position it [21]. Knowledge-based cities have form owing to the development of a knowledge economy and globalization, as well as global competitiveness. Many researchers have proposed to combine knowledge application with local environment and ability, further leading to the differentiation of regions [3,22,23]. Promoting the energy of innovation leads cities to focus on competitive strategies. Hence, transformations in information technology have also elevated the value of knowledge-based activities in the economy [22]. The use of information and the knowledge economy has also been used to increase development. Furthermore, knowledge has acquired a critical role in urban development through a variety of sources, including energetic social civilization, conservation of a rich natural environment, a high-quality artificial environment, tolerance, multicultural acceptance, democracy, frankness, government with vision, and rich human resources [3,4].

2.1.1. The Key Factor to Successful Urban Development Led by Knowledge

Knowledge-based urban development provides good life quality, because knowledge-based cities aim to attract talent and investments as well as promote city competitiveness [10–13]. A knowledge-based city consists mainly of an economy, social culture, urban environment, and management system. Individual and social development can flourish in a city whose local economy is based on technology and knowledge [24,25]. Growth can come from SMEs that adopt specialist practices of knowledge management, acquiring new organizational and managerial competence in the field of knowledge management; maturity can come from SMEs that invest in new technology and that acquire new technological competence in the field of knowledge management [26,27]. Creating diversity and independently achieving social fairness require the establishment of complete social networks as well as strong human and social capital. Sustainable city development also requires balancing environmental conservation with development as well as the establishment of strong spatial networks between cities [28,29]. Finally, knowledge-based cities systemize interdisciplinary group learning and agglomerate the actors and stakeholders. Furthermore, sustainable economic development of a city can be achieved by forcing the establishment of knowledge-based management, creating social diversity, and conserving and balancing the eco-environment. For the Most Admired Knowledge Cities Awards in 2008, an economic model based on tangible and intangible capitals was adopted for scoring. A rational communication and strategy, considering endogenous assets and developable assets when executing city planning, could replace the traditional planning by demand [30].

2.1.2. The Motivations to Incorporate Research, Development, and Innovation in a Knowledge-Based City

Government acts as an initiator in a knowledge-based city, where the related policies encourage knowledge generation in the city and further attract investments and talents to gather in the city. Most countries believe that the establishment of the living environment

and services in a city assist in the formation of knowledge-based groups, which retain and attract knowledge workers in the city. This work reviews the literature on the motivations for establishing a knowledge-based environment for a city and categorizes the motivations into four groups (Figure 1).
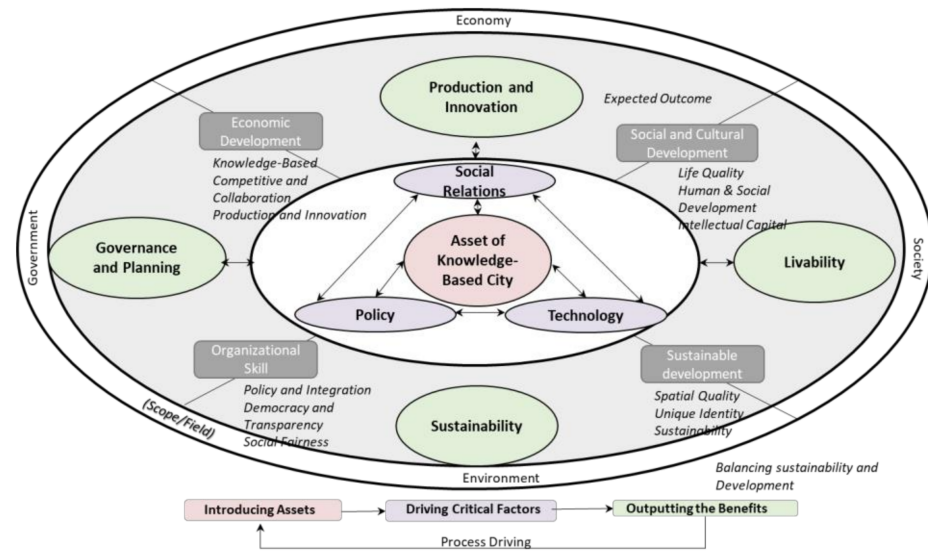

Figure 1. The structure of research, development, and innovation for knowledge-based cities. Source: Revised from Yigitcanlar et al., 2018; Yigitcanlar and Velibeyoglu, 2008; this research.

A. Environmental asset: The transformation based on the development of traditional industries

Industrial activities are transforming from labor-intensive to knowledge- and technology-based development, changing the local environment and turning knowledge-based development for industries into the foundation of sustainable city development [28]. Consequently, in addition to enhancing knowledge interactions, industries also foster a multicultural environment, promoting social improvement and development. The fast growth of the knowledge economy and the intensive traffic connections have led labor-intensive industries or contract manufacturing to gradually focus on knowledge promotion, generating personal brands with innovative energy. Environmental assets are key to retaining knowledge. Good living quality helps a city to resolve living issues, acquire knowledge, and innovate [4]. An eco-friendly, unique, and sustainable environment shapes the network relations that are suitable for urban development and knowledge-based gathering.

Advanced countries have actively integrated advanced modern technologies into traditional industries, stimulated industry transformation and economic growth, and improved quality of life by decreasing the consumption of environmental sources [31]. The identity of a city with strong and energetic social civilization is shaped by the city environment, e.g., crime prevention, social welfare, public facilities, a rich natural environment, and cultural assets. The environmental assets help a city to attract and retain innovators from various cultural backgrounds [3,4] and cultivate an environmental atmosphere suitable for developing a sustainable city.

B. Knowledge-based asset: Talent attraction based on good life quality of a city

Knowledge helps to resolve living issues, acquire knowledge, and initiate technological innovation in a city [4]. The knowledge sharing process helps a city to accommodate and adjust its development, because the use of the Knowledge Sharing Environment (KSE) accustoms the users in the environment to the knowledge exchange mechanism. Accordingly, tacit knowledge transforms and forms knowledge-based networks in which knowledge sharing and accumulating occur, invoking innovative activities. Van Winden [12] evaluated the degree of development of a city based on indices including innovation, numbers of

patents, and research input and concluded that the most important components of the knowledge economy originate from technology, science, and innovation. The transformation of knowledge sources and the impetus of regional development support a city's sustainable development [28]. Technology content has become the critical factor to measure knowledge-based cities in a knowledge economy shaped by technology, science, and innovation [32]. Healthy circulation of knowledge improves its creation and transfer, thus indicating how knowledge was rooted, and is a significant source of regional development, achieving the creation and application of knowledge.

C.   Human asset: The stimulation by knowledge interaction with the neighboring regions

Research in economic geography and urban planning has confirmed the relationship between the growth of human capital and the economic growth of a city. Human capital is critical to achieving production demand in a region or city specialized in industry and sustains the continuous economic growth and development of a city [33,34]. A city that seeks to develop startups or new industries benefits from having leading or pioneering industries or high-level research institutes, owing to the effect on the local environment and emergence of new industries and technologies. Studies have indicated that cultural diversity influences knowledge structure, the motivation to start new businesses, and marketing development in a diverse way [35–37].

Specialized cities, industries, and research institutes, which motivate regional innovation and development, enhance spillover of knowledge by the rise and stimulation of technology and industries. Human capital, in addition to the number of works, the composition, and sources, also includes the cultivation of talents and industry-university collaboration. The exchange and interaction of professional knowledge enable a city or region to benefit from integrating innovative energy and promoting knowledge-based development. Innovative energy is not limited to the industry itself, but also spreads to the city where the industry is located and the surrounding areas, and thus has become a new source of power for urban development, maintaining frequent and diverse knowledge interactions.

D.   Relational asset: Strong economic background

The industrial structure of a city is correlated with urban space development at a certain level, and the two factors normally interact with each other. Relational assets represent the relations of the firm spatial networks between cities. Relational networks are significantly linked with the spatial formation of KBUD and the connections [5,19]. The ratio of overall industrial development to the urban development of a city shows the ability to adjust the structure and enhance the development of the city, emphasizing the matchmaking and management between organizations. The development of information, communication, and technology through knowledge distribution expedites city evolution, resulting in the development of a knowledge-based city. The gathering of knowledge-based groups for urban planning and development based on the traditional strategies requires a different path [38].

In addition to the external networks, the solidity of the relational assets, with regard to the relation between global competitiveness and the networks, is also directly influenced by the internal political systems and the level of public participation and open information. Knowledge networks are strengthened and connected to the surrounding areas to raise global competitiveness through clusters specially formed in some locations of the region. The economic system of a city is thus clustered by region and is based on further established networks. The system is linked to the surrounding areas or other regions in the production and forms various knowledge-based environments. Localized characteristics thus develop based on the different demands of activities and functions in different regions.

Based on the literature review, this work categorizes the driving forces for the development of knowledge-based cities into community, technology, and policy, with five expected outcomes, defined as the interrelationships between productivity, sustainability, accessibility, livability, and governance. With the spillover effect of knowledge flow driven

by the technology of information transmission, innovators have begun cross-regional collaborations, unimpeded by geographic boundaries. Spatial planning tends to improve the quality of life and integrate local and cross-regional technologies as well as complementary knowledge and the ability to form network structures. This critical strategy has quickly adapted to the dynamic industrial environment [15]. In other words, knowledge innovation and accumulation are considered to be the core of urban planning and economic growth, in which knowledge cultivation, innovative technology, research and development, and the development of creativity are encouraged. Yigitcanlar [39] proposed that balancing the economy, society, environment, and governance of a city helps increase its research and innovative energy and is also important in developing a knowledge-based city.

These driving forces build the framework for a knowledge-based city, and each represents a unique city characteristic [40]. The driving forces are further categorized into four subgroups: the economy, society and culture, environment and city, and the system. A rational communication and strategy for urban planning has also been suggested. The interaction and circulation of the four subgroups resulted in the formation of the following critical factors leading toward a knowledge-based city:

1. Changes in the overall environment trigger a source of knowledge to become the driving force for development, which further leads to industrial transformation.
2. The good quality of life of a city attracts talent.
3. The diversity of information and culture affects the knowledge structure, the driving force to start a business, and market development and stimulates knowledge interaction for the neighboring regions.
4. A good economic base implies the effectiveness of matchmaking and management between organizations.

To achieve a comprehensive understanding of the differences in research and innovative energy among cities, this work investigates the differences in the four factors among Helsinki, Melbourne, and Hsinchu, based on the above hypothesis. For instance, detailed information about the economic environment, global competitiveness, innovative energy, population composition, research institutes, social environment, and internal and external environment were collected and discussed.

3. Concept and Method—The Driving Forces for Developing a Knowledge-Based City

The most challenging part of this comparison of different countries was the data collection. This work established and investigated quantitative indices used for the evaluation of knowledge-based cities [41]. Research revealed that knowledge management was perceived to be more about developing knowledge culture than about managing organizational processes and structure. However, when facilitators for knowledge creation and knowledge sharing were rated, organizational structure was perceived to be more important than organizational culture and information technology [42]. The research summarizes the values of various indices, namely environment, human resources, knowledge, and relational assets. The cities in the analysis were Helsinki, Melbourne, and Hsinchu. Helsinki, the representative of Europe, participates in global networks, attracts innovative industries and talents, integrates a local innovative environment with global innovative ecology, and benefits by learning from innovative networks. Melbourne, a representative city in Australia, demonstrates good life quality and diverse culture, with the continuous development of innovation, culture, and attractions. Hsinchu was selected for comparison in the study as it has the highest knowledge density in Northern Taiwan. Finally, by identifying the differences in evaluation indices and considering the different backgrounds of the cities, this work investigated the strategic differences in urban innovation among cities and recommended rules for the development of knowledge-based cities.

This research summarized the driving forces and outcomes and established four aspects of evaluation for knowledge-based cities. The driving forces were community, technology, and policy, and the anticipated outcomes were productivity, sustainability, accessibility, livability, and governance. By comparing the cities awarded Most Admired

Knowledge City, this work identified the similarities and differences in urban development and adopted the observations to be the references for promoting knowledge-based cities. Helsinki, a city in Finland, was chosen as a city in a location that lacks natural resources. The second city, Melbourne, Australia, contains a variety of natural resources and explores a knowledge-based development. The two selected cities have different resources, but both plan to develop into knowledge-based cities. Accordingly, the two cities were further compared with Hsinchu.

This work attempted to establish an evaluation system using different aspects. The official statistics, including the global competitiveness report, National Statistics, Department of Training and Workforce Development of Australia, expenditure from Statistics Finland, and the statistics for population, were gathered and adopted to evaluate the application of KBUD in the cities. To understand the formation of knowledge networks during urban development oriented by knowledge in Melbourne, Helsinki, and Hsinchu, a comprehensive analysis for the role of knowledge in the cities was conducted using a literature review [5,40]. Descriptive statistics were incorporated, and four aspects were evaluated, namely knowledge-based assets, human assets, environmental assets, and relational assets. Table 1 shows details of the indices. The fluctuation of the driving forces was identified from the dominant performance indices in each region.

Table 1. Detailed indices used for the evaluation of knowledge-based cities.

Aspect of Evaluation	Item of Evaluation	Details of Evaluation	References
Environmental asset	Social environment	The trend of housing prices, social welfare, quality of public facilities, medical expenses per person (USD), performance of criminal prevention, transportation, and land use (person/km^2)	Florida [4]; Baum [43]; Yigitcanlar [44]
	Cultural preservation/tolerance	Preservation of material and cultural assets and intangible cultural assets, as well as ethnic diversity	
Knowledge-based asset	Economic environment	Employment-to-population ratio, GDP per capita (USD), consumer price index (CPI), unemployment rate, average income (USD)	Knight [28]; Van Winden [32]
	Global competitiveness	Global enterprises, amount of foreign trade (million USD)	
	Innovative energy	Creativity, numbers of patents applied	
Human asset	Population composition	Source of workers, migration rate, structure of workforce	Black and Henderson [33]; Glaeser [34]
	Education and learning	Investment rate for education, popularity of professional skills	
	Research institute	Rate of higher education, the quality of research institutes, collaboration of university/research institutes and industries	
Relational asset	Internal relations	Build-up of international and national image, establishment of public networks, global competitiveness, number of sister cities	Kunzmann [38]; Yigitcanlar [5,19]; Graham [45]; Hackler [46]; Baum [3]

In the next part, we will compare the circular stimulation of innovation in the three cities. We will clarify the background analysis for the cities incorporated for the case study and then analyze the performance indices of knowledge-based cities. In other words, we will empirically evaluate the knowledge-based cities and then discuss the similarities and differences of the three cities.

4. Comparison of Circular Stimulation of Innovation in Different Cities

4.1. Background Analysis for the Cities used for the Case Study

The developmental stage of the cities was analyzed from the relationship with the surrounding regions, social culture, economy, and politics. Based on the development in the same direction, the cities for the case study were selected for the following reasons: (1) they are famous for high-tech development and manufacturing worldwide; (2) many talented individuals live there, owing to the strategic position and economic growth of the cities; and (3) the cities have quickly adapted to the knowledge-based development process, providing effective and diversified development.

Considering that asset-oriented planning advocates rational communication and strategy in the method of planning, this work identified the critical points for development using background analysis (see Table 2), considering the internal assets and the enhancement of potential developmental assets and positive aspects [30].

A.   The formation of clusters by the application of knowledge-intensive interactions [47] has resulted in the persistence of a city's creativity, an increase of identity and intangible assets, and enhancement of the platform for knowledge-based groups. The major changes in Helsinki are the revolution in public services and innovation and the support of innovative activities.

B.   Melbourne has attracted global companies and talents to settle, with a good living environment and eco-environment. It encourages knowledge transfer and research activities through the stimulation and integration of multiple creativities [32]. The complete system of intellectual property rights protects and ensures the rights of enterprises. Multiple-knowledge stimulation has become popular in Melbourne, further leading to circular stimulation of innovation in the region.

C.   Asset-oriented planning based on existing and intangible assets has introduced various methods for development, such as bring-in of the new technology, talent cultivation, and technology services and transfer. A complete network for knowledge-based capital has been established to continuously provide energy for industrial development and innovative development [5]. This network enhances production networks, technical infrastructure, and the communication and interaction between universities and informal information in the neighboring regions. Additionally, industrial, government, and academic sources are integrated with innovation and future development based on existing sources.

Table 2. Comparison of the knowledge-based cities selected for case study.

Background	· Melbourne, located in southern Victoria State on the east coast of Australia, is the state's capital and the biggest city. The land area is 2664 square kilometers. The average population density is 1764 persons/km^2. It is one of the most livable and biggest cities in the world. · Melbourne began its urban development oriented by knowledge in the early 1990s, integrating knowledge with urban development. The city became a main area for the aerospace industry and research institutes in the Asia Pacific, due to related policies and finance established by national and local governments and supports offered by startup companies. It is now an important industrial center for heavy machinery, textiles, the pulp and paper industry, electronics, chemicals, metal processing, automobiles, food, biotechnology, financial services, and the design industry. · To provide a high-quality living environment and retain knowledge workers, Melbourne increased its competitiveness by establishing a learning and training mechanism and expanding its creativity and innovation. High-performance information and communication facilities were engaged to develop e-commerce.
Melbourne	

Table 2. *Cont.*

	Greatest Achievement	· The collaborative relationships between local government, private sectors, and communities. · Proposing technical training plans for youth. · Employment plan for youth and communities. · Good city management. · Incentives to support innovative industry and labor. · Promoting travel, physical education, art, and cultural activities.
	Characteristics	· Developing biotechnology networks. · Improving construction technology. · Innovative startups. · Establishing local business culture. · Promoting higher education. · Multiple developments and skilled workforce. · Enhancing the livability and life services of the city. · Developing affordable housing and the education system.
Helsinki	**Background**	· Helsinki, the capital of Finland, is the biggest city in Finland. The land area is 214.21 square kilometers. The population is 629,500, with an average population density of 2938 persons per square kilometer. · The capital region, Greater Helsinki, consists of Helsiki, Espoo, Vantaa, and Kauniainen. · Helsinki, the main base of knowledge production in Finland, contains five universities, forming a knowledge-based district. · Helsinki, combining its natural scene with a high-tech and modern style, was awarded the World Design Capital in 2012. · Developing the strength of NOKIA-constructing internet infrastructure and upgrading network processor, router, wireless communication technology, etc. Customers were narrowed down to the wireless service provider, such as Verizon and AT&T.
	Greatest Achievement	· Population with higher education/high quality of life/high quality of local facilities/high accessibility/investment in large art and cultural facilities/high level of social fairness. · Owing to a large telecommunications company, NOKIA.
	Characteristics	· Complete vision and planning mechanism. · The dynamic innovation becomes the world commercial center. · Economic development based on knowledge. · Concentrated regional development. · Investing in ICT research and development. · Developing high-quality infrastructure and services.
Hsinchu	**Background**	· Hsinchu, where the first science park in Taiwan is located, leads the development of Taiwanese high-tech industries. It is also called oriental silicon valley. The land area of Hsinchu is 1532 square kilometers, with a population of 991,000. The average population density is 2305 persons per square kilometer. · Hsinchu is the high-tech town of Taiwan, containing various industries, such as integrated circuits, computers, communications, optoelectronics, precision devices, and biotechnology. · Many research institutes located in the city drive the development of high-tech industries and the upstream and downstream industries. · The infrastructure and environment trigger knowledge production and exchange and further cultivate new businesses and promote competitiveness. Thus, regional economic growth was driven and the city's value was created.

Table 2. *Cont.*

Greatest Achievement	·	The core of a knowledge-based economy, stimulating the research, development, and innovation of the value chain.
	·	Creating high-tech-based economic development in Taiwan.
	·	ICT product design and manufacturing.
Characteristics	·	ICT industry, from the contract manufacturing of electronics, to a global computer production center, to the center of semiconductor and ICT product design and manufacturing.
	·	Developing high-quality infrastructure and services.

Source: Yigitcanlar [19,48]; Shu [49]; Vaattovaara [50]; Abetti [47]; Anttiroiko [51]; Van den Berg [52]; Shaw [53]; Van Winden [32]; Annual report published by Hsinchu Science Park, 2016; Mathie and Cunningham [30]; this research.

4.2. Analysis of the Performance Indices of Knowledge-Based Cities

Providing research and innovative energy for a city benefits urban development, further enhances the economy, and brings order to social space within the region. A city with a good reputation is likely to have strong quality of living, employment, and investment, thus achieving a virtuous cycle. While facing the era of the global knowledge economy, cities have attempted to increase competitiveness, cultivate talent, and make accurate and strategic investments to enable the city to flourish and to improve the quality of life [48]. This work analyzed the system of a city by identifying the city composition, including knowledge, human resources, environment, and relations. The diverse innovation and creativity of a knowledge-based city and the complex knowledge have led to the intensive development of the regional environment and continuously provide energy for city growth by increasing competitiveness in the changing environment [54,55]. Therefore, this work analyzed the evaluated items for knowledge-based cities, established the standard for the knowledge-based dimension, and categorized the development indices for knowledge-based cities by standardizing the collected data.

The statistics indicate that among the three cities, Helsinki ranked first in most development indices, particularly those related to environment and knowledge. Helsinki had 42.94% top ranking among all indices for building a knowledge-based city. Melbourne (24.96%) had top rankings in social welfare, cultural assets, and GDP per capita, implying that residents would be happier living in that city than in the others surveyed. Hsinchu (32.10%), the location of the first science park in Taiwan, had the top rankings in trading activities, medical resources, stable politics, professional techniques, and workforce. The trading activities and professional methods in Hsinchu can easily trigger and stimulate innovation. Consequently, the establishment of Hsinchu Science Park has had a strong impact on innovation in the region.

As well as deriving the dominant indices, this work standardized the collected data with the performance indices to further analyze the performance and the level of innovative stimulation of the surveyed knowledge-based cities. The analysis shows that social environment and internal relations were categorized as relatively important indices, with a performance value > 5 (Table 3). Melbourne, where the weighted average performance was 5.13, performed the best overall. Melbourne performed strongest in the social environment (5.36), education and learning (7.15), and internal relations (6.92), among all indices. Melbourne and Helsinki both demonstrate the importance of education investment, professional techniques, and social environment. Hsinchu performed strongest in research institutes among the three cities. The location of Hsinchu Science Park has resulted in related research and education institutes gathering in Hsinchu, as well as enhanced innovative knowledge interactions, resulting in the formation of a knowledge-intensive environment that encourages sustainable urban development.

Table 3. The indices for the performance evaluation of urban development.

		Evaluation Details	Melbourne		Helsinki		Hsinchu	
Environmental asset	Social environment	The trend of housing prices [56–59]	8.61		10.68		8.68	
		Social welfare [60,61]	8.22		8.08		8.00	
		Quality of public facilities [62,63]	4.90		6.20		5.50	
		Medical expenses per person (USD) [61]	4.55	5.36	4.04	5.88	1.39	5.39
		performance of criminal prevention (%) [62,63]	6.10		6.70		5.00	
		Transportation (%) [59,60,64]	4.51		5.48		4.61	
		Land use (person/km^2) [58,61]	0.63		4.80		4.55	
	Cultural tolerance	Preservation of material and cultural assets [65–67]	1.42		2.85		5.71	
		Preservation of cultural assets and intangible cultural assets [65–67]	6.95	3.30	0.43	2.29	2.60	4.39
		Ethnic diversity [65–67]	1.53		3.58		4.87	
Knowledge-based asset	Economic environment	Employment-to-population ratio [60,68,69]	6.25		7.15		5.92	
		GDP per capita (USD) [59,60,64]	4.42		4.05		1.51	
		Consumer price index (CPI) [59,60,64]	2.48	4.74	1.04	4.63	1.20	2.83
		Unemployment rate (%) [60,68,69]	5.99		7.20		3.80	
		Average income (USD) [60,68,69]	4.58		3.70		1.72	
	Global competitiveness	Global enterprises [60,61]	5.90		6.60		5.50	
		Amount of foreign trade (million USD) [59,60,62]	3.74	4.82	1.91	4.26	5.24	5.37
	Innovative energy	Creativity [60,61]	4.10		5.50		5.00	
		Numbers of patents applied for [60,61,70]	5.80	4.95	6.30	5.90	5.20	5.10
Human asset	Population composition	Source of workers [70–72]	4.50		5.30		4.00	
		Migration rate (%) [70–72]	3.67	4.94	0.56	4.05	0.87	4.01
		Structure of workforce (%) [60,70–72]	6.65		6.30		7.17	
	Education and learning	Investment rate for education (%) [60,61]	10.00		7.00		3.07	
		Popularity of professional skills (%) [60,61,73]	4.29	7.15	4.27	5.64	4.43	3.75
	Research institute	Rate of higher education (%) [60,61,74]	1.63		2.31		5.03	
		Quality of research institutes [60,61,74]	5.80	4.08	5.80	4.70	5.10	5.08
		Collaboration of university/research institute and industries [60,61,74]	4.80		6.00		5.10	
Relational asset	External relations	Build-up of international and national image [60,75]	5.50		6.10		5.50	
		Establishment of public networks [60,75]	6.10		6.00		5.40	
		Global competitiveness [60,75]	5.15	5.09	5.45	4.80	5.28	5.23
		Number of sister cities [60,61,76]	3.61		1.66		4.72	
	Internal relation	Stability of political system [60,61]	4.90		5.90		5.40	
		Social awareness and civil participation [60,61]	6.36	6.92	5.88	6.83	6.58	7.36
		Government transparency [60,61,77]	9.50		8.70		10.10	
Weighted average performance indices			5.13		4.90		4.85	
Advantaged performance value of detailed indices			24.96%		42.94%		32.10%	

This work categorized the evolution of development, oriented by circular stimulation, in each city, based on the characteristics of its development and different accumulating approaches. The energy fluctuation of the cities selected for the case study was analyzed from changes in the environmental, knowledge-based, human, and relational performance indices (Figure 2). These cities displayed various interactions under different characteristics.
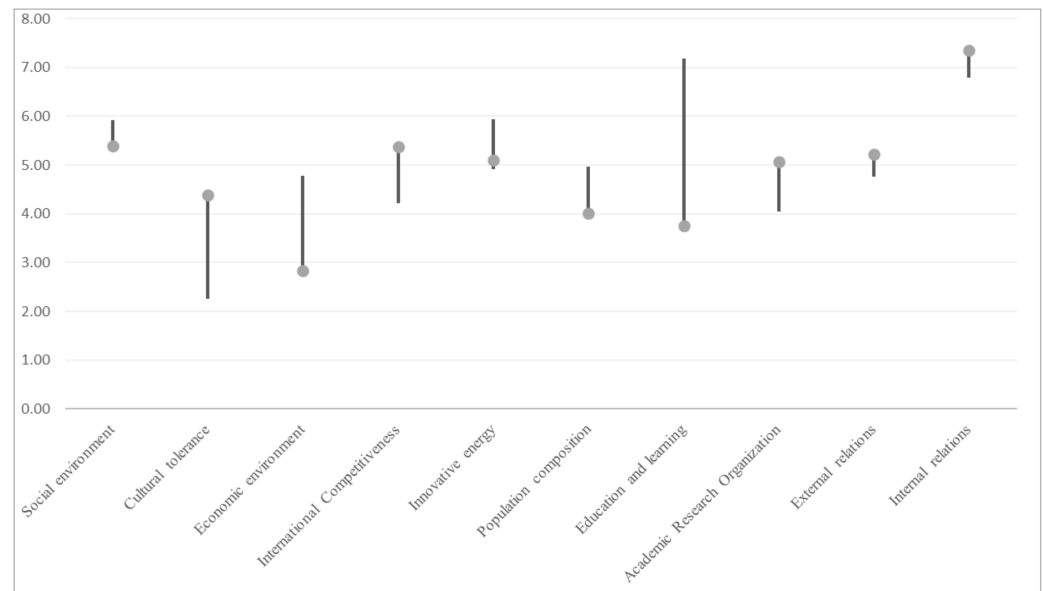

Figure 2. Indices for urban development oriented by knowledge. Source: this research.

Among all the indices analyzed, the social environment and internal relations had the highest consistency and significance. In contrast, the factors of education and learning indicated the biggest differences among the three cities. The core factor in the evolution toward circular stimulation was thus concluded to be the cultivation of human assets, executed by education and learning. Incorporating knowledge-based assets with the establishment of environmental and relationship networks promotes changes in government, enterprises, and residents. Moreover, collaboration in planning, revising, and executing projects generates vision as a result of innovative circular stimulation.

5. Conclusions and Suggestions

This work discusses economic collaboration and regional development. Regional development oriented by knowledge helps promote city competitiveness. The accumulation of knowledge-based, human, environmental, and relational assets gradually forms the power for continuous development and further leads a city into a virtuous cycle. Accumulating development and innovative energy is a critical factor for building a knowledge-based city. This work observes that urban development, consistently transforming the focus of a city from manufacturing to creation, has become an important factor. Innovation and technology represent intangible power and knowledge, complementing tangible assets such as land, capital, and workforce. Urban development is also a continuous learning process. Circular innovation and stimulation of knowledge enhance the knowledge content in a city and improve the overall city environment, owing to the promoted creativity. To continuously promote circular stimulation in a city, the index of education and learning, cultivating human assets, should be improved, along with the significant indices of the social environment and internal relations (Figure 3). The circular stimulation to promote the three key indices helps to stabilize the internal relations through the formation of the local environment. Consequently, the city attracts talent, driving innovative and creative circulation.
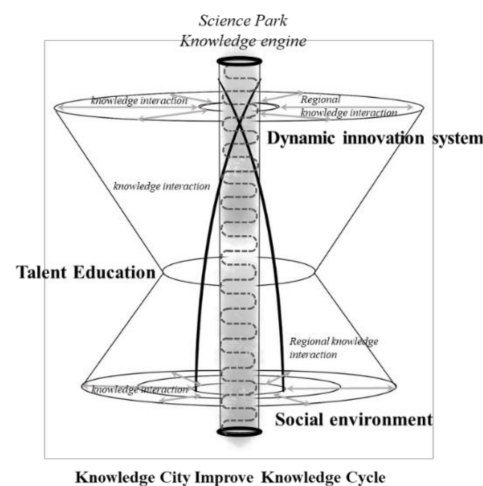
Figure 3. The critical components of development, innovation, and circular stimulation for knowledge-based cities. Source: this research.

First, the development and innovative energy assist in urban development, potentially developing the economy and organizing the social space. A city with a good reputation becomes fascinating to visitors, residents, employers, and investors, leading to the formation of a virtuous cycle. The collaboration of environmental, human, and relational assets settle the circular stimulation of innovation in a city. Hsinchu Science Park demonstrates the effectiveness of such collaborations. This work demonstrates that Hsinchu Science Park is a knowledge engine, with very high interactions and stimulations. The stable social environment and talent networks promote the circular stimulation of a knowledge-based city and further shape the key factors in its evolution.

To stabilize the foundations for knowledge development, the first input of a city should be education and learning. Stabilized relational networks and social environments could provide an appropriate mechanism for talent cultivation for academia and industries. Elevating the cultivation of talents may encourage high-density knowledge-based networks on top of sustainable knowledge-based development. Three critical factors shape circular stimulation: (1) a livable social environment to attract talent and stabilize knowledge-based networks; (2) continuous input for talent cultivation, retention, and recruitment; and (3) stabilized relational networks that help in the construction of innovative modes to stimulate knowledge feedback, promote knowledge circulation, and further generate continuous innovative interactions in the city. The follow-up study will focus on the analysis of more cases and perform gap analysis for urban development among cities. A more complete evaluation system will be established to change the direction of urban development toward the evolution of innovative circular stimulation.

In this research, we put forward the key factors to promote the circular development of KBUD, so that cities can develop through circular innovation. Several factors still need to be considered, including the differences in local assets and their lack of permanence and need for adjustment over time. However, our concept is still influential: that is, cities continuing to develop in a sustainable manner and maintain a knowledge base and innovative energy for future planning.

Author Contributions: Conceptualization, T.-S.H.; Data curation, H.-P.L.; Formal analysis, S.-C.P. and H.-P.L.; Funding acquisition, T.-S.H.; Investigation, S.-C.P.; Methodology, T.-S.H.; Project administration, T.-S.H.; Software, S.-C.P.; Writing—Original draft, H.-P.L.; Writing—Review & editing, T.-S.H. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement: Please refer to Appendix A.

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

Appendix A

Knowledge-Based Asset		Human Asset		Environmental Asset		Relational Asset	
Indices	Evaluation Details	Indices	Evaluation Details	Indices	Evaluation Details	Indices	Evaluation Details
Economic environment	Employment-to-population ratio (%)	Population composition	Source of workers	Social environment	The trend of housing price	External relations	Build-up of international and national image
	GDP per capita (USD)		Migration rate (%)		Social welfare		Establishment of public networks
	Consumer price index (CPI)		Structure of workforce (%)		Quality of public facilities		Global competitiveness
	Unemployment rate (%)	Education and learning	Investment rate for education (%)		Medical expenses per person (USD)		Numbers of sister cities
	Average income (USD)		Popularity of professional skills (%)		Performance of criminal prevention (%)		Stability of political system
Global competitiveness	Transnational enterprises	Research institute	Rate of higher education (%)		Transportation accessibility (%)	Internal relations	Social awareness and civil participation
	Amount of foreign trade (million USD)		Quality of research institutes		Land use (person /km^2)		Government transparency
Innovative energy	Innovativeness		Collaboration of university/research institute and industries	Cultural tolerance	Preservation of material and cultural assets		
	Numbers of patents applied				Preservation of intangible assets		
					Ethnic diversity		

References

1. Christopherson, S.; Michie, J.; Tyler, P. Regional resilience: Theoretical and empirical perspectives. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 3–10. [CrossRef]
2. Simmie, J.; Martin, R. The economic resilience of regions: Towards an evolutionary approach. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 27–43. [CrossRef]
3. Baum, C.F. *An Introduction to Modern Econometrics Using Stata*; Stata Press: College Station, TX, USA, 2006.
4. Florida, R. *Cities and the Creative Class*; Routledge: London, UK, 2005.
5. Yigitcanlar, T.; Velibeyoglu, K.; Martinez-Fernandez, C. Rising knowledge cities: The role of urban knowledge precincts. *J. Knowl. Manag.* **2008**, *12*, 8–20. [CrossRef]
6. Carrillo-Hermosilla, J.; Del Río, P.; Könnölä, T. Diversity of eco-innovations: Reflections from selected case studies. *J. Clean. Prod.* **2010**, *18*, 1073–1083. [CrossRef]

7.   Laszlo, K.C.; Laszlo, A. Fostering a sustainable learning society through knowledge-based development. *Syst. Res. Behav. Sci. Off. J. Int. Fed. Syst. Res.* **2007**, *24*, 493–503. [CrossRef]

8.   Bontje, M.; Musterd, S.; Kovács, Z.; Murie, A. Pathways toward European creative-knowledge city-regions. *Urban Geogr.* **2011**, *32*, 80–104. [CrossRef]

9.   Hsieh, H.-N.; Chen, C.-M.; Wang, J.-Y.; Hu, T.-S. Knowledge-intensive business services as knowledge intermediaries in industrial regions: A Comparison of the Hsinchu and Tainan metropolitan areas. *Eur. Plan. Stud.* **2015**, *23*, 2253–2274. [CrossRef]

10.   Knight, J. *Higher Education in Turmoil: The Changing World of Internationalization*; Brill: Leiden, The Netherlands, 2008.

11.   Kunzmann, K.R. Culture, creativity and spatial planning. *Town Plan. Rev.* **2004**, *75*, 383–404. [CrossRef]

12.   Yigitcanlar, T. Planning for knowledge-based urban development: Global perspectives. *J. Knowl. Manag.* **2009**, *13*, 228–242. [CrossRef]

13.   Yigitcanlar, T.; Metaxiotis, K.; Carrillo, F.J. *Building Prosperous Knowledge Cities: Policies, Plans and Metrics*; Edward Elgar Publishing: Cheltenham, UK, 2012.

14.   Lee, D.-S. Pattern Discovery on Networks of Geographical Co-invention. *Procedia Comput. Sci.* **2017**, *112*, 1984–1993. [CrossRef]

15.   Presutti, M.; Boari, C.; Majocchi, A.; Molina-Morales, X. Distance to customers, absorptive capacity, and innovation in high-tech firms: The dark face of geographical proximity. *J. Small Bus. Manag.* **2019**, *57*, 343–361. [CrossRef]

16.   Jacobson, A. *A Cohesive Downtown from a Knowledge City Perspective—A Study in Urban Planning*; Jönköping School of Engineering: Jönköping, Sweden, 2012.

17.   May, T.; Perry, B. Urban research in the knowledge economy: Content, context and outlook. *Built Environ.* **2011**, *37*, 352–367. [CrossRef]

18.   Yigitcanlar, T.; Sarimin, M. The role of universities in building prosperous knowledge cities: The Malaysian experience. *Built Environ.* **2011**, *37*, 260–280. [CrossRef]

19.   Sassen, S. Cities in the Global Economy. In *Handbook of Urban Studies*; SAGE Publications: London, UK, 2001; pp. 256–272.

20.   Hall, P.A.; Hall, P.A. *Governing the Economy: The Politics of State Intervention in Britain and France*; Oxford University Press: New York, NY, USA, 1986.

21.   Hu, T.-S.; Lin, C.-Y.; Chang, S.-L. Role of interaction between technological communities and industrial clustering in innovative activity: The case of Hsinchu district, Taiwan. *Urban Stud.* **2005**, *42*, 1139–1160. [CrossRef]

22.   Porter, M.E.; Stern, S. Innovation: Location matters. *MIT Sloan Manag. Rev.* **2001**, *42*, 28.

23.   Adam, F.; Makarovic, M.; Rončević, B.; Tomšič, M. *The Challenges of Sustained Development: The Role of Socio-Cultural Factors in East-Central Europe*; Central European University Press: Budapest, Hungary, 2004.

24.   Ovalle, M.D.R.G.; Márquez, J.A.A.; Salomón, S.D.M. A compilation of resources on knowledge cities and knowledge-based development. *J. Knowl. Manag.* **2004**, *8*, 107–127. [CrossRef]

25.   Baskerville, R.; Dulipovici, A. The theoretical foundations of knowledge management. *Knowl. Manag. Res. Pract.* **2006**, *4*, 83–105. [CrossRef]

26.   Centobelli, P.; Cerchione, R.; Esposito, E. Environmental sustainability in the service industry of transportation and logistics service providers: Systematic literature review and research directions. *Transp. Res. Part D Transp. Environ.* **2017**, *53*, 454–470. [CrossRef]

27.   Knight, R.V. Knowledge-based development: Policy and planning implications for cities. *Urban Stud.* **1995**, *32*, 225–260. [CrossRef]

28.   Yigitcanlar, T. Making space and place for the knowledge economy: Knowledge-based development of Australian cities. *Eur. Plan. Stud.* **2010**, *18*, 1769–1786. [CrossRef]

29.   Mathie, A.; Cunningham, G. From clients to citizens: Asset-based community development as a strategy for community-driven development. *Dev. Pract.* **2003**, *13*, 474–486. [CrossRef]

30.   Bătăgan, L. The use of Intelligent Solutions in Romanian Cities. *Inform. Econ.* **2012**, *16*, 37–43.

31.   Van Winden, W.; Van den Berg, L.; Pol, P. European cities in the knowledge economy: Towards a typology. *Urban Stud.* **2007**, *44*, 525–549. [CrossRef]

32.   Black, D.; Henderson, V. *Urban Evolution in the USA*; Brown University: Providence, RI, USA, 1998.

33.   Glaeser, E.L. The new economics of urban and regional growth. *Oxf. Handb. Econ. Geogr.* **2000**, *37*, 289–302.

34.   Audretsch, D.B.; Belitski, M.; Desai, S. Entrepreneurship and economic development in cities. *Ann. Reg. Sci.* **2015**, *55*, 33–60. [CrossRef]

35.   Audretsch, D.B.; Belitski, M.; Korosteleva, J. Cultural diversity and knowledge in explaining entrepreneurship in European cities. *Small Bus. Econ.* **2021**, *56*, 593–611. [CrossRef]

36.   Spanjer, A.; van Witteloostuijn, A. The entrepreneur's experiential diversity and entrepreneurial performance. *Small Bus. Econ.* **2017**, *49*, 141–161. [CrossRef]

37.   Kunzmann, K.R. The strategic dimensions of knowledge industries in urban development. *DISP-Plan. Rev.* **2009**, *45*, 40–47. [CrossRef]

38.   Yigitcanlar, T. *Technology and the City: Systems, Applications and Implications*; Routledge: London, UK, 2016.

39.   Yigitcanlar, T.; Kamruzzaman, M.; Buys, L.; Ioppolo, G.; Sabatini-Marques, J.; da Costa, E.M.; Yun, J.J. Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework. *Cities* **2018**, *81*, 145–160. [CrossRef]

40. Huggins, R.; Izushi, H. Regional benchmarking in a global context: Knowledge, competitiveness, and economic development. *Econ. Dev. Q.* **2009**, *23*, 275–293. [CrossRef]

41. Zhou, A.Z.; Fink, D. Knowledge management and intellectual capital: An empirical examination of current practice in Australia. *Knowl. Manag. Res. Pract.* **2003**, *1*, 86–94. [CrossRef]

42. 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.

43. Yigitcanlar, T.; Baum, S.; Horton, S. Attracting and retaining knowledge workers in knowledge cities. *J. Knowl. Manag.* **2007**, *11*, 6–17. [CrossRef]

44. Graham, S.; Marvin, S. Planning cybercities? Integrating telecommunications into urban planning. *Town Plan. Rev.* **1999**, *70*, 89–114. [CrossRef]

45. Hackler, D. High-tech growth and telecommunications infrastructure in cities. *Urban Aff. Rev.* **2003**, *39*, 59–86. [CrossRef]

46. Abetti, P.A. Government-supported incubators in the Helsinki region, Finland: Infrastructure, results, and best practices. *J. Technol. Transf.* **2004**, *29*, 19–40. [CrossRef]

47. Yigitcanlar, T.; Lönnqvist, A. Benchmarking knowledge-based urban development performance: Results from the international comparison of Helsinki. *Cities* **2013**, *31*, 357–369. [CrossRef]

48. Shu, P.; Steinwender, C. The impact of trade liberalization on firm productivity and innovation. *Innov. Policy Econ.* **2019**, *19*, 39–68. [CrossRef]

49. Vaattovaara, M. The emergence of the Helsinki Metropolitan Area as an international hub of the knowledge industries. *Built Environ.* **2009**, *35*, 204–211. [CrossRef]

50. Anttiroiko, A.-V. City-as-a-platform: The rise of participatory innovation platforms in Finnish cities. *Sustainability* **2016**, *8*, 922. [CrossRef]

51. Van den Berg, G.J.; Van der Klaauw, B.; Van Ours, J.C. Punitive sanctions and the transition rate from welfare to work. *J. Labor Econ.* **2004**, *22*, 211–241. [CrossRef]

52. Shaw, K. Discretion vs. regulation and the sorry case of Melbourne city plan 2010. *Urban Policy Res.* **2003**, *21*, 441–447. [CrossRef]

53. Carrillo, F. *Knowledge Cities*; Routledge: London, UK, 2006.

54. Cooke, P. Regional innovation systems: General findings and some new evidence from biotechnology clusters. *J. Technol. Transf.* **2002**, *27*, 133–145. [CrossRef]

55. Turok, I. Cities, regions and competitiveness. *Reg. Stud.* **2004**, *38*, 1069–1083. [CrossRef]

56. Statistics on Housing Affordability. Available online: https://pip.moi.gov.tw/V3/E/SCRE0105.aspx (accessed on 12 February 2015).

57. Property Prices in Helsinki, Finland. Available online: https://www.numbeo.com/property-investment/in/Helsinki?displayCurrency=USD (accessed on 10 October 2016).

58. Current Property Prices Index. Available online: https://www.numbeo.com/property-investment/rankings_current.jsp (accessed on 10 October 2016).

59. Statistics Finland's free-of-charge statistical databases. Available online: https://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/ (accessed on 18 December 2016).

60. Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Taiwan. Available online: https://win.dgbas.gov.tw/fies/a11.asp?year=106 (accessed on 5 January 2016).

61. The Global Competitiveness Report 2015–2016. Available online: https://www3.weforum.org/docs/gcr/2015-2016/Global_Competitiveness_Report_2015-2016.pdf (accessed on 16 February 2016).

62. Global Open Data Index: Survey. Available online: http://global.census.okfn.org/year/2015 (accessed on 8 February 2015).

63. National Statistics, Taiwan. Available online: https://nstatdb.dgbas.gov.tw/dgbasall/webMain.aspx?k=engmain (accessed on 6 February 2016).

64. Australian National Accounts: State Accounts, 2017–2018. Available online: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5220.02017-18?OpenDocument (accessed on 20 November 2018).

65. Australia—NESCO World Heritage Centre. Available online: https://whc.unesco.org/en/statesparties/au (accessed on 13 June 2015).

66. Finland—NESCO World Heritage Centre. Available online: http://whc.unesco.org/en/statesparties/fi (accessed on 13 June 2015).

67. Premier's Reports to the Legislature, Executive Yuan, Taiwan. Available online: https://english.ey.gov.tw/Page/A19632D1DB6324A5 (accessed on 8 June 2016).

68. Australia Employment status. Available online: https://profile.id.com.au/australia/employment-status (accessed on 3 August 2015).

69. Helsinki Quarterly. Available online: https://www.hel.fi/hel2/tietokeskus/julkaisut/pdf/quarterly_03_11_verkko.pdf (accessed on 6 June 2015).

70. International connections—City of Melbourne. Available online: https://www.melbourne.vic.gov.au/business/grow-business/international-opportunities/international-connections/Pages/international-connections.aspx (accessed on 7 June 2015).

71. Finland Demographics Profile. Available online: https://www.indexmundi.com/finland/demographics_profile.html (accessed on 6 June 2015).

72. Statistics, National Immigration Agency. Available online: https://www.immigration.gov.tw/5475/5478/141478/141380/ (accessed on 10 October 2016).

73. Datasets, National Development Council, Taiwan. Available online: https://data.gov.tw/en (accessed on 8 June 2015).

74. Australian Bureau of Statistics. Available online: https://www.abs.gov.au/statistics (accessed on 9 December 2016).

75. Data, Organisation for Economic Co-operation and Development. Available online: https://data.oecd.org/ (accessed on 15 January 2016).
76. International Relations, City of Helsinki. Available online: https://www.hel.fi/helsinki/en/administration/enterprises/competitive/international-activities/ (accessed on 10 December 2015).
77. Victorian Electoral Commission. Available online: https://www.vec.vic.gov.au/ (accessed on 16 September 2017).