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Measuring the development of innovations districts through performance indicators: 22@Barcelona Case

Abstract

Innovation Districts are rising as the banners of the new urban, economic, and social paradigm and as a solution to the renaissance of inner cities since they expedite the creation and commercialization of new ideas which leverage the city goals and its technologic and economic attributes. The configuration of accurate indicators to measure the degree of achievement of the innovation district goals is one of the main requirements to ensure district proper development. Even when the study of innovation districts is a topic that is increasingly under study, little is still known about the insight, and it is still needed tools that favor their evolution and development. The aim of this paper is two-fold: on the one hand, it seeks to collect and analyze the indicators that have been used in literature to measure the degree of maturity over the course of the 20-year existence of the 22@Barcelona, an area of innovation that transformed an old industrial district into a knowledge-based one. On the other hand, guided by the four dimensions of the Knowledge Base Urban Development theory and the main actors that make up Triple Helix approach, the paper designs a framework of indicators in the four spheres that shape the regeneration of the district, that is, urban, economic, social and governance. As we shall see, a total of 47 indicators are proposed, indicating for each of them: the environment in which it is applied, the main purpose to which it responds, and the main actor with the greatest power of action over it.

Keywords: Innovation District, Indicator, Triple Helix, Knowledge Base Urban Development, 22@Barcelona, Development, Sustainability, Evolution

Entenent el desenvolupament de districtes d'innovació a través d'indicadors: El cas del 22@Barcelona

Resum

Els districtes d'innovació estan augmentant com a abanderats del nou paradigma urbà, econòmic i social i com a solució al renaixement del centre de les ciutats ja que acceleren la creació i comercialització de noves idees que aprofiten els objectius de la ciutat i els seus atributs tecnològics i econòmics. La configuració d'indicadors precisos per mesurar el grau d'assoliment dels objectius dels districtes d'innovació és un dels principals requisits per garantir el desenvolupament adequat del districte. Fins i tot quan l'estudi dels districtes d'innovació és un tema cada vegada més estudiat, encara es coneix poc sobre la seva execució, i calen eines que analitzin i afavoreixin la seva evolució i desenvolupament. L'objectiu d'aquest document és doble: d'una banda, tracta de recollir i analitzar els indicadors que s'han utilitzat en la literatura per mesurar el grau de maduresa durant el transcurs dels 20 anys d'existència del 22@Barcelona, una àrea d'innovació que va transformar un antic districte industrial en un de coneixement. D'altra banda, guiat per les quatre dimensions de la teoria del Desenvolupament Urbà basat en el Coneixement i els principals actors que componen l'enfocament de la Triple Hèlix, l'article dissenya un marc d'indicadors en les quatre esferes que formen la regeneració del districte, és a dir, la urbana, econòmica, social i de governança. Com veurem, es proposen un total de 47 indicadors que indiquen per a cadascuna d'elles: l'entorn en el qual s'aplica, l'objectiu principal al qual respon, i l'actor principal amb el major poder d'acció sobre aquest tema.

Paraules clau: Districte d'Innovació, Indicador, Triple Hèlix, Desenvolupament Urbà Basat en el Coneixement, 22@Barcelona, Desenvolupament, Sostenibilitat, Evolució

La medición del desarrollo de distritos de innovación a través de indicadores de resultados: el caso del 22@Barcelona

Resumen

Los distritos de innovación están aumentando, como abanderados del nuevo paradigma urbano, económico y social, y como solución al renacimiento del centro de las ciudades, ya que aceleran la creación y comercialización de nuevas ideas que aprovechan los objetivos de la Ciudad, y sus atributos económicos y tecnológicos. La configuración de indicadores precisos para medir el grado de desarrollo de los objetivos de los distritos de innovación es uno de los principales requisitos para garantizar el desarrollo adecuado del distrito. Incluso cuando el estudio de los distritos de innovación es un tema cada vez más estudiado, sabemos poco sobre su acción, y se precisan herramientas que analicen y favorezcan su evolución y desarrollo. El objetivo de este documento es doble: de un lado recoger y analizar los indicadores que se han utilizado en la literatura para medir el grado de madurez durante los últimos 20 años de existencia del 22@Barcelona, un área de innovación que transformó un antiguo distrito industrial en un polo de conocimiento. Por otro lado, y guiado por las cuatro dimensiones de la teoría del Desarrollo Urbano basado en el Conocimiento, y los principales actores que componen el enfoque de la Triple Hélice, el artículo diseña un marco de indicadores en las cuatro esferas que forman la regeneración del distrito, es decir: la urbana, la económica, la social, y la de la gobernanza. Como veremos, se proponen un total de 47 indicadores que indican, para cada una de ellas: el entorno en el que se aplica, el objetivo principal al que responde, y el actor principal con mayor poder de acción sobre este tema.

Palabras clave: Distrito de innovación, Indicador, Triple Hélice, Desarrollo Urbano basado en el Conocimiento, 22@Barcelona, Desarrollo, Sostenibilidad, Evolución

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1. Introduction

In recent years, changes in market demands have seen a drive towards products and services with high customer and technology orientation. This, together with increasing confluence of populations in large cities has led to revaluation of urban spaces. The innovation spaces become the “highest and best use” to enhance urban competitiveness according to many land-use policies and urban planning practices (Jiwu Wang 2021) and from here, innovation is a key driver of economic growth and competitiveness, and innovation clusters house much of the innovation generating high-tech and creative industries (Yigitkanlar et. al. 2020).

The behaviour of critical actors in innovative territories and the domains in which urban ecosystems are specialised have been analysed within theories such as the Knowledge Base Urban Development Model (KBUD) (Sarimin and Yigitcanlar 2012), and the Triple Helix (TH) theory (Etzkowitz and Leydesdorff 2000) to understand the generation of wealth and value in the knowledge economy.

Innovation districts and their static territorial impact have been largely studied. Over the past two decades, studies have been conducted on how cities manage to adapt to the global economy (e.g. (Grimaldi and Fernandez 2017)). This ranges from general analyses of the development and organization of inner cities (Sassen 1991,1998 and 2002; Knight, 1995; Gospodini 2006), to more specific topics such as sustainable development (Hall 1997), health and urban ecosystem (McMichael 2000), gentrification effects (Atkinson 2004), competitiveness of cities (Brotchie et al. 1995; Jensen-Butler, Sharchar and Van Weesep 1997; Lever 1999; Strambach 2002), to urban regeneration policies (Marcotullio 2003; Atkinson 2004; Thomson et al. 2006). Improvement in the development of a new economy in inner cities has awakened a deep interest (Hutton 2000 and 2004), as well as urban parks of knowledge (Bugliarello 2004), creative and

knowledge cities (Lever 2002, Florida 2005, Costa et al. 2008, Pratt 2008) and knowledge-based urban developments (Carrillo et al. 2014).

However, evaluation of the process by which these kinds of districts are transformed and their degree of maturity, deserves more attention and it is time to indicate which parameters are the most required or frequent, so that good practices can be repeated in future developments of the Innovation District. This literature gap becomes the research question that this paper seeks to answer, which is: what indicators are necessary to assess performance in Innovation Districts. Understanding how innovation districts evolve is the starting point to accomplish their vision and goals. As point of departure, measuring where they are today and identifying the next milestone is essential. To do this, it is necessary to define a set of indicators from a holistic perspective to collect the information to be analysed (Ramírez et al. 2021). Answering this research question becomes the main objective of the present research.

This piece of research sheds new light on the main indicators used in an innovation district to guide its development. Taking as a fundamental idea the main domains proposed by KBUD theory, and the actors anticipated by the Triple Helix model, exploratory work has been carried out on the case study of the 22@ Innovation District of the city of Barcelona (22@Barcelona), analyzing the existing bibliography over the course of its twenty years of evolution.

The 22@Barcelona innovation district has largely been studied in academia (Pareja-Eastaway and Pique 2011; Cohendet, Grandadam and Simon 2011; Casellas and Pallarès 2009; Gianoli and Palazzolo-Henkes 2020; Charnock and Ribera-Fumaz 2011 and 2014; Leon 2008; Piqué, Miralles, and Berbegal-Mirabent 2019; Pareja-Eastaway and Piqué 2014; Dot-Jutgla and Pallares-Barbera 2015, Paül, 2017; Bottero et al. 2020). International stakeholders such as the International Association of Science Parks and Areas of Innovation (IASP) consider

22@Barcelona as a reference source for policy transferability and experience-based knowledge. As testament to its popularity, the 22@ received more than 354 delegations from all continents (Piqué, Miralles and Berbegal-Mirabent 2019).

2. Theoretical Framework

The theoretical framework that provides the basis for this research comes from two models that frame and structure the environment under analysis. We have chosen two theoretical models, firstly, the Knowledge-based Urban Development theory (KBUD), that propose the existence of four dimensions to explain the knowledge-based development of cities and the Triple Helix (TH) model (Etzkowitz and Leydesdorff 2000) which seeks to explain the operation of R&D&I systems from the perspective of the interaction between three main actors: Government, Industry and Academia. They become a way of contextualizing the dimensions that make up an innovation district (KBUD) and within them the main actors present and their most relevant functions (TH).

Organizing the ecosystem of the innovation district (ID) in domains and knowing the main actions carried out in them, becomes a necessity for proposing indicators, since indicators, by definition, measure how close actions bring us to the objectives established for each of the main stages of a project (development of an ID). This way of modeling the reality under analysis facilitates our understanding of it and helps to give it a structure that orders the work. Therefore, it is necessary to be able to set out the foundations of these areas and their concomitant activity, so that they guide the proposal of indicators in a comprehensive and effective way.

2.1. Triple Helix Model

The Triple Helix thesis emerged in the mid-1990s, a time when universities and industries were exhorted by policy makers to work together more closely for the benefit of society, generating an upward trend in the commercialization of new knowledge. The thesis became articulated as a confluence between Henry Etzkowitz' long-term interest in the study of university-industry relations and Loet Leydesdorff's focus on an evolutionary model in which there is an overlay of communications between different and independent spheres of activity (Lawton Smith and Leydesdorff 2012). The Triple Helix model is formulated as a model for helping with the explanation of a phenomena. In this sense, it is a methodological tool: the focus on the recursive overlay of communications among universities, industries, and governments allows for the organization of research questions in relation to the various models and metaphors (Leydesdorff and Etzkowitz 1998).

The Triple Helix model postulates that interaction among university-industry-government is the key to improve conditions for innovation in a knowledge-based society (Piqué 2018).

From this perspective, the role played by each actor in this model is crucial for the development of an innovation district. Academia is considered as generators of new programs and knowledge to guarantee the transfer of technology and innovation. It is also regarded as providers and attractors of talent, essential for sustained and sustainable development. The Industry acts as a source of investment and as center of production and development of products and services according to the requirements of the environment. It is the main actor in the creation of economic value. The Government behaves as a generator of incentives and policies to guarantee stable contractual relationships between the different interest groups (Grimaldi and Fernandez 2017).

As interactions within this framework increase, each component evolves to adopt some characteristics of the other institution, resulting in hybrid institutions. In this sense, in the case of interaction between the university and the industry, it focuses on two main elements: education and research, where the university provides the research on which industry will base production of commercial goods and therefore transmission of people between university and industry constitutes a very important knowledge transfer. And since innovation is increasingly based on scientific knowledge, the role of universities as creators of knowledge is more valuable. In the case of the interaction of the university with the government, it depends on the particular involvement of the government in general education policies. That is, in cases where higher education is largely public, the government has a greater influence as the main source of funding. But in cases where higher education institutions are mostly private in origin, greater economic independence can be achieved. Although the presence of the state can continue to exert synergies based on its policies, legislation that favors the birth of companies within the universities themselves or could be a good facilitator by financing strategic disciplines. Finally, interaction between the Industry and Government depends to a great extent on the degree of government intervention in the market, but in any case the Government is the main party responsible for the creation of a clear and efficient regulation that streamlines and promotes economic development projects.

Other authors added a fourth sphere to the Triple Helix model, that of civil society, relabelling it as the Quadruple Helix (Carayannis and Campbell 2009). In this research, the social sphere is included in the KBUD dimension. Another transformation of the initial model adds a fifth dimension, now a Quintuple Helix model, which adds the environment as a key agent in knowledge and innovation models (Carayannis, Barth and Campbell 2012). In the same

manner, for the purpose of this research, we include the environment in the urban dimension of the KBUD.

To summarize, the successful management of triple, quadruple and quintuple helix models implies an effective long-term strategic direction taking into account the role played by each actor or institution. A comprehensive analysis of the value chain in each of the stages needs to be assessed. In addition, government might act as a facilitator, where spaces for interaction and exchange are favored, through the design and application of instruments that allow alliances between actors to turn the scenario into an advantageous one.

2.2. Knowledge Base Urban Development

Knowledge Based Urban Development (KBUD) is spurred by the growth of knowledge economy, which refers to the generation of income through the creation, production, distribution and consumption of knowledge and knowledge based products (Yigitcanlar, Velibeyoglu and Baum 2008a, and 2008b). The outputs of the knowledge economy are not necessarily raw materials and production of quantified goods, but also highly skilled and educated labour force producing abstract goods such as information, software and management, and transferring skills and knowledge particularly via the internet and other online vehicles (Yigitcanlar and Sarimin 2010). KBUD involves contemporary understanding and management of value dynamics, capital systems, urban governance, development, and planning (Yigitcanlar and Velibeyoglu 2008).

Several models have been proposed for the conceptualisation of KBUD (Sarimin and Yigitcanlar 2012), yet, they all include the governance development (e.g. public and/or private bodies that manage the urban transformation and the process of citizen participation), the

economic development (e.g., R&D centres, knowledge based companies and start-ups), the social and cultural development (e.g., housing, community facilities, education, social capital and knowledge workers) and the environment and urban development (e.g. green areas, green infrastructures—mobility, energy, waste, water—and green building) (Piqué 2018).

KBUD transcends many areas of economic, social and urban policy, and two of its main broad purposes (Yigitcanlar, Velibeyoglu and Baum 2008a) are directly linked to the substrate that is intended to be established in this theoretical framework since they are: firstly, in KBUD perspective instrumentation of the knowledge-based development of cities is critical to bring together all of the key actors and sources, organize and facilitate necessary knowledge-intensive activities and plan strategically for knowledge city transformation. Secondly, KBUD builds a strong spatial relationship among knowledge community precincts for augmenting the knowledge spillover effect that contributes significantly to the establishment and expansion of creative urban regions and supports linkages and knowledge transfer between these precincts (Yigitcanlar, Velibeyoglu and Martinez-Fernandez 2008).

2.3. Case of Study: Innovation District 22@Barcelona

The vision to create the first innovation district in Europe was conceived in Barcelona in 1998 as a way to enhance the competitiveness of the city, betting on innovation, creativity, design and technology. In 2000, the 22@Barcelona, aimed at transforming 198.26 ha in the industrial area of the Poblenou District, became one of the most ambitious and visionary projects in the city. This large project was not merely a planning initiative but signalled a new way of understanding the city (Oliva 2003); its main objective was to transform Barcelona into a leading knowledge society, in particular by encouraging new-generation activities related to

and requiring education, creativity and innovation (Crossa et al. 2010). In the last thirty years the 22@Barcelona has played a pivotal role in the rebirth of the city.

To achieve these goals, the “Modification of the General Metropolitan Plan (MPGM) for the renovation of the industrial areas of Poblenou” was approved in 2000, which aimed at restructuring the urban concept of the city; protecting and promoting access to housing, redeveloping industrial land in Poblenou to provide adequate infrastructures for businesses and activities, and defining the characteristic activities of the district that would enhance their development. Thus 22@Barcelona was shaped around three axes: the urban, economic, and social renewal of an area, all framed within the overall transformation of the east of the city together with the La Sagrera station, the Vila Olímpica (Olympic Village), and the Forum (Pareja-Eastaway 2017).

The main objectives to be achieved with the development of the three pillars were:

- Urban pillar, that seeks to respond to the need to recycle an obsolete industrial fabric, creating a compact, diverse and balanced environment, in which productive spaces coexist with protected housing, facilities and green areas that improve the quality of life and work (Urbanism22@Barcelona 2012). This axis focuses on the reconditioning of streets (115 blocks), with a comprehensive approach that includes energy, mobility and urban planning aspects. It also involves the renovation of existing houses and the construction of new units. Also in generating the appropriate space and the consequent construction of new facilities and green areas, this includes facilities for the productive fabric (for example, the MediaTIC building or the business incubator Almgòvers Business Factory). Considering the subsequent economic transformation that the area would experience, it was necessary to provide a critical mass of high-density office

buildings, appropriate to a central business district that aimed to be competitive on a global scale, capable of competing in the real estate market and of attracting new economic activity (Mur and Clusa 2014; Pareja-Eastaway 2017)

- Economic pillar, this axis is supported by backing a model characterized by the ‘internationalization of the economy, the tertiarization of activity, the growing productive flexibility, and the emergence of a new technological paradigm around information and communication technologies’ (Trullén 2011; Pareja-Eastaway 2017). In this field, focus was placed on the development and attraction of new businesses to the district, thus generating recruitment of professionals of all kinds, focusing on freelance workers with high training levels and also promoting exports and the positive result of the trade balance.
- Social pillar, that is characterized by the creation of space for professionals and citizens, trying to favor the interrelation between the different professionals who work in the area and to promote and support innovative projects that encourage collaboration between companies, institutions, neighbors and entities from social, educational and cultural spheres (Urbanism22@Barcelona 2012). For this purpose, the development of formal and informal relational networks was endorsed, this included collaborative projects, use of new information and communication technologies and participation of citizens and companies with social, educational and cultural organization in the district. This led to an increase in the population of the district, with a strong presence of residents of foreign nationality, due to the internationalization of the businesses, which has also generated an increase in household disposable income.

In 2016, a citizen participation movement began to jointly rethink a strategy in the face of the current social, economic and urban challenges of Poblenou and 22@. The local government launched “Repensem el 22@” with the will to develop, through a open and inclusive methodology that guarantees real participation of citizens, shared diagnosis of challenges and needs and a strategic proposal to rethink 22@.

3. Methodology

This study reports on an analysis conducted to start filling the knowledge gap generated around the smart and sustainable development of Innovation Districts and provides insights into what indicators Innovation Districts should consider assessing performance when approaching the design and implementation of strategies for smart development. Since the first step in defining a strategy is to make a diagnosis, and from that, to guarantee the accomplishment of the objectives, controlling the evolution of main factors is essential and key indicators become a factor for success. To meet this aim, twenty years of evolution of 22@ Innovation District in Barcelona are analysed (from its beginning to its maturity) and main variables of analysis are collected, clustered and detailed.

The clustering process is conducted by means of the theoretical approach: first, to understand how cities are transformed with respect to different dimensions: urban, economic, social and governance the Knowledge Based Urban Development (KBUD) approach is considered (Yigitcanlar, Velibeyouglu and Martínez-Fernandez 2008; Yigitcanlar 2008). Second, considering the Triple Helix model (Etzkowitz and Leydesdorff 2000) which focuses on the relationships between universities, government and industry, used as a framework that helps to better understand how ecosystems of innovation develop in cities. From these two theories, KBUD leads to the definition of four innovation Dimensions (Urban, Economic, Social and

Governance) where indicators will be organized (Table 1). And Triple Helix model actors (University, Government, and Industry) are considered to indicate the main action agents of each indicator (Table 2).

TABLE 1. Knowledge Base Urban Development Dimension

KBUD Dimension	Description
A. Urban	Green areas, green infrastructures —mobility, energy, waste, water— and green building
B. Economic	R&D centres, knowledge-based companies and startups
C. Social	Housing, community facilities, education, social capital, and knowledge workers
D. Governance	Public and/or private bodies that manage the urban transformation and the process of participation citizens

Source: own elaboration.

TABLE 2. Triple Helix Action Agents

KBUD Dimension	Description
i. University	Including institutes of technology and research centres, which are the magnets for international talent, stimulate the development of local talent, and are sources of scientific and technological knowledge for business.
ii. Government	Large corporations, SMEs and startups, which are the key for the creation of economic value. Entrepreneurship is what translates the knowledge and talent of the individuals, teams and companies into innovation.
iii. Industry	Local, regional, national and international, which becomes the third party providing an active role in scientific, technological, business, and land use policy making.

Source: own elaboration.

The literature review focuses on the science interested to date in 22@Barcelona innovation district over the course of its lifecycle, in the areas of Business Economics and Urban Studies. For this purpose, the articles published under these criteria were analyzed (Web of Science and Scopus databases were used as sources of information). Secondary data was collected from Barcelona City Council and reports from other local bodies that were focused on planning and evolution of this district. This results in 25 documents (Table 3) on which the main concepts for the development of the district have been documented and the indicators found were grouped into the 4 proposed dimensions and ordered by frequency of appearance, from the most

named to the least. These concepts come from the same literature review, based on the notions that science and public administration have used to measure evolution or propose as important to guarantee the development of the district.

TABLE 3. Sources of information & analysis

Doc no.	Doc Name	Source	Authors	Year
1	Modification of the pgm (general municipal plan) for the renovation of the industrial areas of poblenou	Barcelona Council	Barcelona Council	2000
2	Poblenou infrastructures special plan	Barcelona Council	Barcelona Council	2000
3	Real estate and urban planning impact of 22 @ 2000-2010 - future perspectives until 2020. - the future central business district of Barcelona	Barcelona Council	Mur, Sara; Clusa Joaquím	2012
4	10 years of 22@: the innovation district	Barcelona Council	Barcelona Council	2012
5	rec64 (economic magazine of catalonia n° 64)	College of economists of catalonia	College of economists of catalonia	2014
6	22@Barcelona plan	Barcelona Council	Barcelona Council	2012
7	22@Barcelona 2000-2015	Barcelona Council	Barcelona Council	2012
8	Assessment of the impact and socio-economic function of 22 @ per to the city of Barcelona	Cerdà institute	Cerdà Institute	2018
9	Agreement towards a more inclusive and sustainable 22@ within poblenou	Fundació Barcelona Institute of technology for the habitat	Fundació Barcelona Institute of technology for the habitat	2019
10	Place making facilitators of knowledge and innovation spaces: insights from european best practices	Web of knowledge/Scopus	Srurabhi Pancholi, Tan Yigitcanlar and Mirko Guaralda	2015
11	City of rents: the limits to the Barcelona model of urban competitiveness	Web of knowledge/Scopus	Greig Charnock, Thomas F. Purcell and Ramon Ribera-Fumaz	2014
12	A new space for knowledge and people? henri lefebvre,	Web of knowledge/Scopus	Greig Charnock and Ramon Ribera-Fumaz	2011

Doc no.	Doc Name	Source	Authors	Year
	representations of space, and the production of 22@Barcelona			
13	Attract and connect: the 22@Barcelona innovation district and the internationalisation of Barcelona business	Web of knowledge/Scopus	Nick Leon	2008
14	The production of urban competitiveness: modelling 22@Barcelona	Web of knowledge	Greig Charnock and Ramon Ribera-Fumaz	2014
15	Areas of innovation in cities: the evolution of 22@Barcelona	Web of knowledge/Scopus	Josep Miquel Pique, Francesc Miralles and Jasmina Berbegal-Mirabent	2019
16	Aplication of the triple helix model in the revitalisation of cities: the case of brazil	Web of knowledge	Josep Miquel Pique, Francesc Miralles, Clarissa Stefani Tteixeira, Jadhi Vincki Gaspar and José Roberto Branco Ramos Filho	2019
17	Spain: creating ecologies of innovation in cities - the case of 22@Barcelona	Web of knowledge/Scopus	Montserrat Pareja-Eastaway and Josep m. Piqué	2014
18	Industrial heritage, economic revitalization and urban compactness in the poblenou-22@Barcelona a new Barcelona model?	Web of knowledge/Scopus	Esteve Dot Jutgla and Montserrat Pallares-Barbera	2015
19	The 22@Barcelona district as part of the businesses relocation process in the city. an analysis of the old and new locations of the corporate headquarters	Web of knowledge	Daniel Paül i Agustí	2017
20	Experimenting community impact evaluation (cie) for assessing urban regeneration programmes the case study of the area 22@ Barcelona	Web of knowledge/Scopus	Marta Bottero, Francesca Bragaglia, Nadia Caruso, Giulia Datola, Federico Dell'anna	2020
21	Innovation districts as turbines of smart strategy policies in us and eu. boston and Barcelona experience	Web of knowledge	Bruno Monardo	2019
22	For a productive city: urban diversity in post industrial transition	Web of knowledge/Scopus	Ana Luisa Barrios and Pedro Brandao	2013
23	Governance, public participacion and economic evelopment: local adaptations to global estrategies	Web of knowledge	Antònia Casellas	2007

Doc no.	Doc Name	Source	Authors	Year
24	Barcelona - from province to metropolis: a cogent strategy for branding the city	Web of knowledge	Ksenia Piątkowska	2016
25	City as a product. architecture as an economic instrument. are global cities people-friendly places?	Web of knowledge/Scopus	Ksenia Piątkowska	2014

Source: own elaboration.

4. Results

The analysis of the 22@Barcelona District literature allows us to summarize the main aspects that were identified as weight parameters in this district. Considering the 4 dimensions proposed by the KBUD model, it could be said that the Economic domain is the one that received more attention, in terms of amount of variables of interest detected. Social and Urban domains follow, while governance indicators are by far, less developed. The different findings are presented below for each of the dimensions as follow:

4.1. Urban Sphere Parameters

Related to the urban sphere, 13 parameters could be identified as relevant according to the literature review. Results show that on the one hand, importance is given to the measurement of the areas dedicated to green spaces, which seeks to make the living space more livable and sustainable and, on the other hand to the square meters dedicated to development of new facilities (schools, hospitals, incubators, etc). The intervention surface also was shown to be important and the amount of investment that comes from all these constructions (investment in infrastructure). Another investment that was frequently found was the investment in real estate with a view to the construction of houses, hotels, and residences in the area. On the other hand the definition of the square meters that can be built, meaning, the construction potential,

the degree of occupancy, which provides information on housing availability and the latent cost in terms of supply and demand, the degree of implementation of construction, as a way of measuring the maturity level of the district, and finally, it was also of interest not only to know the number of dwellings, but also their typology, that is, number of hotels, student residences and the new value of the property in the district driven by the revaluation of the space due to its technological development (Table 4).

TABLE 4. Parameters of the Urban sphere

Nº	Dimension	Concept analysed	Sources
	Urban		
1		Square meters of a stationary or floating district created by a local government to promote sustainable practices, to help reduce environmental impacts, and to help revitalize an area (Green Zone, Green Area or Green Space)	[17]
2		Intervention surface: total area in which a modification of the urban space can be carried out (Area)	[17]
3		Investment in infrastructure	[14]
4		Square meters of spaces or buildings dedicated to special activities for the community (Hospitals, Schools, Business Incubator, etc.) (Facilities)	[13]
5		Houses (Household or Housing Units).	[12]
6		Investment in Real Estate	[12]
7		Constructive Potential: square meters that can be built. (Potential Floor, Potential Ground).	[11]
8		Number of hotels	[10]
9		Linear kilometres of street or road.	[9]
10		How much have been achieved, in terms of construction implementation, with respect to the objectives set.	[7]
11		Number of Student Residences	[7]
12		Square meters that are actually occupied or rented (Degree of Occupability, Occupancy Rate)	[6]
13		Existing houses prices	[3]

Source: own elaboration.

4.2. Economic Sphere Parameters

The economic sphere resulted in the identification of 16 parameters of interest, first of all those that provide information on available jobs and the number of companies, to measure the

evolution of job and business creation. Secondly, the generation, type and number of business clusters in the district begins to take relevance quickly, as well as the investment and development of start-ups, the turnover, size and quantity exported by these companies. In a similar vein, other concepts were identified that measure generation and attraction of new companies, the number and type of companies that have left, size and intensity of knowledge of these companies, and those that differentiate the companies that are knowledge-based ones, the number of papers written, the number of innovation projects generated and patents registered by this organizations, wich contribute to the strategic positioning. Finally, other indicators of relevance were the creation of technological, research and innovation spaces in the district and the number of freelance workers. (Table 5).

TABLE 5. Parameters of the Economic sphere

Nº	Dimension	Concept analysed	Sources
	Economic		
14		Number of Jobs	[16]
15		Number of Companies	[15]
16		Number of Clustered companies	[13]
22		Number of Start-ups created in the district	[12]
18		Types of existing clusters	[11]
21		Number of Companies that have been attracted, and therefore, relocated in a year.	[11]
17		% Companies or businesses with a higher share of knowledge for production of goods and services compared to other factors. An institute with a minimum of 75% of its assets in intangible form.	[10]
20		% Companies according to their size in terms of the number of employees	[10]
23		% Companies or businesses according to knowledge intensity in the district	[10]
19		Money taken by a business in a particular period (Turnover).	[9]
24		% Companies that export products	[7]
25		Number of Innovation projects generated	[5]
28		Papers written by district organizations	[5]
26		Freelance workers (or Freelance Professional)	[4]
27		Patents registered by district organizations	[4]
29		Investment received by start-ups of the district	[1]

Source: own elaboration.

4.3. Social Sphere Parameters

14 aspects were identified in Social Domain. Concepts like the number of inhabitants, number of students were identified as a way to measure talent creation. The number of University Centers and the percentage of workers with higher education were identified. Other aspects were also considered in the literature like the number of innovation centres, the number of research centres, and the number of international workers in the district. Additionally, the number of events to develop the community of professionals, the number of cultural activities and the number of people who have participated in cultural activities were taken into account. (Table 6).

TABLE 6. Parameters of the Social sphere

Nº	Dimension	Concept analysed	Sources
	Social		
30		Research Centres or Institutions	[12]
31		Social housing built	[11]
33		Universities Centres	[9]
34		Technologies Centres	[9]
35		Cultural activities (or Cultural offering)	[9]
32		Number of Inhabitants (or Citizens)	[8]
36		Percentage of workers with higher education	[8]
37		Innovation Centres or hubs	[7]
38		International workers who are in the district	[7]
39		Number of Students	[5]
40		People who have participated in district events	[5]
41		People doing internships.	[4]
42		Events to develop the community of professionals	[4]
43		People who have participated in district Cultural Activities	[3]
44		People who have used the district portals to promote their vocation	[3]

Source: own elaboration.

4.4. Governance Sphere Parameters

Governance sphere, as mentioned at the beginning of this section, is the least developed in terms of the number of registered concepts. But even so, the importance given to the creation of cross-cutting organizations is evident, which enable and increase co-creation and cooperation, with their inherent synergies. Parameters such as the number of neighbourhood and cluster associations and the number of members of horizontal associations were established here (Table 7).

TABLE 7. Parameters of the Governance sphere

Nº	Dimension	Concept analyzed	Sources
	Governance		
45		Neighborhood associations (or neighborhood group)	[9]
46		Members of horizontal associations	[5]
47		Cluster associations	[4]

Source: own elaboration.

5. Discussion

Innovation districts are urban areas that host a high concentration of technology companies, research centers, specialized scientific agencies and technology transfer support platforms. Because of this it is of paramount importance for them to have a tool that allows them not only to direct their efforts and actions toward creating this environment, but also to ensure that those actions bring the district closer to its goal on a sustained basis over time. Based on the results obtained in the 22@Barcelona case study, this section proposes and describes a set of indicators to evaluate the process of development of an innovation district. Also analysed here is the ultimate purpose of the indicator proposed and the main agent of the Triple Helix model involved in its implementation and development. This can help in implementation of the

roadmap for development of the innovation district, shedding light on which aspects must be monitored.

The following table (Table 8) presents the indicators proposed for each dimension of the KBUD model.

TABLE 8. Set of Indicator for the development of an Innovation District

Dimension	Nº	Indicator	Description	Aim	Main TH Action Agent
Urban					
	1	Area	Intervention surface: total area in which modification of the urban space can be carried out	Establishing the dimensions of the intervention project, affects the amount of investment and the impact of the initiatives.	Government
	2	Potential Floor	Constructive Potential: square meters that can be built.	Gives an idea of the economic value of the land.	Government
	3	Degree of Occupability	How many square meters are currently occupied or rented	Provides information on housing availability and the potential cost in terms of supply and demand	Industry
	4	Streets	Linear kilometres of street	Gives an idea of the necessary investment and dimensioning services (for example: mobility, energy, etc).	Government
	5	Green Zones	Square meters of a stationary or floating district created by a local government to promote sustainable practices, to help reduce environmental impacts, and to help revitalize an area	Make living and workspaces more liveable. Quality of life.	Government
	6	Households	Number of houses	Offer spaces for workers and their families. Attract and retain talent	Government/ Industry
	7	Hotels Units	Number of hotels	Attract and retain talent	Industry

Dimension	Nº	Indicator	Description	Aim	Main TH Action Agent
	8	Student Residences Units	Number of Student Residences	Attract and retain talent	University
	9	Real Estate Investment	Investment in Real Estate	Indicator of investment received in the district. The more investment, the more development, which provides insight into the development of the district.	Industry
	10	Infrastructure Investment	Investment in infrastructure	An indicator of investment received in the district. The more investment, the more development, then it provides insight into the development of the district.	Government
	11	Construction implementation degree	How much has the district achieved, in terms of construction implementation, with respect to the objectives set.	Degree of maturity of the district development	Industry
	12	New facilities	Square meters of spaces or buildings dedicated to special activities for the community (Hospitals, Schools, Business Incubator, etc.)	Meters available to improve quality of life in the district	Government
	13	Second-hand houses price	Existing home prices	Indicates how the area was revalued when developing the innovation district.	Industry
Economic					
	14	Jobs	Number of jobs	Evolution of job creation	Industry
	15	Companies	Number of companies	Evolution of business creation	Industry
	16	Turnover	Amount of money taken by a business in a particular period	Market Position – Competitiveness	Industry
	17	Companies Size	Percentage of companies according to their size in terms of the number of employees	Cost - Barriers to entry	Industry

Dimension	Nº	Indicator	Description	Aim	Main TH Action Agent
	18	Clusterization of Companies	Number of clustered companies	Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	19	Companies clusterization type	Types of existing clusters	Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	20	Exporting companies	Number of companies that export products	Trade Balance - Competitiveness	Industry
	21	knowledge-based companies	Number of companies with the higher share of knowledge for production of goods and its services compared to other factors. Institute with a minimum of 75% of its assets in intangible form.	Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	22	Companies Knowledge Intensity	Percentage of companies according to knowledge intensity in the district	Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	23	Relocated companies	Number of companies attracted, and therefore, relocated in a year.	Business attraction	Industry
	24	Freelance workers	Number of freelance workers		Industry
	25	Number of Startups	Number of startups created in the district	Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	26	Startups Investment	Amount of money dedicated to the development of startups	Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	27	Research Development	Number of papers written by district organizations	R&D&I - Leverage the innovation capacity	University
	28	Technology Created	Number of patents registered by district organizations	R&D&I - Leverage the innovation capacity	Industry/University
	29	Innovation Pilots	Number of innovation projects generated	R&D&I - Leverage the innovation capacity	Industry/ University

Dimension	Nº	Indicator	Description	Aim	Main TH Action Agent
Social					
	30	Citizens	Number of inhabitants		Government
	31	Students	Number of students	Talent Creation	University
	32	University Centres	Number of universities Centres	Talent Creation	University
	33	Technology Centres	Number of technologies Centres	Talent Attraction - Strategic positioning - Competitiveness - Leveraging innovation capacity	University / Industry
	34	Innovation Centres (private sector)	Number of Innovation Centres	Talent Attraction - Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	35	Research Centres	Number of Research Centres	Talent Attraction	University
	36	Higher Education Qualification	Percentage of workers with university education	Strategic positioning - Competitiveness - Leveraging innovation capacity	Industry
	37	International Workers	Number of international workers in the district	Talent Attraction	Industry
	38	Social Housing Units	Number of social housings built	Diversity and Inclusion	Government
	39	Internship's participation	Number of people doing internships.	Talent Development	Industry
	40	Professional Development Events	Number of events to develop the community of professionals	Talent Retention	Industry
	41	Social Events Participation	Number of people who have participated in district events	Talent Retention - Quality of life - Diversity and Inclusion	Industry
	42	Cultural Activities	Number of cultural activities	Talent Retention - Quality of life - Diversity and Inclusion	Government
	43	Cultural Activities Participation	Number of people who have participated in district cultural activities	Talent Retention - Quality of life - Diversity and Inclusion	Government
	44	Job's vocations	Number of people who have used the district portals to promote their vocation	Promote the vocation of young talent	Industry

Dimension	Nº	Indicator	Description	Aim	Main TH Action Agent
Governance					
	45	Horizontal Association Size	Number of members of horizontal associations	Social Network creation	Government / Industry / University
	46	Cluster Associations	Number of cluster associations		Government / Industry / University
	47	Neighbourhood Association	Number of neighbourhood associations	Social Network creation. Improve quality of life	Government

Source: own elaboration.

5.1. Urban Domain

The urban sphere mainly seeks to convert infrastructure and with it, to provide more amenities that improve quality of life and thus attract talent to the district. Indicators proposed here must satisfy these requirements and information as the total area in which modification of the urban space can be carried out becomes essential, since it helps to establish the dimensions of the intervention project, and define the impact of the initiatives and the amount of investment required in infrastructure. Other mandatory information is the constructive potential: square meters that can be built, since it gives an idea of the economic value of the land and the potential uses of the space. The linear kilometres of street, that in addition to the investment, also provide guidance on the dimensioning of services (for example: mobility, energy, etc). Additionally, to satisfy the requirement of attraction and retention of talent, it is necessary to provide metrics that promote the development of healthy, harmonious and sustainable living spaces, for this it is fundamental to have indicators that offer information about square meters of a stationary or floating district, to promote sustainable practices, to help reduce environmental impacts, and to help revitalize an area (green areas). Also about areas for new facilities, which can be measured as the square meters of spaces or buildings dedicated to special activities for the community (hospitals, schools, business incubator, etc.), which are also elements that improve the quality of life in the district, making it more attractive. The number of houses, number of

hotels, number of student residences also acquires relevance for contributing to the same purpose.

It is also worth discussing whether the incorporation of indicators that measure operational aspects of these ecosystems gives differential value. Aspects related to energy consumption, generated waste, transportation or facility management could also be included as a way to improve the efficiency of services offered by the district, and with it, quality of life of its inhabitants.

Another discussion that should be addressed is the inclusion of more concepts related to the environment, such as air quality, noise pollution, degree of recycling, energy savings, percentage of companies that use green energy, business carbon footprint; since sustainability is practically inherent in any smart development to ensure its continuity over time, so to include and measure this aspects could generate greater value to improve living conditions by promoting and guaranteeing these practices based on their monitoring.

Additionally, the urban domain presents a clear differentiation between the indicators, according to the life cycle of their use, which is not as noticeable in the other domains. This difference shows two groups, on the one hand, the group made up of indicators typical of urban regeneration projects, which has a beginning and an end in its use, such as the measures that analyze the area of exploitation, the kilometers of streets, the degree of progress of the structural actions implemented, etc; where the use of the indicator begins and ends with the particular project of which it is part. On the other hand, is the group of indicators that analyze the exploitation actions of the district, so that its life extends during the entire time that the district is in activity.

In terms of the main actor involved in the urban sphere, the government emerges as key, given that urban planning measures predominate here, where its interference and investment is mandatory. Its actions are complemented by the industry as a materializing actor of the planned measures.

5.2. Economic Domain

This domain looks for the internationalization of the economy, the productive flexibility and the emergence of new technological paradigms around information and communication technologies. The set of indicators should be good at offering information about these aspects as a way to ensure compliance. The indicators such as the number of knowledge-based companies, the number of companies with knowledge intensity, the number of start-ups and the number and type of clustered companies, reinforce these objectives and help to improve strategic positioning, competitiveness and to leverage innovation capacity. Indicators such as the number of innovation pilots and technology created, similarly, contribute to increasing the innovation capacity, but also to developing the research and development potential, so necessary for the promotion of continuous improvement through research and technology. The number of international workers, as a talent attraction meter, also contributes to these purposes. Indicators which measure number of job positions, number of companies and turnover help to control and improve, when necessary, the evolution of jobs and business creation, and to define and expand market positioning and competitiveness. Additionally, in order to know the number of relocated companies, provides a clearer picture of the performance or capacity of the district in terms of business attraction. Knowing the investment in startups serves to guarantee that the district takes actions to promote their proliferation, essential to achieve the goal of developing an economy based on knowledge and innovation.

In terms of the main actor, industry has emerged as a lead player in the economic sphere. Even so, its association with the University takes on vital importance as a fundamental partner for the development of research that enables the creation of technology.

5.3. Social Domain

Social domain attempts to create networks of social contentment which boost professional and personal development. Indicators that measure the number of students and university centers intended as spaces for talent creation are key. Then, to visualize the number of innovation, research and technology centres and the number of international workers, attracts new and competitive talent, and also contributes to strengthening the muscle necessary to generate the foundations of development, which begins with individuals, but with them, increases the maturity of the district as a whole. Additionally, knowing the percentage of workers with university education favors t strategic positioning, competitiveness and leverage innovation capacity. Furthermore, to measure the number of professional and social events, the participation of people, their integration and the cultural activities, constitutes a way to improve the talent development and retention, the quality of life, the diversity and the social inclusion. Finally, the internship participation and the job vocation indicator promote the vocation and development of young talent in the district.

As mentioned in the theoretical framework, a fourth actor is proposed by an evolution of the Triple Helix towards the Quadruple Helix model. This fourth participant is civil society, which is covered precisely by the social domain of the KBUB theory, as a field. Of course, civil society, as an actor, has a strong influence in this field, but the model of three main actors has been maintained, since they are the ones who adopt a role that is mainly a provider of solutions and services, while the social player takes a position of receiving or demanding these solutions.

As regards main actors in the social sphere, a confluence of players is evident. While in all areas there are hybrid situations, in this particular domain, an even more efficient coordination and joint work is necessary, given the transversality of the social figure.

5.4. Government Domain

Being the main roles of the government leadership, generating environments and clear rules that favor exchange and promote participation, value would be added by the development of direct or indirect measurement that can infer the progress of this role, and to enhance the cross-promotion function of governance. Also, acting as a facilitator or meeting point for different organizations, including measurements that analyze the result of their actions in this area could provide differential value for the development of this type of ecosystems. Indicators that measure horizontal, cluster and neighbourhood associations, help to develop and improve this aspect? However other successful innovation district could still be considered to complement this analysis.

6. Conclusions

Innovation districts are home to economic, physical, intellectual and networking assets. They seek to incorporate all the elements that foster a knowledge-based development economy, which include, shared working spaces, community colleges advancing specific skill sets, tech transfer offices, proof-of-concept centers, accelerators and incubators. Their development requires the coordinated and organized joint action of all actors present in the ecosystem in order to achieve a successful? Result, superior to what would be achieved by the mere sum of individual actions. Being able to count on a set of indicators that establishes the main parameters and, consequently, the actions and actors linked to them, entails a source of support for the

organization and functionality required, and works as a control and evolution guide for future development of innovation districts.

Through analysis of the bibliography generated over 20 years of evolution of the 22@Barcelona innovation district, this work proposes to provide urban innovation ecosystems, which are those that develop innovation districts, with a set of indicators that serve to identify and establish feasible and measurable objectives in the four main dimensions proposed by the Knowledge Base Urban Development theory (urban, economic, social and governmental). Thus, 47 indicators are proposed. The urban domain consists of 13 indicators which aim to guarantee good design and correct development of infrastructures and appropriate urban spaces for development of the necessary services. The economic domain consist of 16 indicators, which aim to guarantee good performance and improvement of the aforementioned products and services. The social domain consist of 14 indicators, which aim to guarantee that the necessary conditions are met not only for the creation of human talent, but also for its attraction, development and retention. The last three indicators point to the reinforcement of the governance activities, as a link between cross-cutting organizations.

The urban domain also presents a clear differentiation between indicators that are activated and deactivated with infrastructural projects, compared to exploitation indicators that remain active throughout the entire life cycle of the innovation district and are predominant in the other domains (economic, social and governmental).

Additionally, every indicator belonging to each domain defined by the Knowledge Base Urban Development theory, is linked to the different actors of the triple helix model and its main role in the development of a knowledge economy, which is the driving force in an innovation district. With this, not only is the indicator itself provided, but also the environment to which it

is applied, the main purpose to which it responds, and the actor with the greatest power of action over it. With this, the districts could be helped to develop actions that respond to their objectives and implement a system of continuous improvement to enhance their virtues.

Even though the discussion section reveals a certain relationship between indicators and moments in which an indicator can be activated or deactivated throughout the district development process, it would add value to delve into these issues in future research to provide tools that complement the entire planning process of this type of ecosystems.

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