BOOSTING TECH INNOVATION

ECOSYSTEMS IN CITIES: A FRAMEWORK FOR GROWTH AND SUSTAINABILITY OF URBAN TECH INNOVATION ECOSYSTEMS

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Cities are increasingly emerging as the new centers of technological innovation. A shift is under way from technology parks in suburban areas, where universities, research labs, and the private sector are located together, to entrepreneurial activity within cities. Studies on venture capital (VC) investment in the United States reveal that innovation is moving from suburbs to downtown cities (MPI, 2014). Today, San Francisco hosts more VC investment than Silicon Valley and New York City, where the innovation startup scene was nascent a decade ago, has become the second-largest tech startup ecosystem in the United States, with over $3.1 billion in VC investment in 2013 (Endeavor Insight 2014). This trend is not unique to the United States. Startups are burgeoning in major cities around the world, including London, Berlin, Madrid, Moscow, Istanbul, Tel Aviv, Cape Town, Mumbai, Buenos Aires, and Rio de Janeiro, to name a few (see Figure 1.1).

Factors such as proximity, density, and variety of people and firms contribute to this phenomenon (Athey et al 2007). New technology trends have lowered the cost of innovation and allowed entrepreneurs to enjoy the benefits from agglomeration economies. Cloud computing, open software and hardware, social networks, and global payment platforms, among other things, have made it easier to create a startup with fewer physical resources and personnel. If in the 1990s an entrepreneur needed $2 million and months of work to develop a minimum viable prototype, today an entrepreneur would typically need less than $50,000 and six weeks of work (Center for an Urban Future 2012) and, in some cases, these costs can be as low as $3,000 (Mytton 2009). This trend is allowing entrepreneurs to take advantage of city agglomeration effects to a greater extent than before.

Entrepreneurs "want to live where the action is" – that is, in places where other young people, social activities, peers, and entrepreneurs are located (Florida 2013). Entrepreneurs look for conventional startup support, such as mentor networks or role models, as well as nightlife, meetups, social activities, and other potential "collision"

points, a combination best provided by cities (Satell 2013). Innovation is becoming urban; what was previously the preserve of "innovation parks" is now growing organically within cities. In this paper, urban technology innovation ecosystems are defined as the collection of stakeholders, assets, and their interactions in city environments resulting in technology (in particular ICT)-based innovation and entrepreneurship. The unit of study of this research is the city area of influence, understood as the core metropolitan area. The terms "urban" and "city" are used interchangeably to refer to the ecosystem.

URBAN TECHNOLOGY INNOVATION ECOSYSTEMS RESULT IN NEW SOURCES OF EMPLOYMENT AND GROWTH

Urban technology innovation ecosystems not only increase the number of technology startups in cities but also result in new employment and economic growth by creation of new businesses and employment categories. In New York City, the technology sector has increased jobs faster than in other sectors and accounts for 12 percent of city tax revenue (HR & A Advisors 2014). From 2006 to 2013, the technology innovation ecosystem in New York City created over 500,000 new jobs (see Figure 1.2). The positive correlation between growth in the ICT industry of a city and job creation is being observed in other cities as well. Bangkok has been adding over 3,000 jobs a year to its ICT industry (National Statistical Office of Thailand). In Barcelona, ICT is recognized as a key industry with 29 percent of all companies and 48 percent of employees involved in the knowledge economy (Barcelona City Council 2012). Medellin generates over $100 million a year from Business Process Outsourcing (BPO) and has attracted a number of multinationals to establish BPO centers in the city (Keshetri et al 2012).

As the economy evolves into what many think is a "third industrial revolution" (*The Economist* 2012) that may erode traditional manufacturing jobs and those requiring routine cognitive skills, the creation of new sources of employment and growth is paramount to maintaining competitiveness, reducing poverty, and increasing shared prosperity.

THE OPPORTUNITY FOR DEVELOPED AND DEVELOPING COUNTRIES

The emergence of technology innovation ecosystems in cities presents an opportunity for developed and developing countries alike. Globally, over half of the population lives in cities (United Nations 2014), and this percentage approaches 80 percent in regions such as Latin America. The fastest

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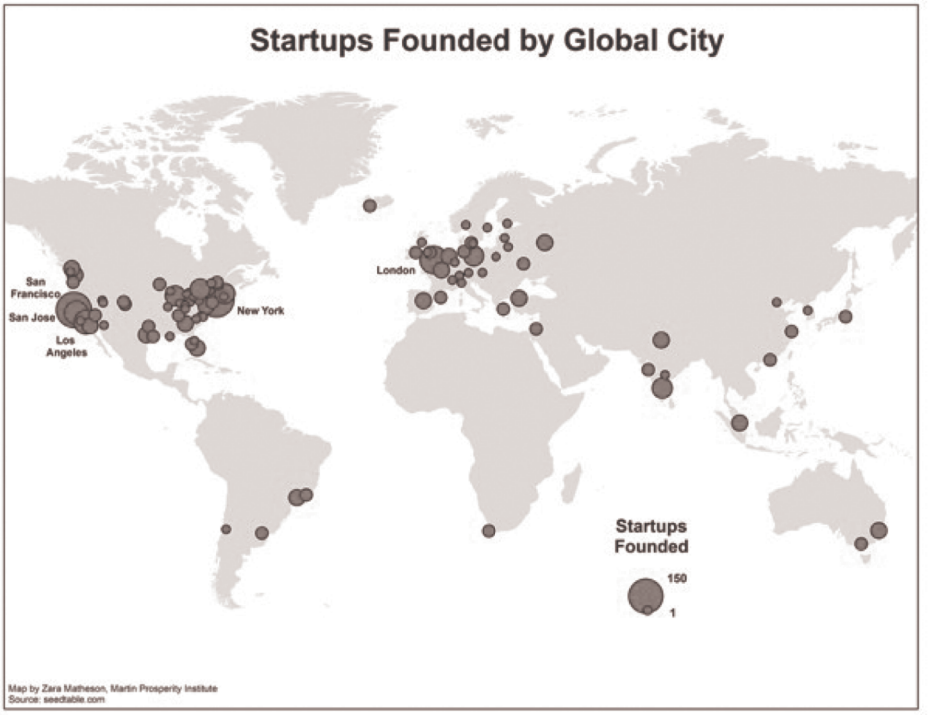

Figure 1.1. Startups Founded by Global City

Source: Florida, 2013.

urbanization rates in the world are in Africa and Asia (Phillips 2014; United Nations 2013; and United Nations 2014). Developing countries can tap into the growing resource of human capital and talent to produce innovation centers within their own countries that generate growth, entrepreneurship, and employability while addressing local problems. Tech and entrepreneurship skills have become easier to develop for unskilled and unemployed populations, especially young people. For instance, coding and open hardware skills that previously took years to learn can now be trained in months or even weeks. There is anecdotal evidence that these programs are increasing employability and entrepreneurship in these ecosystems (Meng 2013; and Amirtha 2014).

However, technology innovation ecosystems are not growing equally in all cities. Some cities are experiencing higher, faster, and more sustainable growth of these ecosystems than others, resulting in a higher number of startups, investment, employment, and economic growth. It is as yet unclear what factors cause different growth rates and how this growth can be supported with policy actions. Research suggests that density of people and firms and agglomeration effects play a critical role (Carlino and Kerr 2014; and Pan et al 2013). There seems to be a positive correlation between the size and density of the city and the organic growth of urban tech innovation ecosystems, as the ecosystems tend to emerge first in the largest cities, such as New York, London, Mumbai, Sao Paolo, or Shanghai (Pan et al 2013). However, it is unclear why some of the largest and densest cities grow their ecosystems at different rates, or why some smaller cities, such as Manchester or

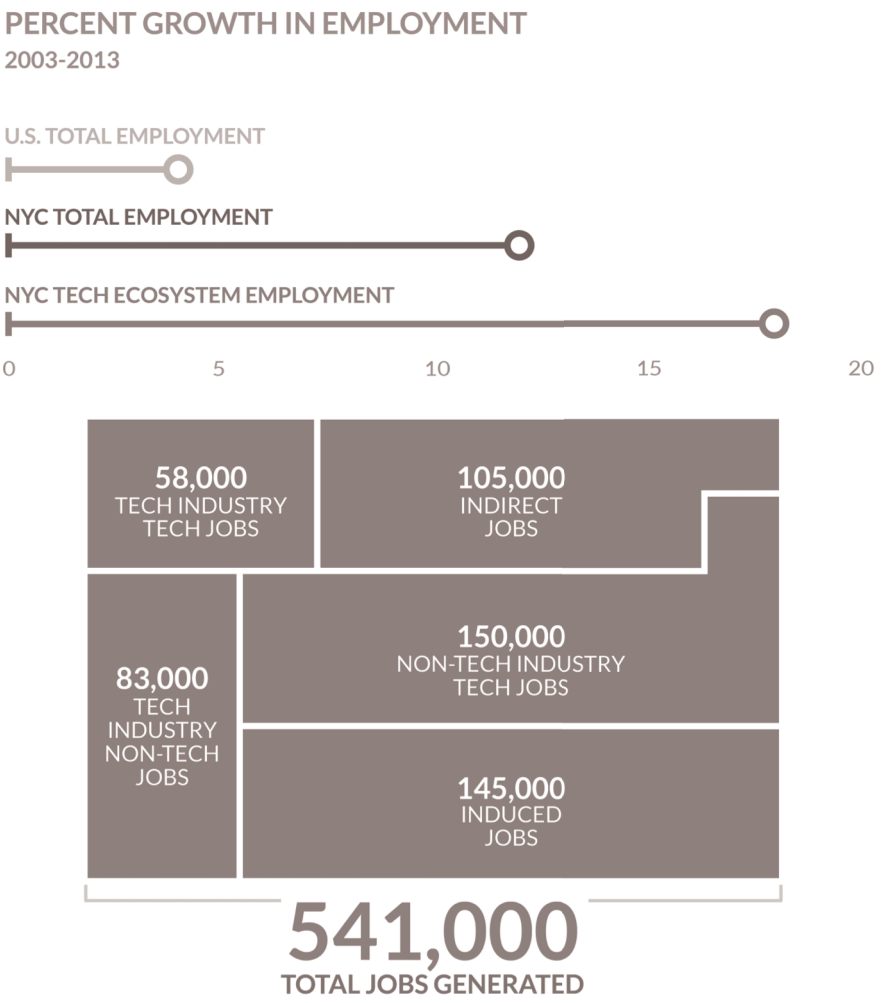

Figure 1.2. Technology Employment Impacts in New York City

Source: Adapted from HR&A Advisors, 2014.

Helsinki, have strong technology innovation ecosystems.

Inputs from Field Experience: Connections and Communities Play a Key Role

The World Bank has been involved in a number of activities with client countries to build ecosystems of technology-led innovation. Through these activities, we have observed factors that support the growth and sustainability of urban technology innovation ecosystems. We find that creating and supporting a community of tech entrepreneurs, coupled with incentives for kickstarting the ecosystem, for example through competitions and challenges, and provision of rapid skills programs, often provides a formula to grow and sustain technology innovation ecosystems. Table 1.1 lists some of the World Bank activities related to technology innovation ecosys-

Project/Activity	City (Country)	Launched (Year) and Status
Mobile Internet Ecosystem Project	Beirut and others (Lebanon)	Prepared 2012, supporting activities started 2014
Colombia Open Innovation for Municipal Services	Barranquilla, Cali, and Manizales (Colombia)	Launched 2012, completed 2013
Smart City Gran Concepcion	Gran Concepcion (Chile)	Launched 2013, completed 2014

Figure 2.1. World Bank activities relating to technology innovation ecosystems

tems that follow this formula. Appendix B provides more details on these activities.

Through these activities, we have observed how urban tech innovation ecosystems develop and grow in cities with different population sizes and wealth characteristics, ranging from three hundred thousand inhabitants in Manizales to two million in Beirut. Anecdotally, we have found that connections and communities play a key role in the surge and sustainability of these innovation ecosystems. Partners in these activities, including city governments and entities supporting urban innovation from Amsterdam, Barcelona, Helsinki, New York, and the Republic of Korea, have arrived at the same conclusions (see Appendix A for details of these partners).

This finding implies that the emergence and sustainability of urban technology ecosystems can be supported with policy actions, and that those policy actions can obtain results in the short term (that is, one to three years). Some cities, such as New York, are already creating technology innovation ecosystems with this hypothesis in mind (see text box).

A FRAMEWORK TO ANALYZE URBAN TECHNOLOGY INNOVATION ECOSYSTEMS

Research Objective and Approach

Given that connections and communities play a key role in the growth and sustainability of innovation ecosystems, which can be supported with policy actions, a research project was developed to identify the key success factors to grow, develop, and sustain technology innovation ecosystems in cities in order to inform policy actions.

Research began by identifying and reviewing existing studies applicable to urban technology innovation ecosystems. Following this review, and taking into account experiences with working with client countries and partners, a framework was developed to test the following hypothesis: **Connections and communities are key success factors for the growth and sustainability of urban technology innovation ecosystems.** This hypothesis was tested for New York City and initial results are presented in this working paper.

The framework identifies and categorizes key success factors for the growth of an urban technology innovation ecosystem and compares the impact of such factors to different ecosystems across cities. Ultimately, it is expected that the framework can be used to assess the impact of policies to grow and sustain urban technology innovation ecosystems.

LITERATURE REVIEW

A review of the literature on innovation ecosystems in cities was conducted, first examining innovation and ecosystems and then considering the applicability of these concepts in the urban context. There are a limited number of studies and frameworks

that specifically address urban technology innovation ecosystems, so the review also included studies on innovation and cities, primarily indexes of city innovation and competitiveness to identify key factors for innovation in cities that could apply to the technology innovation ecosystems. The key findings from this review are that:

- There is only a limited consensus on the how urban innovation ecosystems develop and grow, and
- A measurable framework is lacking that enables urban innovation ecosystems to be compared across cities.

However, there is consensus on the critical factors that impact innovation in cities. Building upon these factors, operations experience, and the experiences of partners, a framework was developed.

INNOVATION AND ECOSYSTEMS

The OECD (2005) defines two forms of innovation:

1 **Technological product innovation:** "the implementation/commercialization of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer."

2 **Technological *process* innovation**: "the implementation/adoption of new or significantly improved *production or delivery methods.* It may involve changes in equipment, human resources, working methods or a combination of these."

This report is concerned with both of these aspects and in their translation through entrepreneurship into startups. The literature is ripe with studies relating innovation to ecosystems (Durst and Poutanen 2013). An innovation ecosystem parallels the environmental concept where interrelated elements strive for equilibrium. The ecosystem is modeled as an economic equilibrium resulting from the interaction between various innovation actors (for example, business, universities, government) (Jackson 2011). There are several definitions of innovation ecosystems in the literature. Mercan and Göktaş (2011) define an innovation ecosystem as consisting of "economic agents and economic relations as well as the non-economic parts such as technology, institutions, sociological interactions and the culture." The Brookings Institution, applying this concept to urban environments, but limiting it to districts, defines an innovation ecosystem as "a synergistic relationship between people, firms, and place (the physical geography of the district) that facilitates idea generation and accelerates commercialization" (Katz and Wagner 2014).

FACTORS FOR INNOVATION AND COMPETITIVENESS IN CITIES

This section begins with a review of indexes and studies that include factors of innovation in cities. This is followed by a review of studies of models for innovation ecosystems in cities. These elements are analyzed to develop an urban tech innovation ecosystem framework.

Several institutions compile city rankings based on various measures of competitiveness, a number of which are related to innovation aspects. These indexes can help identify factors to develop innovation within cities and were used as a starting point in developing our framework:

- *Hot Spots 2025: Benchmarking the future competitiveness of cities* (EIU 2013) notes, "Global business is beginning to plan strategy from a city, rather than a country perspective." It defines a city's competitiveness as the ability to attract capital, businesses, talent, and visitors, also important criteria for city innovation ecosystems. The index ranks 120 cities across the

New York City Policies to Create a Sustainable and Vibrant Tech Innovation Ecosystem

The growth of New York City's tech innovation ecosystem is not entirely random. It has received active support from Government of New York City, with targeted and strategic policy actions. New York consciously followed this strategy to create new sources of income and competitiveness during the financial crisis. Despite the size and importance of New York, the challenges faced by the city to develop a technology-based innovation ecosystem were similar to those facing many other cities. This included: (i) lack of technology-specialized talent, (ii) insufficient sources of seed capital for startups, (iii) lack of physical space for entrepreneurs, and (iv) a limited and uncoordinated community of tech-led innovators and entrepreneurs.

New York addressed these challenges through a strategic program with targeted policies. Specific actions included (i) promoting collaborator spaces linked to mentor networks and incubators, (ii) fostering entrepreneurial funds to attract VCs into New York startups, (iii) attracting engineering schools to develop programs in the city and providing basic skills training and access to open hardware tools in public spaces (for example, libraries), and (iv) energizing the community through competitions and challenges (based on city problems). This last strategy is accomplished by the city opening data, developing mentorship networks for tech entrepreneurs, and promoting the tech community, including promotion campaigns, support of high-ranking city officials, and public awards. These actions were conducted in partnership with the community and private sector, thereby providing incentives

world using 32 mainly qualitative indicators grouped into eight categories: economic strength, physical capital, financial maturity, institutional character, human capital, global appeal, social and cultural character, and environment and natural hazards.

- *The Global Cities Index (GCI)* (A.T. Kearney 2014) states, "By creating an environment that spawns, attracts, and retains top talent, businesses, ideas, and capital, a global city can generate benefits that extend far beyond municipal boundaries." The GCI measures the level of city global engagement covering 84 cities using 26 metrics in five categories: business activity, human capital, information exchange, cultural experience, and political engagement.
- A study ranking cities by GDP per capita (OECD 2006) finds that labor productivity is the main factor in explaining differences. Innovation is intimately tied to productivity; cities with high value-added activities such as high-tech and advanced services are closely linked to R&D activities and the generation of innovation. The study notes that applicants located in cities file over 80% of patents in the countries studied.
- *The Most Innovative Cities in Asia Pacific* (Solidance 2013) uses six categories to measure the level of innovativeness in 16 cities in the region: human talent, knowledge creation, technology, society, government, and global integration. The findings are aimed at informing companies about the "most attractive places" in terms of an effective innovation ecosystem. Key factors include availability of educated and skilled people attracted by diversity and amenities; ability of universities, enterprises and government to produce knowledge; the livability of a city and its ability to sustain culture; the level

to the latter. The focus on community development, collaboration spaces, and mentorship networks proved to be a success, attracting a community that is self-sustainable and continues to grow.

New York City's success in developing a sustainable technology-led innovation ecosystem presents lessons for cities around the world, in both developed and developing countries. As its ecosystem grew, New York also actively engaged poor neighborhoods through training and integration into new employment opportunities generated by the ecosystem. Almost half of the jobs generated in the New York tech ecosystem do not require a bachelor's degree (HR & A Advisors 2014). Pilot initiatives targeting poor and unskilled population from neighborhoods, such as the Coalition for Queens, confirm that rapid skills training with mentorship results in direct employability. From the first batch of this program, 20 graduates, 70 percent obtained full-time employment, 15 percent became entrepreneurs, and the rest entered formal education programs (Hsu 2014). Further, almost a quarter of New York tech startup founders do not have any technical background, and most of these startups focus on non-tech sectors, introducing technology-driven innovation to existing industries and businesses (HR & A Advisors 2014).

New York has been able to develop one of the largest tech-innovation ecosystems with limited tech talent, which is a constraint many cities face. New York is not the only city applying these policies and support. Other cities—including Amsterdam, Barcelona, Helsinki, and London, to name a few—are also actively supporting the growth and sustainability of their innovation ecosystems with similar policies and areas of focus targeted to their local needs.

of technology in the city; a favorable regulatory environment; and global integration and future orientation.

- The New York Economic Development Corporation has created a New York innovation index. The index tracks progress in six dimensions related to resources directed towards innovation and the results of such innovation in the city's economy. Inputs to innovation include R&D, Finance, Human Capital; outputs include Intellectual Property, High-tech Gross City Product, and Entrepreneurship and Employment Dynamics (NYEDC 2011).

A review of the indexes in Table 2.1 shows that similar factors are used in the reviewed indexes to determine innovation within cities. The factors that are most common in these indexes are:

- Human capital
- Business activity
- Government
- Information/knowledge
- Infrastructure
- Finance
- Social/cultural Aspects
- Existing Frameworks to Understand Urban Innovation Ecosystems

Few studies have proposed frameworks to explain innovation ecosystems in urban environments. From the review, six approaches were identified. These frameworks and their key factors were compared with those identified from the city indexes review. This analysis formed the basis for the proposed framework. This section describes the six framework approaches that were reviewed:

Hot Spots 2025	Global Cities Index	Most Innovative Cities in Asia Pacific	New York Innovation Index
Economic strength	Business activity		Entrepreneurship and employment dynamics / high-tech gross city product
Physical capital		Technology	
Financial maturity			Finance
Institutional character	Political character	Government	
Human capital	Human capital	Human talent	Human capital
Global appeal		Global integration	
Social and cultural character	Cultural experience	Society	
Environment & natural hazards			
	Information exchange	Knowledge creation	Intellectual property / R&D

Table 2.1. Comparison of Indexes Related to Competitiveness and Innovation in Cities

Winden et al (2007) in a first approach looking at the knowledge economy in cities finds that the quality of city foundations and successful organizing capacity are important for generating human capital and knowledge-based industries that then generate innovation. This framework focuses on factors to develop the knowledge economy in cities, including the knowledge base (human capital), the industrial structure, quality of life and amenities, accessibility (infrastructure), diversity, scale, and social equity.

Schaffers et al (2011), taking the perspective of smart cities, propose a framework where all city economic activities and utilities form the innovation ecosystem, with citizens and organizations participating in its development via supply and consumption of goods and services.

Crowley (2011) proposes a framework with three main elements: urban firms and entrepreneurs, institutions, and human capital (see Figure 2.1). Firms and entrepreneurs are at the core, driving the supply and demand for innovation. Institutions, including governments, universities, research centers, business organizations and others, create and spread knowledge, a key driver of innovation. The third component in this framework is human capital. Crowley (2011) argues, "The concentration of highly skilled people in one place promotes the exchange of ideas and learning, facilitating the process of innovation." Cities need to attract talent by providing the adequate environment. Three key drivers of innovation are proposed: networks, markets, and wider conditions. Firms and entrepreneurs connect with institutions and people through networks. These networks promote collaboration, and help generate ideas and disseminate knowledge. Markets, including consumer markets and public procurement, drive the demand for new products and services. People's mobility within the labor market contributes to knowledge dissemination. Finally, Crowley finds that the wider conditions, such as good schools, availability of financial resources, well-maintained infrastructure, and adequate housing available, also contribute to the success of an innovation ecosystem.

The European Commission (EC) (2013) considers a city innovation ecosystem to consist of the processes linking citizens (People) with a built environment (Place) and public organizations and policymakers

(Public) through business (Private) (see Figure 2.2). With over two thirds of Europeans living in urban areas, the EC recognizes the importance of promoting innovation to enhance economic growth and increase citizen welfare.

Bell (2014) proposes nine elements that make innovation ecosystems succeed in cities:

- **Talent:** people with the right skills and passion;
- **Customers:** although clients can be found around the globe thanks to the use of internet, some product sales depend on the local market;
- **Capital:** financing available for new product developments;
- **Academic institutions:** supply skilled labor and promote the development of new ideas;
- **Heroes:** examples of successful startups;
- **Guides:** provide advice and help;
- **Support services:** include lawyers, government officials, public relations firms, advertising firms, etc.;
- **Gathering places:** promote "collisions" and the generation of ideas; and
- **Comparative advantages:** unique characteristics of the city.

The Brookings Institution focuses on innovation districts (Katz and Wagner 2014). This focus is limiting as it reduces the scope of innovation across a city and ignores the social connections generated beyond geography. However, some of the concepts and factors identified can be applicable to the city as a whole and inform a wider approach of the city as the innovation ecosystem. The Brookings Institution's framework finds that economic, physical, and networking assets are present in all innovation districts (see Figure 2.3). These three assets classes are described as follows:

Economic assets refer to institutions, organizations and enterprises that drive, cultivate or support innovation. Thus, economic assets are categorized in three types: (i) Innovation drivers, focused on developing cutting-edge products and services (for example research institutions); (ii) Innovation cultivators, support the growth of entrepreneurs (for example incubators, accelerators, coworking spaces, community colleges); and, (iii) Neighborhood-building amenities, provide support to workers and residents (for example, coffee shops, retail stores).

Physical assets refer to private and public buildings and infrastructure that allow collaboration and connectivity. Public assets include parks and streets. Public spaces not only bring people together, but they also can serve as labs to test new products. Private assets include private spaces and buildings, such as office affordable office spaces for startups. There are also physical assets that help "knit the district together", such as sidewalks, bike lanes and public spaces, and others that connect the district to the city and the world, such as transportation and broadband.

Networking assets refer to the relationship between the ecosystem's actors. These networks and cultivate and accelerate innovation through the exchange of information and ideas, and the increased collaboration. Networking assets can build strong ties (for example, workshops and conferences) or weak ties (for example, networking events and hackathons).

A NEW APPROACH TO URBAN TECHNOLOGY INNOVATION ECOSYSTEMS

Through the literature review on indexes and frameworks related to innovation in cities and innovation ecosystems in urban

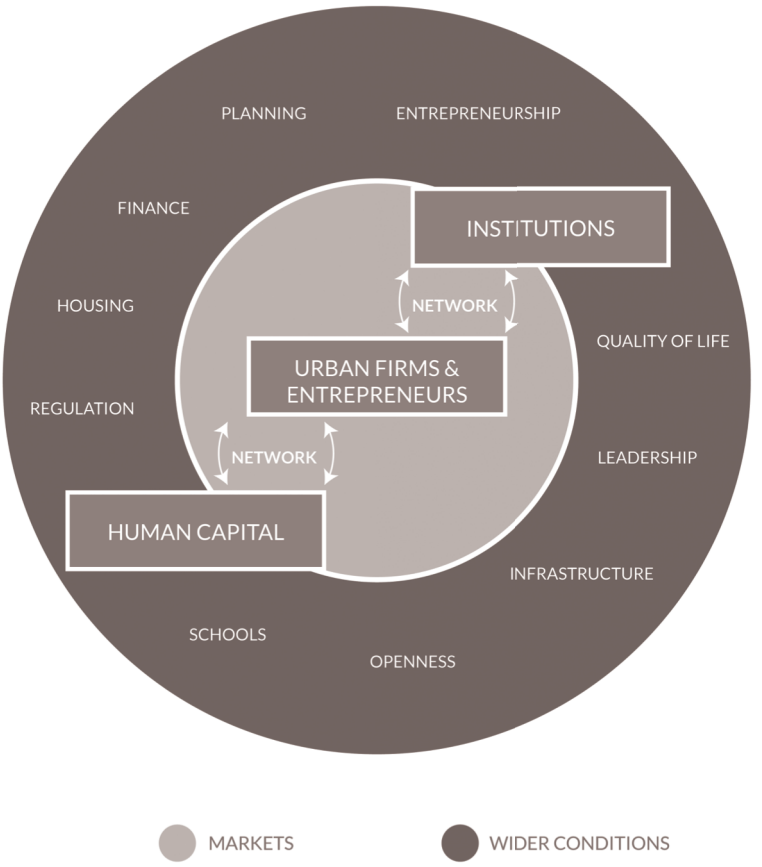

Figure 2.1. Crowley's Innovation Ecosystem Framework

Source: Crowley 2011

environments, four main categories to grow and sustain innovation ecosystems emerge:

- Human capital or people
- Physical assets or infrastructure
- Economic assets, and
- Government and policy or enabling environment

These four categories are connected through networks and markets. This last element finds traction in the most recent two frameworks proposed (Bell and The Brookings Institution). The Brookings Institution framework expands the concept to networking assets, which include events that create community, such as meetups or challenges and collaboration spaces, such as coworking spaces, accelerators, or incubators.

Work with country clients on activities related to developing and strengthening urban innovation ecosystems corroborates these categories. Several urban innovation ecosystems have been mapped by the World Bank and the Research Partners (see Appendix A for World Bank activities and Appendix B for Research Partners). Through these mapping efforts, these four categories have been identified as the main components of city innovation ecosystems.

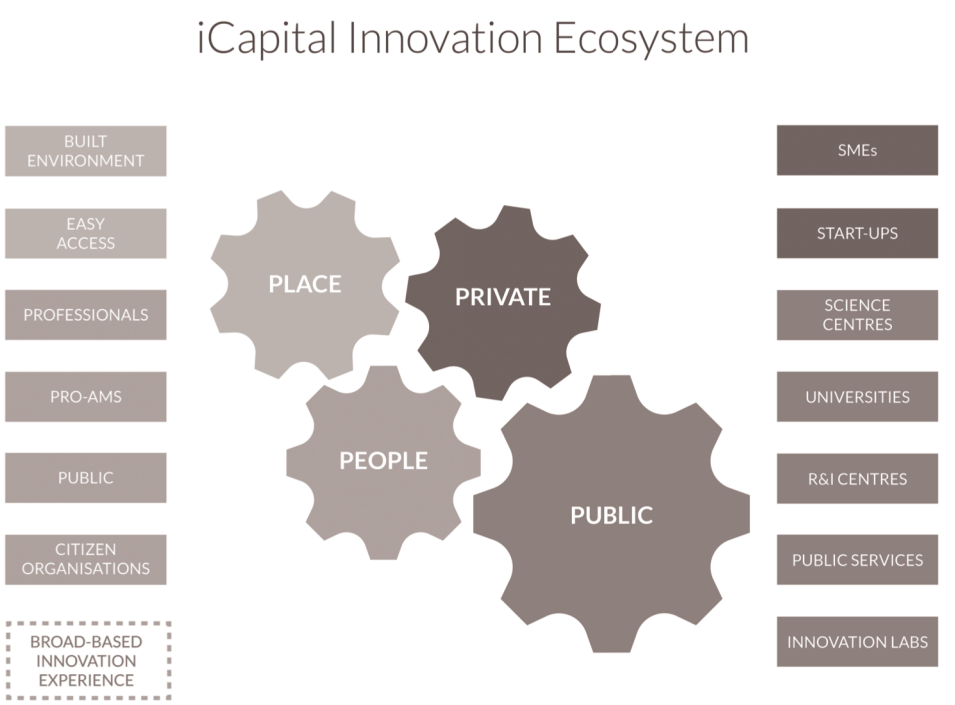

Figure 2.2. European Commission Innovation Ecosystem Framework

Source: European Commission 2013

As urban innovation ecosystem growth and development relies increasingly on community building and sustainability, networking assets have become more relevant and central. This importance is also experienced by city partners, which are focusing on developing and sustaining these communities (see Appendix B).

The first four elements result from agglomeration effects and provide a picture of the ingredients that the city must possess in order to develop and grow its innovation ecosystem. The networking element acts as a multiplier of these factors that can boost the size and rate of growth of the ecosystem. As creators and sustainers of communities, the networking element can increase the number of "collisions" that result in innovation within cities. Collisions are random encounters with people one would normally not meet. The theory of collisions argues that these encounters bring new ideas, perspectives, and value for creating opportunities and innovation (Kaplan 2012). The more collisions individuals have with people with different ideas, the more creative and innovative these individuals may become (Satell 2013). Hence, the potential for collisions stimulates innovation and entrepreneurial opportunities (Roberts 2014). Networking assets (as defined in the following section) increase the potential for collisions, acting as a multiplier of the existing elements produced by the agglomeration effects in the city innovation ecosystem (see Figure 3.1).

Based on this premise and borrowing concepts from the literature review, a holistic framework to map and diagnose city innovation ecosystems in developed and developing countries was proposed. The follow-

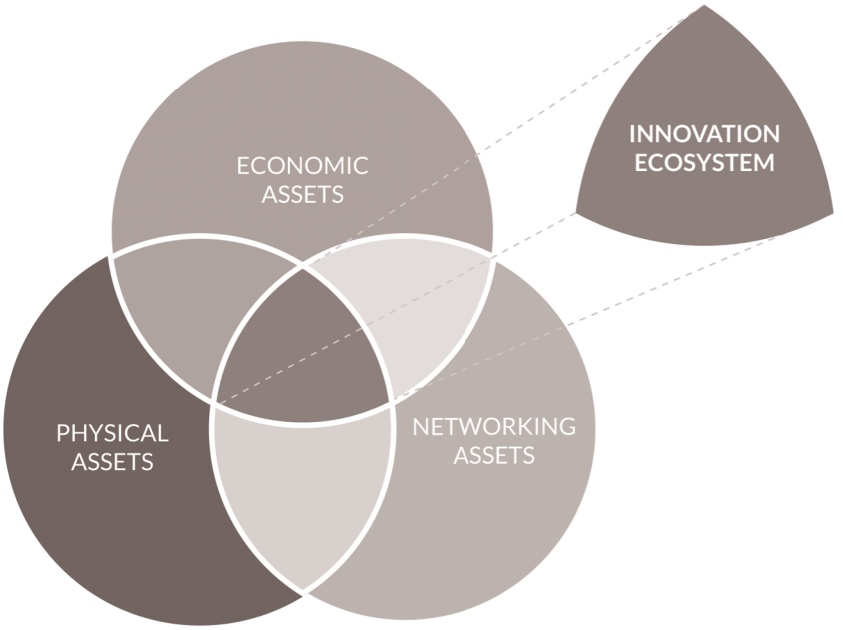

Figure 2.3. Brookings Innovation Ecosystem Framework

Source: Katz and Wagner 2014.

ing section describes this framework and its elements.

A HOLISTIC FRAMEWORK TO MAP AND DIAGNOSE CITY INNOVATION ECOSYSTEMS

The framework to map and diagnose urban innovation ecosystems comprises two layers. The first introduces the four categories that result from agglomeration effects and that are common in the literature. The second layer, which is a multiplier of the agglomeration effects, is networking assets. All these elements interact with each other, but only networking assets function as multiplier for the ecosystem growth. This framework is presented visually in Figure 3.2.

People are the basic element for innovation to happen. Innovation results from the interactions and the work of people. A survey of tech entrepreneurs in the United States highlighted the talent pool of employees as being the most important business-related resource that cities offered (Endeavour Insight 2013). The "creative class" has been cited as an important factor for generating economic output in cities (Florida 2002). A number of characteristics of a city's population have a bearing on innovation and growth. One of the most important is that growing populations generate an increase in productivity (Hardesty 2013). Other people-related factors affecting innovation include the share of immigrants, number of residents with a college degree, the labor force and its characteristics, the number of patent holders, and so on. People also form part of the innovation support network by serving as mentors and guides and are a testing ground for innovative products and services. Within the proposed framework, this category maps the characteristics of people that increase the

Winden et. al. (2007)	Schaffers (2011)	Crowley (2011)	European Commission (2013)	Bell (2014)	Brookings Institution (2014)
Human capital / scale / diversity	Citizens	Human capital	People	Talent	
Quality of life / amenities (infrastructure)	Utilities	Wider conditions (infrastructure)	Place (infrastructure)	Gathering places / competitive advantage	Physical assets (infrastructure)
		Institutions / government	Policymakers		
Industrial science	Organizations / economic activities	Research centers / businesses / universities / urban entrepreneurs	Private (businesses)	Academic institutions / capital / support services	Economic assets
		Networks		Guides / heroes	Networking assets
	Supply of goods and services (markets)	Markets		Customers	

Table 2.2. Comparison of Categories Related to Innovation Ecosystems in Cities

potential for innovation, including their diversity, in terms of background and education, their level of education, and the education and training capacity of the city, including provision of technology-related training.

Economic Assets include the elements that: (i) interact with people to increase the number of ideas resulting in innovation and, (ii) allow for implementing these ideas into practical innovation. This category maps elements such as the variety of industries, business and sectors; the size, amount, and diversity of companies and businesses; the universities and research and development facilities; the maturity and size of the technology and creative industries; and the availability and size of innovation-oriented investment firms, particularly for providing seed financing.

Infrastructure facilitates interactions among people and economic assets. This category maps the infrastructure in the city that: (i) provides basic living conditions, (ii) facilitates access to people and knowledge, or (iii) facilitates random collisions. This includes transportation infrastructure, broadband access, parks and venues for events, festivals, cafes, restaurants, theaters, and so on. Green spaces attract talent to live in the city and provide a venue for collisions, in the same way as the amenity sector. Offices are needed to house tech firms; startups need inexpensive and adaptable venues (that is, flexible office space). Physical and digital connectivity—transport and communications networks—bind city neighborhoods "together and/or tie it to the broader metro area" (Katz and Wagner 2014).

Enabling Environment refers to public policies and the government commitment to promote innovation. This category identifies: (i) the enabling environment provided by the government for innovation to occur, and (ii) the degree of commitment, promotion and facilitation by the government for development of the innovation ecosystem. This category maps policies such as doing business, property and IP protection, business associations, as well as specific policies to promote the innovation ecosystem, such as open data, challenges, innovation promotion, and so on.

Networking assets increase the number of collisions in the ecosystem, multiplying the

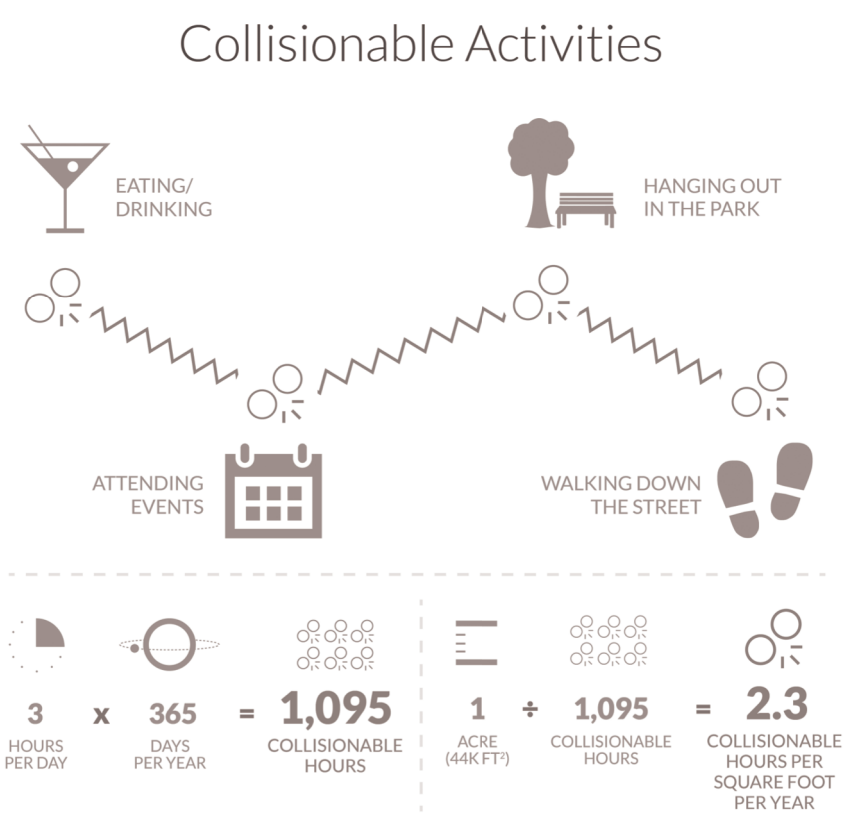

Figure 3.1. Networking Assets as Multipliers of Random Collisions

Source: Minges, 2014, adapted from Roberts, 2014.

effect provided by agglomeration. Innovation ecosystems will produce higher results in terms of, for instance, (i) increased number of startups, (ii) increased value of startup exits, (iii) increased employment in tech innovation related activities, if the number of random collisions increases. This category maps the main networking assets, including meetups, tech community events, bootcamps and skill training programs, collaboration spaces, accelerators, incubators, angel investors, venture capital, and networks of mentors.

Accelerators, incubators, angel investors, and venture capital are hybrid assets with economic assets but the impact of their network of mentors and entrepreneurs makes them more valuable for the growth and sustainability of the ecosystem; therefore, they are categorized as networking assets. The financing functions of these assets are included in economic assets under seed capital and financing. Table 3.1 presents an indicative list of networking assets.

Findings from Networking Assets Analysis

If networking assets are multipliers of the agglomeration effects in urban innovation ecosystems this means that networking assets are central to the ecosystem and that connections among stakeholders are central to the growth and sustainability of such

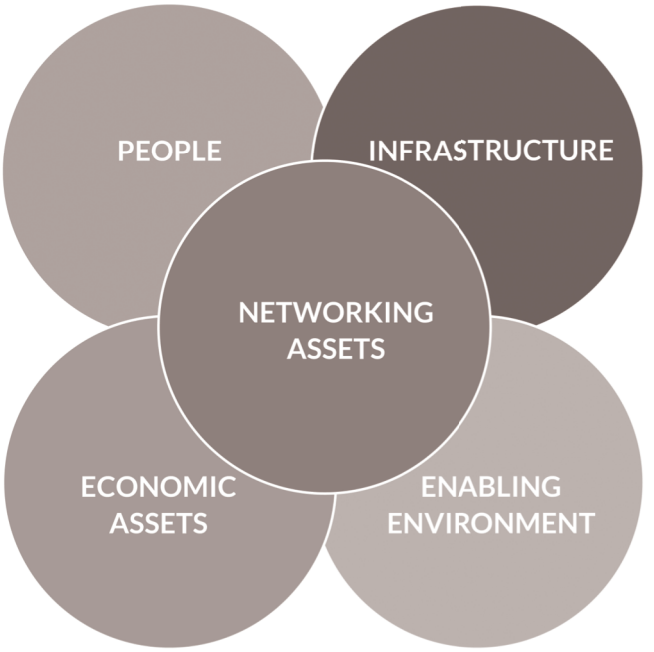

Figure 3.2. City Innovation Ecosystem Framework

ecosystems. This rationale supports the understanding of urban technology innovation ecosystems as a community (or a combination of communities) (see Appendix B).

This hypothesis was tested through a combination of qualitative (interviews) and quantitative (data analytics) approaches in New York City's ecosystem. To familiarize itself with the city ecosystem and its main actors—government agencies, entrepreneurs, coworking spaces, and accelerator spaces—the team conducted 21 interviews with actors to learn about the development of New York City's tech innovation ecosystem. From these discussions, the team began to identify sources of data in New York City that describe the tech innovation ecosystem. The interviews also provided insights on New York City's ecosystem, its growth, and the role of networking assets, such as meetups, competitions and collaboration spaces. The interviews also allowed the team to learn about the policies of New York City, its impact, its successes and failures, and how it evolved to support the growth and sustainability of the ecosystem.

For the data analysis, the team used available data sources to quantify the value of networking assets via their centrality in the ecosystem as well as the impact of geography on the ecosystem and how geographical and social connectivity centrality affected the performance of startups (in terms of capital raising). Because it used mainly CrunchBase and Angel List data, the team focused the analysis on accelerators and incubators. These are collaboration spaces providing investment along with (and sometimes as primary function to) their networking functions. This phase of the research did not analyze community building events or skills training programs and events because insufficient sources of data were available. In addition, because this phase of research focused on testing the

effectiveness of the proposed social network analysis methodologies against publicly available data sources, research focused on exploring the dataset at a static point in time and did not explore impacts over time. These additional perspectives can be addressed in future research (see Chapter 4).

The findings from the analysis of four research questions in relation to New York City's urban innovation ecosystem are summarized below. As mentioned above, the results presented here, and in more detail in Appendix E, are interim findings resulting from the data sources and limitations of this research. Final outputs will be produced as a result of forthcoming research and analysis. Data sources and methodologies are also described in detail in Appendix E.

In order to measure the value of networking assets in urban innovation ecosystems, research explored the impact of connections on ecosystem success outcomes. Following this, the value of incremental connections was quantified, enabling us to rank and value individual networking assets by multiplying their success in creating new connections by the value of incremental connections.

Connections are defined as either social or geographic. While there are multiple metrics that can be used to define success, this analysis considers the raising of a round of funding as a successful outcome for startups and by extension the ecosystem as a whole. As such, the analysis focuses on examining the interplay between the geographic, social, and funding dynamics within New York City's urban innovation ecosystem.

The findings of this analysis (see Appendix E) support the hypothesis that the social dimension, or the connections and communities, of the ecosystem is critical for the growth and sustainability of the ecosystem and that networking assets, defined as community building events, skills training events, collaboration spaces, and networking of mentors, are central to this social dimension. First, networking assets (using accelerators and incubators as a proxy) are central to the ecosystem's social dimension, being nodes of connection for startups and other stakeholders. Second, social momentum of startups has a direct impact in their success (in terms of funding). However, there is not such impact with the geographic dimension of startups. Finally, the social dimension of startups expands and provides diversity to the ecosystem beyond geographical clustering or technology districts' boundaries.

Networking Assets are Central to the Ecosystem

These initial findings support the hypothesis that networking assets are central to urban technology innovation ecosystems. This implies that networking assets are the connectors which: (i) sustain the social network of the ecosystem, and (ii) have the potential to boost the ecosystem's growth by increasing the collisions that result from social connections. By being central to the ecosystem and these connections, networking assets would play a critical role in the growth and success of urban technology innovation ecosystems. Either the social dimension of startups determines their success (in terms of capital raising) or success determines the of startups centrality for the ecosystem (in its social dimension).

Compared to this social dimension, the geographic dimension or clustering of startups does not seem to play a critical role in their success (in terms of capital raising) or centrality within technology urban innovation ecosystems. This seems to imply that the geographic dimension of startups is just one of many mechanisms to contribute to the social dimension of startups. In urban environments, the geographic dimension becomes less relevant. In particular, in New York City, with an extensive, affordable and fluid transportation network, the geograph-

Community building events	Skills training events	Collaboration spaces	Collaboration spaces / networks of mentors	Network of mentors
Meetups	Bootcamps and technology training linked to community building	Collaboration and community building spaces e.g. coworking spaces, maker spaces, fablabs	Accelerators (network value)	Angel investors (network value)
Tech community events / conferences	Rapid technical and entrepreneurial skills training programs		Incubators (network value)	Venture capital (network value)
				Networks of mentors and startup "alumni" networks (if different from accelerators, incubators, angel investors, and venture capital)

Table 3.1. Networking Assets

ic contribution seems to be rather small compared to that of networking assets.

These initial findings have important implications because they position networking assets as significant factors of technology innovation ecosystems in cities. The significance of these assets combined with the importance of a startup's social dimension compared with its geographic dimension are important considerations that should inform the policy of cities that support the growth and sustainability of these types of ecosystems (see section 3.4).

These findings are preliminary and based on limited sources of data. However, in combination, they provide support to the hypothesis that: (i) fostering the increase of connections, and building a community are critical actions to grow and sustain technology innovation ecosystems, and (ii) that networking assets play a key role in creating both of them. These findings are reinforced by the insights from the interviews the team conducted and the recent research produced in New York City's technology innovation ecosystem by Endeavor Insight. This research (Endeavor Insight 2014) found that connections have been critical in the growth and sustainability of the ecosystem and that they provide a virtuous cycle for growth. Endeavor Insight mapped the connections of over 650 entrepreneurs and key actors in the ecosystem, showing the growth in size (about 25 per cent CAGR from 2003 to 2013) and complexity (see Figure 3.3) as the ecosystem grew exponentially to become the largest in the United States during that period of time.

These findings are limited by the characteristics of the city object of this research (New York City), the limitations of data sources (see Appendix E) and scope of analysis (limited types of networking assets). Transportation and connectivity (for example, broadband) infrastructure in New York City provides easy physical and digital transit within the city, and may reinforce the importance of social connectivity compared with geographic connectivity. In other cities, different transportation and connectivity infrastructure (for example, long daily commute, poor public transport, limited broadband access), may impact this result. Data from voluntary reporting by members of the ecosystem may not provide a complete or unbiased picture of reality. Finally, networking assets, such as community building events and skill training programs, are critical in the hypothesis of ecosystems as a community (or combination of communities). This research did not analyze the impact of these events and programs. For these reasons, the findings presented in this paper should be considered as interim and further research and analysis is planned in a

subsequent phase of the study (see Chapter 4).

Policy Implications

The significance of networking assets for the growth and sustainability of technology innovation ecosystems in cities and the importance of startups' social dimension compared with their geographic dimension have policy implications for cities and other policy actors that want to support the growth and sustainability of technology urban innovation ecosystems.

The most relevant implications for policy design and implementation are that: (i) technology innovation ecosystems in cities need to be understood as a community or combination of communities, and (ii) the focus of policies to support these ecosystems is the community (defined by its social dimension) and not a geographic area (for example, a district or technology park) within the city.

Addressing ecosystems as a community

By understanding the innovation ecosystem as a community, where social connections play a critical role, policies can better target the bottlenecks and market failures precluding or slowing the growth of the ecosystem.

Policy to support the ecosystem should focus on fostering the development of networking assets that kickstart communities (for example, challenges, hackathons or competitions), build networks (for example, meetups, networks of mentors), or provide platforms for community building (for example, collaboration spaces). Bringing legitimacy to the community can play a critical role in its initial growth and further expansion. Promotion campaigns and support that produce role models and highlights the community of entrepreneurs help to support this goal. Additionally, providing rapid skills training programs enlarges the potential members of the community and expands the sense of belonging by providing cohorts of new members.

This is one of the approaches pursued by New York City, and many other cities with growing ecosystems are now following their lead (see Box 1.1). Furthermore, this approach is also shaping the World Bank's innovation ecosystem-related activities (see Appendix B). The research team will review policies adopted by cities and other relevant actors as well as case studies and lessons learnt in the following phase of this research in collaboration with city partners to expand the diagnosis tool (see chapter 4).

The focus of policies should be the community and not a limited geographic area

If the focus of policies to support the growth and sustainability of the ecosystem is the community, these cannot be limited to a geographic area (that is, a district or technology park). Policies that focus on the geographic will have less impact and may completely ignore the key factors that make an ecosystem sustainable.

This, of course, does not mean that policies that target specific geographic areas (for example, neighborhoods or districts) cannot be effective. However, if the objective of such policies is to support the technology innovation ecosystem, their target should be the features of the ecosystem's social dimension. Geographically targeted policies should only complement this broader objective.

NEXT STEPS AND FUTURE WORK

The findings presented in this working paper are the outcome of the beginning of a larger research. Some of the findings are based on initial analysis and need further work, largely because of limited data and because research was mainly restricted to New York City.

For future research, the sources of data will need to be expanded, additional cities will need to be researched (including those in both developed and developing countries), and the analysis of networking assets will need to include the remaining assets that could not be covered in the initial phase. This research will need to be carried out with research and city partners (see Appendix A).

The scope of future research can be expanded to investigate issues such as:

- how technology innovation ecosystems impact employment and economic growth, with a particular focus on generation of new sources of jobs in both developed and developing country cities, and
- how city governments can build effective policies to support the growth and sustainability of urban technology ecosystems.

The first topic will provide insights into the potential for employability and growth in the current environment of economic transformation where traditional sources of employment are changing. Existing policies and their impact on ecosystem's growth and sustainability will be analyzed as well as the results in producing employability.

Additional resources and partnerships will be required in order to undertake some of this additional research. The next steps and future work that the research team envisions undertaking is described below.

Further research on the role of networking assets

The team will plan to continue its research on networking assets and their role and impact on the growth and sustainability of urban technology innovation ecosystems. The team will need to access more data sources (including enriched data from survey and interviews and social network data) and will need to work in more cities as it conducts data gathering with its city partners (see below). The team will then explore the role of community building networking assets (for example, events to kickstart and sustain communities, collaboration spaces and mentors of networks) and analyze impacts over time.

Expanding scope to more cities and refining the diagnosis tool

The scope of research will need to be expanded to include more cities. This includes working with partner cities to collect data through a common methodology agreed with the research partners. For the data collection process, cities will be prioritized based on those in the Working Group that have shown interest in participating in this process. The list of city members of the Working Group is shown in Appendix A.

Impact of technology innovation ecosystems on employment and economic growth

Research on the impact of urban technology innovation ecosystems on employment and economic growth will be expanded. This will include exploring the relationship between ecosystems and the creation of new jobs, the role of the ecosystem as an ad hoc skills training program, and the impact of networking assets and rapid technical training programs on employability, with a particular focus on the poor and uneducated population. It will also explore the impact of the ecosystem on economic growth and economic transformation within cities, and in poverty reduction. Research will be focused on developing country cities to explore the potential of these ecosystems for providing additional sources of inclusive growth.

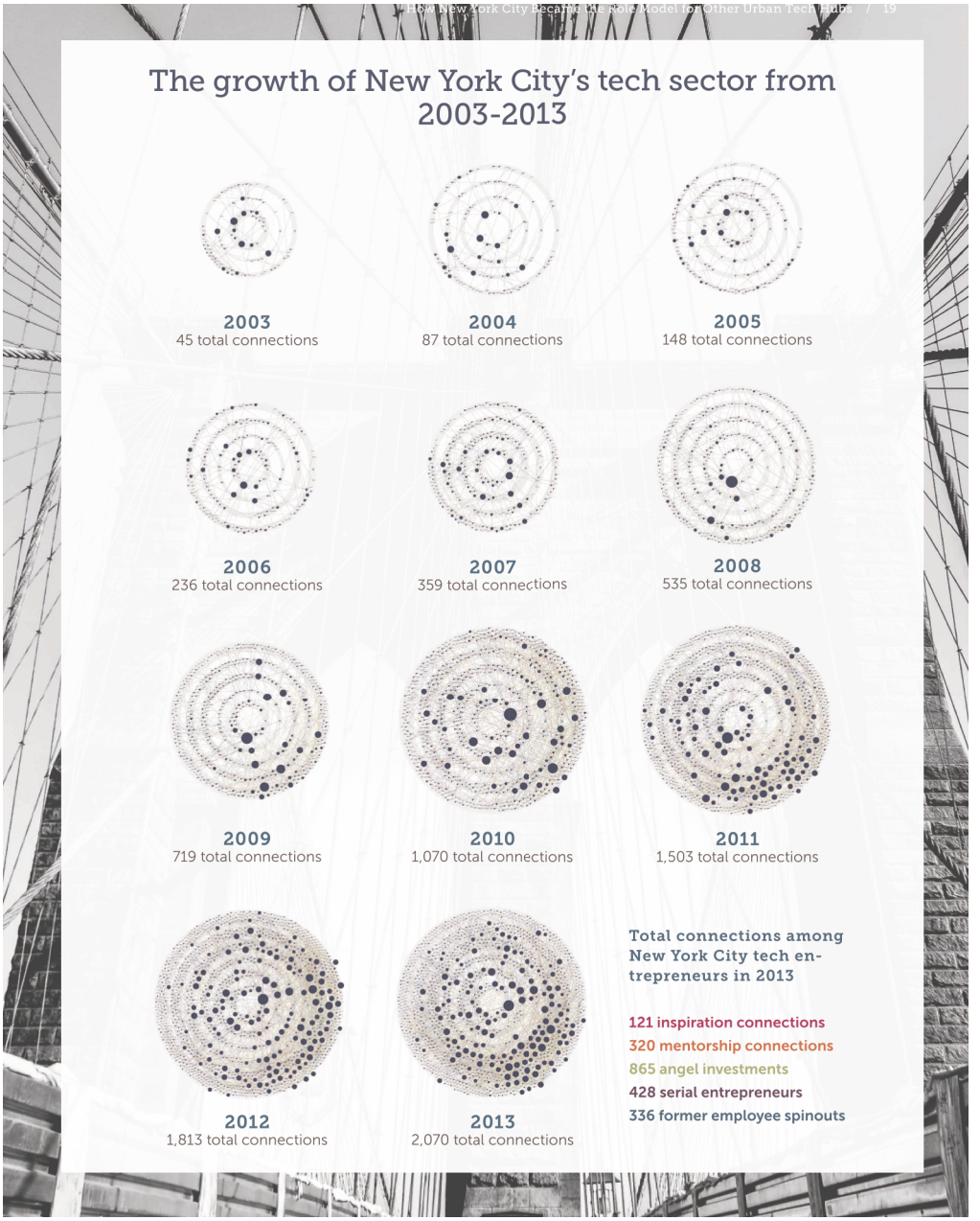

Figure 3.3. The Growth of New York City's Tech Sector from 2003-2013

Source: Endeavor Insight, 2014.

Compilation of policies and analysis of impact

The team will also work with its city partners to compile and analyze policies applied to support urban technology innovation ecosystems. This compilation will provide additional resources for policymakers to understand approaches to: (i) support the growth and sustainability of urban technology innovation ecosystems, and (ii) increase

the impact of the ecosystem for employment and growth. Case studies to highlight best practice will be provided.

APPENDIX A. RESEARCH PARTNERS

Computation Institute, Harris School of Public of Policy, University of Chicago

The Computation Institute (CI) was established in 2000 as a joint initiative between The University of Chicago and Argonne National Laboratory to advance science through innovative computational approaches. Scholarship in the sciences, arts, and medicine depends increasingly on collection and analysis of large quantities of data and detailed numerical simulations of complex phenomena. Progress is gated by researchers' ability to construct complex software systems, to harness large-scale computing, and to federate distributed resources. The CI is both an intellectual nexus and resource center for those building and applying such computational platforms for science. As an intellectual nexus, it brings together researchers from different disciplines with common interests in advancing the state-of-the-art in computing and its applications. As a resource center, it provides expert assistance to scholars whose work requires the most advanced computational methods.

Endeavor Insight

Endeavor Insight is the research arm of Endeavor, which seeks to deepen understanding of how high-impact entrepreneurs contribute to job creation and long-term economic growth in order to educate key constituencies, such as policy makers. Endeavor Insight seeks to serve as a knowledge center for high-impact entrepreneurs, VCs and others in order to provide useful information and tools that assist high-impact entrepreneurs as they grow their business.

Global Entrepreneurship Research Network (GERN)

"A collaboration of research organizations around the world whose goals are to generate useful and actionable knowledge for entrepreneurs, policymakers, and others; fill gaps in what we know about entrepreneurship; standardize data, especially longitudinal survey work; conduct experiments and evaluation of entrepreneurship education and training programs; and, gain a better understanding of policy barriers and what the right policies are for fostering entrepreneurship. The organizations participating in this network commit to collecting and sharing research results so they are accessible, usable, and open. Key founding partners, along with Kauffman, are Endeavor Insight and the World Bank."

MaRS Innovation and NESTA are also participating in similar research on urban innovation ecosystems as part of GERN.

City Partners

City partners include agencies and departments from local city governments as well as innovation hubs and collaboration spaces. The list of city partners includes the members of the Working Group on urban innovation ecosystems from the Community of Practice of Open Innovation in Cities. In addition, a ministry and a national agency also participate. The list of city partners is as follows:

- Economic Affairs Department, CTO Office, Amsterdam, Netherlands
- Economic Promotion Department, Barcelona, Spain
- Fukuoka Directive Council, Fukuoka, Japan
- Forum Virium, Helsinki, Finland

- iHub, Nairobi, Kenya
- Ruta N, Medellin, Colombia
- Laboratorio para la Ciudad, Mexico City, Mexico
- New York City Economic Development Corporation (NYCEDC), New York, United States
- Metropolitan Region Government, Santiago, Chile

National Entities

The list of national entity partners is as follows:

- Enterprise team, Ministry of Economy, Lebanon
- National IT Promotion Agency (NIPA), Republic of Korea

APPENDIX B. WORLD BANK OPERATIONS AND ACTIVITIES

Innovation ecosystem-related projects the team has been working with include, but are not limited to:

Lebanon Mobile Internet Ecosystem Project (MIEP)

MIEP's objective is to strengthen technology-led innovation ecosystem and foster entrepreneurship and employability in Lebanon. The project focus is to grow and sustain the ecosystem community, expand technical and entrepreneurial skills and to expand the technology ecosystem throughout the economic sectors in Lebanon.

The project is a 4-year program with a budget of USD 12.8 MM with four main activities:

1 **Skills training for youth and entrepreneurs.** The activity will develop a series of crowdsourcing competitions, which will include intense hand-on training (for example, bootcamp style) with a light acceleration phase. The result of this competition will be a series of startup projects (that is, minimum viable prototype beta tested, a business plan and a pitch). The competitions will also include an international mentorship program and exchange to connect the Lebanese ecosystem to others. In addition, this activity will create a university-industry platform for industry project training and a series of technology skills activities for schools. The university-industry platform will provide final-year students to team up with industry to solve real challenges from companies through a start-up or product projects in a 6-month timeframe.

2 **Growth and sustainability of the tech-innovation community.** The activity will develop network of mentors, links among entrepreneurs and networking events (for example, meetups) to support existing community. The activity will also complement existing collaboration spaces and provide technology tools (for example, maker space), labs (for example, living labs), and a space for community networking. This space will be managed by an innovation hub (the Mobile Innovation Hub, MiHub), which will serve to coordinate the community and the community-building activities. The MiHub will also take the role of promoting the community and its exemplary members.

3 **Innovation for legacy industry and other sector of the economy.** The activity will develop a series of hands-on workshops and activities between technology startups and entrepreneurs, and legacy industries that have not integrated widely technology in their production processes. This activity will also develop exchange activities with experts from other innovation ecosystems globally. This project is supported by a Trust Fund of the Korean-World Bank partnership.

Smart City Gran Concepcion

Smart City Gran Concepción activity objectives are: (i) to introduce open innovation in municipal government, (ii) to use the government as a platform to kickstart the local technology innovation ecosystem, and (iii) create the mechanisms to develop a sustainable technology innovation ecosystem to solve city challenges and create entrepreneurship and employability.

The activity focused on the transport sector and follows four consecutive components that result in the above-mentioned goals:

- Hands-on skills training on open innovation methodologies to city officials.
- Cocreation of a vision for technology support for urban transport with the city ecosystem (for example, government, academia, private sector, civil society, technology hubs, citizens).
- Challenge competition of city challenges to kickstart the technology innovation ecosystem and develop solutions to city problems.
- Cocreation of local innovation hub with the stakeholders of the city ecosystem (for example, government, academia, private sector, civil society, technology hubs, citizens).

This activity was funded by the Spanish Trust Fund for Latin America and the Caribbean.

Colombia Open innovation for Municipal Services

The objectives of this activity are to promote local government transparency, efficiency and e-services delivery to improve public service delivery and ultimately the quality of life of the population. To achieve this goal, the activity introduced open innovation in three cities in Colombia: Barranquilla, Cali and Manizales.

The activity worked in the sectors that each city selected and followed a sequential approach comprised of the following components:

Cocreation of e-services (for example, mobile apps) with city officials and rapid prototyping.

Cocreation of a roadmap for technology support to city services and eliminating departmental silos.

Challenge competition of city challenges as mechanism of open innovation for municipal governments and development of local entrepreneurship.

Development of strategic plan with local ecosystem stakeholders (for example, government, academia, private sector, civil society, technology hubs, citizens) to support government's open innovation and development of local entrepreneurship.

This activity was funded by the Information Communications Technologies (ICT) Korean Trust Fund.

Global: Barcelona Urban Technology and Innovation Hub

The objectives of this activity is the co-creation of new knowledge and the dissemination of good practices on urban technology and innovation that the city of Barcelona and its partners have developed over the years. The main areas of focus relates to bottom-up innovation and how city government can engage with the city ecosystem to develop innovation and entrepreneurship that addresses urban challenges. The activity organizes Citisense (an annual event on bottom-up approaches to urban innovation) together with Smart City Expo World Congress, and the City as a Laboratory training course (a practical program for policy-makers to introduce open innovation in city government) and develops common research on urban innovation and entrepreneurship

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References

Ajuntament de Barcelona. 2014. "Anuario Estadístico de La Ciudad de Barcelona 2014." http://www.bcn.cat/estadistica/castella/dades/anuari/index.htm.

Amirtha, Tina. 2014. "Do Coding Bootcamps Produce Inferior Engineers?" *Fast Company.* http://www.fastcolabs.com/3028635/do-coding-bootcamps-produce-inferior-engineers.

Athey, Glenn, Catherine Glossop, Ben Harrison, Max Nathan, and Chris Webber. 2007. *Innovation and the City: How Innovation Has Developed in Five City-Regions.* NESTA. http://www.nesta.org.uk/sites/default/files/innovation_and_the_city.pdf.

A.T. Kearney. 2014. *Global Cities Index.* http://www.atkearney.com/research-studies/global-cities-index.

Atkinson, Robert D., and Adams Nager. 2014. *The 2014 State New Economy Index.* Washington, DC: The Information Technology & Innovation Foundation. http://www.itif.org/publications/2014-state-new-economy-index.

Baigorri, Manuel. 2013. "Spain's Startups Leave in Search of Venture Capital." *BloombergBusiness.* http://www.bloomberg.com/news/articles/2013-04-21/spanish-preference-for-property-over-startups-deepens-woe-tech.

Barcelona City Council. 2012. ICT Sector in Barcelona. http://barcelonacatalonia.cat/b/wp-con-

tent/uploads/2012/12/eng-ICT-23-03.pdf.

Barrera, Alex. 2013. "The Spanish VC Industry Has One Big Problem: It Doesn't Exist". tech.eu. http://tech.eu/features/51/spain-vc-industry-missing/.

Barth, Alex. 2013. "New York City and OpenStreetMap Collaborating Through Open Data". Mapbox. https://www.mapbox.com/blog/nyc-and-openstreetmap-cooperating-through-open-data/.

Belderbos, Rene, Shanqing Du, and Dieter Somers. 2014. "Global Cities as Innovation Hubs: The Location of R&D Investments by Multinational Firms." In DRUID Academy. Aalborg, Denmark. http://druid8.sit.aau.dk/druid/acc_papers/rdv4by82h7nbyph96iuix18cu71s.pdf.

Bell, Thatcher. 2014. "Elements of an Innovation Ecosystem." http://thatcher-bell.vc/elements-of-an-innovation-ecosystem/.

Bloomberg. 2014. "Silicon Savannah: Kenya's Billion Dollars Tech Bet." http://www.bloomberg.com/news/videos/b/fa73fc02-c511-4824-806d-5656acdfae7c.

Burke, Adrienne. 2013. "Why Zappos CEO Hsieh Wants To Enable More Collisions In Vegas." *Forbes,* November 15. http://www.forbes.com/sites/techonomy/2013/11/15/why-zappos-ceo-hsieh-wants-to-enable-more-collisions-in-vegas/.

Carlino, Gerald and William Kerr. 2014. *Agglomeration and Innovation.* Harvard Business School. http://www.hbs.edu/faculty/Publication%20Files/15-007_e181fd00-4426-4db8-8f70-89b1b5054a8f.pdf.

Center for an Urban Future. 2012. New Tech City. https://nycfuture.org/pdf/New_Tech_City.pdf

Cowan, Matt. 2013. "The Origins of Silicon Roundabout." Wired, April 9. http://www.wired.co.uk/magazine/archive/2013/04/londons-moment/birth-of-a-meme.

Crowley, Lizzie. 2011. Streets Ahead: What Makes a City Innovative? The Work Foundation. http://www.theworkfoundation.com/Reports/306/Streets-Ahead-What-makes-a-city-innovative.

CrunchBase. 2014. CrunchBase Data Exports. 2014. http://info.crunchbase.com/about/crunchbase-data-exports/.

Cushman & Wakefield. 2014. "Office Space Across the World 2014." http://www.cushmanwakefield.hk/en-gb/research-and-insight/2014/office-space-across-the-world-2014/#anchor.

Durst, Susanne, and Poutanen, Petro. 2013. "Success factors of innovation ecosystems - Initial insights from a literature review." http://blogs.helsinki.fi/pkpoutan/files/2014/03/Durst_Poutanen_CO_CREATE2013.pdf.

The Economist. 2012. "The Third Industrial Revolution." http://www.economist.com/node/21553017.

The Economist Intelligence Unit (EIU). 2013. Hot Spots 2025: Benchmarking the Future Competitiveness of Cities. http://www.citigroup.com/citi/citiforcities/pdfs/hotspots2025.pdf.

Endeavor Insight. 2013. What Do the Best Entrepreneurs Want in a City? http://www.endeavor.org/blog/endeavor-insight-report-reveals-the-top-qualities-that-entrepreneurs-look-for-in-a-city/.

Endeavor Insight. 2014. The Power of Entrepreneur Networks: How New York City Became the Role Model for Other Urban Tech Hubs. http://www.nyctechmap.com/nycTechReport.pdf.

European Commission. 2013. European Capital of Innovation Award. http://ec.europa.eu/research/innovation-union/pdf/icapital/poster.pdf#view=fit&pagemode=none.

Florida, Richard. 2002. "The Rise of the Creative Class." Washington Monthly, May. http://www.washingtonmonthly.com/features/2001/0205.florida.html.

— 2013. "The New Global Startup Cities". http://www.citylab.com/work/2013/06/new-global-start-cities/5144/.

Hardesty, Larry. 2013. "Why Innovation Thrives in Cities." MIT News, June 4. http://newsoffice.mit.edu/2013/why-innovation-thrives-in-cities-0604.

HR&A Advisors. 2014. "The New York City Tech Ecosystem." http://www.nyctecheconomy.com.

Hsu, Jukay. August 2014. Telephone interview.

International Labour Organization. International Standard Classification of Occupations (ISCO). http://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm.

Jackson, Deborah J. 2011. "What Is an Innovation Ecosystem?" http://erc-assoc.org/sites/default/files/download-files/DJackson_What-is-an-Innovation-Ecosystem.pdf.

Kaplan, Saul. 2012. "The 'random collision' theory of innovation." *Fortune*. http://fortune.com/2012/05/09/the-random-collision-theory-of-innovation/.

Katz, Bruce, and Julie Wagner. 2014. "The Rise of Innovation Districts: A New Geography of Innovation in America." Metropolitan Policy Program. Brookings Institution. http://www.brookings.edu/about/programs/metro/innovation-districts.

Kshetri, Nir, Marleny Cardona, Hugo Diaz, and Suelen Castiblanco. 2012. "The Colombian Outsourcing and Offshoring Industry: The Effects of Institutions and Agglomeration Economies." In *Conferencia Deslocalización de Servicios Y Cadenas Globales de Valor: ¿Nuevos Factores de Cambios Estructurales En América Latina Y El Caribe*? Santiago, Chile. http://www.redlas.net/materiali/priloge/slo/colombian_outsourcing_industry_nir_kshetri.pdf

Martin Prosperity Institute (MPI). 2014. "Startup City: The Urban Shift in Venture Capital and High Technology." http://martinprosperity.org/media/Startup-City.pdf

Massachusetts Technology Collaborative. 2014. The Massachusetts Innovation Economy Annual Index. http://masstech.org/press-releases/masstechs-annual-innovation-index-shows-new-opportunities-and-emerging-challenges.

Meng, Victoria. 2013. "The Ultimate Guide to Coding Bootcamps: The Most Selective Bootcamps." Skilledup. http://www.skilledup.com/articles/the-ultimate-guide-to-coding-bootcamps-the-most-selective-bootcamps/.

Miller, P. and Bound, K. 2011. *The Start Up Factories*. NESTA. http://www.nesta.org.uk/sites/default/files/the_startup_factories_0.pdf.

Morris, Keiko. 2014. "Widening Tech 'Alley' Outgrows Name." The Wall Street Journal, April 29. http://www.wsj.com/articles/SB10001424052702304393704579531812139707966

Mulas. 2014. "Categorizing the collaboration and community promotion spaces that make urban innovation ecosystems tick." http://blogs.worldbank.org/ic4d/categorizing-collaboration-and-community-promotion-spaces-make-urban-innovation-ecosystems-tick.

Mytton, David. 2010. "How much does it cost to start a tech company?" https://blog.serverdensity.com/how-much-does-it-cost-to-start-a-tech-company.

NAICS Association. North American Industry Classification System (NAICS). http://www.naics.com.

National Statistical Office of Thailand. Various years. Labor Force Survey. http://service.nso.go.th/nso/nso_center/project/search_center/23project-en.htm.

NYCEDC. 2011. NYCEDC Innovation Index. http://www.nycedc.com/sites/default/files/filemanager/Resources/Economic_Data/InnovationIndexReport.pdf.

OECD. 2005. Oslo Manual. http://www.oecd.org/innovation/inno/oslomanualguidelinesforcollectingandinterpretinginnovationdata3rdedition.htm.

—. 2006. OECD Territorial Reviews: Competitive Cities in the Global Economy. http://www.oecd.org/gov/regional-policy/oecdterritorialreviewscompetitivecitiesintheglobaleconomy.htm.

— 2010. Measuring Innovation: A New

Perspective. http://www.oecd.org/site/innovationstrategy/measuringinnovationanewperspectiveonlineversion.htm#agenda.

Owen, Vicki. 2014. "High Rents Driving Technology Start-ups Out of London's 'Tech City'." This is Money. August 2. http://www.thisismoney.co.uk/money/smallbusiness/article-2714273/High-rents-driving-technology-start-ups-Londons-Tech-City.html.

Pan W., Ghoshal G., Krumme C. Cebrian M. and Pentland A. 2013. "Urban characteristics attributable to density-driven tie formation." Nature Communications. http://dspace.mit.edu/openaccess-disseminate/1721.1/92362.

Phillips. 2014. "African Urbanization." *Harvard International Review*. http://hir.harvard.edu/archives/6038.

Roberts, Bryce. 2014. "Collision Hours." Bryce Dot VC. http://bryce.vc/post/81685761115/collision-hours.

Satell, Greg. 2013. "Why Cities Are Our Most Important Innovation Platform". http://www.forbes.com/sites/gregsatell/2013/11/09/why-cities-are-our-most-important-innovation-platform/.

Schaffers, Hans, Nicos Komninos, Marc Pallot, Brigitte Trousse, Michael Nilsson, and Alvaro Oliveira. 2011. "Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation." In The Future Internet, 431–46. Lecture Notes in Computer Science 6656. Springer Berlin Heidelberg. http://link.springer.com/chapter/10.1007/978-3-642-20898-0_31.

Scola, Nancy. 2014. "The 'Choreography of Collisions' That Makes Innovation Districts Tick." Next City. http://nextcity.org/daily/entry/brookings-institution-innovation-districts-report.

Shanghai Municipal Government. 2014. "Infrastructure of Information." http://www.stats-sh.gov.cn/tjnj/nje11.htm?d1=2011tjnje/E1418.htm.

Solidance. 2013. "The Most Innovative Cities in Asia-Pacific." http://www.asiainnovativecities.com.

Tammy, Johns, and Lynda Gratton. 2013. "The Third Wave of Virtual Work." *Harvard Business Review*. http://www.crowehorwath.com/folio-pdf-hidden/TheThirdWaveofVirtualWork_FW13206V.pdf.

United Nations. International Standard Industrial Classification of All Economic Activities. Revision 4. http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=J.

United Nations. 2014. World Urbanization Prospects. http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf.

United Nations. Economic and Social Commission for Asia and the Pacific. 2013. Statistical Yearbook for Asia and the Pacific 2013. http://www.unescap.org/stat/data/syb2013/ESCAP-syb2013.pdf.

US Census Bureau. 2014. "County Business Patterns (CBP)." http://www.census.gov/econ/cbp/.

—. 2014. "American Community Survey." http://www.census.gov/acs/www/.

Winden, Willem van, Leo van den Berg, and Peter Pol. 2007. "European Cities in the Knowledge Economy: Towards a Typology." Urban Studies 44 (3): 525–49. doi:10.1080/00420980601131886.

World Bank. 2014. Doing Business Database. February, 2015. http://www.doingbusiness.org/Custom-Query/chile.