Smart Cities and the Quadruple Helix Innovation Systems Conceptual Framework: The Case of Portugal

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8.1   INTRODUCTION

"Cities are considered key elements for the future" (Albino et al. 2015). They are hubs of innovation and growth, but they have also become the major contributors to the global problems the world is facing such as climate change, social exclusion and migrations.

Urban spaces around the globe concentrate economic, social and institutional resources, competing for the attraction of talent and investments. In 2013, 80 % of the world's global GDP was concentrated in cities, number that will grow to 85 % by 2050. Moreover, according to the MacKinsey Global Institute (2011), by 2025, the 600 biggest cities in the world are projected to account for 60 % of global GDP.

However, a rapid urbanisation process is taking place on a global scale. The UN report "World Population Prospects" projected a growth in world population of 2.3 billion between 2009 and 2050, from 6.8 billion to 9.1 billion, with all of this growth concentrated in urban areas. Cities represent around 70 % of global energy demand and 70 % of total energy-related

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carbon emissions. The energy and carbon footprint of urban areas will increase with urbanisation and the growing economic activity of citizens. Continuing the current energy system trends, urban primary energy demand will increase by 70 % between 2013 and 2050. In parallel, carbon emissions from energy use in cities will increase by 50 % (UN 2015).

Cities are a major part of the problem but they also have the potential to be part of the solution. For that, a new urban development model is needed as the response to the economic importance of cities, to the process of urbanisation, and to the demand for sustainable development and a post-carbon model.

This transition towards a new urban development model is reinforced by the opportunities offered by the digital revolution. The digitisation has "grown out of a rapidly advancing technological capability in terms of ICT infrastructure (including sensors), personal technologies (smart phones and use of internet, etc.), and data storage and processing capability" (Cosgrave et al. 2013).

Fixed and mobile internet, ubiquitous computing, social media and Web 2.0 applications, database design and systems of information management, distributed storage of data and new forms of data analytics are key elements of this digital revolution (Kitchin 2014).

According to Shadi et al.'s (2015) estimations, the number of internet users will grow from 2.9 billion to 4 billion by 2020. Smartphone usage will increase from 2 billion connections to 6 billion connections by 2020. Moreover, the global daily traffic is estimated to rise from 2 exabytes to 120 exabytes by 2020. And the number of connected devices will grow from 25 billion to 50 billion by 2020.

Data are viewed as an essential component to realising a smart city vision (Kitchin 2014). More data are being produced every two days at present than in all history prior to 2003. According to Rial (2013), 1.7 million bytes of data per minute are being generated globally. This hype of big data is "a transformation in the knowledge governance of cities through the creation of a data deluge that seeks to provide much more sophisticated, wider-scale, fine grained, real time understanding and control of urbanity" (Kitchin 2014), enacting new modes of governance, empowering citizens and stimulating economic growth and innovation.

"Smart cities" have been commonly referred as the answer to these challenges. This is a new paradigm on how to build cities, which requires new strategies, technologies, models and urban processes in order to meet

the current challenges related to quality of life, environment protection and resource efficiency, equality and social inclusion.

In this chapter we will analyse the collaborative dynamics within the smart city field, namely the interaction among smart city actors in Portugal. We will test the validity of the application of the Quadruple Helix (QH) Innovation Systems Conceptual Framework to these dynamics, both theoretical and operationally.

In the first part we will present our vision about the smart city concept and domains, followed by the analysis of the interaction among smart city actors using the Quadruple Helix Innovation Systems Conceptual Framework and some international policy benchmarks. Then, we will analyse the case of Portugal with the presentation of the Smart Cities Portugal platform, and the collaborative dynamics among Portuguese smart city players. Some preliminary conclusions will be extracted.

8.2   SMART CITY MODELS AND APPROACHES

8.2.1   Smart City Concept and Domains

There is not a universal concept of "smart city" shared among academics and policy-makers. However, smart cities are getting attention in the media, from technology companies and entrepreneurs, and from local governments and civil society (Cohen 2015).

The common denominator of smart city conceptions "seems to be access to data and intelligent tools to connect knowledge and people to drive change" (Copenhagen Cleantech Cluster 2012).

It is possible to define two extreme ideological visions about smart cities both in terms of policy and practice: a technology-driven and a people-centred approach.

Smart Cities Technology-Driven
In this vision, technology is the key component of smart cities. Global technology providers such as IBM, Cisco and Siemens are leading this movement characterised by technological determinism.

They are massively selling technologies to municipalities who do not have adequate capabilities to understand the impacts of these solutions on citizens' quality of life. Moreover, there is a risk of lock-in and path-dependency.

According to Hollands (2008) "a (…) element characterizing self-designated smart cities is their underlying emphasis on business-led urban development (…) there is a general world-wide recognition (…) of the domination of neo-liberal urban spaces, a subtle shift in urban governance in most western cities from managerial to entrepreneurial forms, and cities being shaped increasingly by big-business and/or corporations".

Masdar (United Arab Emirates), Songdo (South Korea) and King Abdullah (Saudi Arabia) are some well-known examples of top-down corporate-designed cities. The majority are newly built cities that make intensive use of ICT, eschewing "actual knowledge about how cities function and represent (ing) empty spaces that disregard the value of complexity, unplanned scenarios, and the mixed uses of urban spaces" (Albino et al. 2015).

French photographer Etienne Malapert spent ten days exploring Masdar city. His images captured the loneliness and emptiness of the city described by him as a "ghost town" (Wired 2016). Futuristic buildings, solar panels, wind towers, personal rapid transit systems, electric cars, smart technologies and shaded streets were not enough to attract people and build a sense of community.

Hollands (2008), Adam Greenfield (2013) and Anthony Townsend (2013) are some of the authors who have criticised these technology-driven urban visions, postulating that they forget the dynamism of how cities interact with their citizens.

Smart Cities People-Centred

Citizens and communities are the central actors in this vision. According to Hollands (2008), smart cities "must seriously start with people and the human capital side of the question, rather than blindly believing that IT itself automatically transform and improve cities". Due to the danger of technological determinism and urban gentrification, the author proposes a progressive concept of smart city.

In this approach technologies empower democracy, enhancing citizens' engagement and co-creation. Citizens are co-designers, co-creators and co-learners with government (Bollier 2016). "Successful smart cities of the future will combine the best aspects of technology infrastructure while making the most of the growing potential of 'collaborative technologies', and above all the citizens who power them" (Saunders and Baeck 2015).

Education, creativity, learning, sharing, collaborative economy and collective intelligence are characteristics of this approach much more centred on issues like equity and social inclusion.

Medellin (Colombia) is an example of community-led cities. From one of the most violent cities in the world to a case study of urban innovation, the city was elected as the Innovative Capital of the Year 2013 and won the Urban Transformation Global Award in 2016. Citizen engagement, co-creation and collaboration between government–academia–industry–civil society are key areas of the city's strategy "Medellin Smart City". For example, the co-creation platform MiMedellin.org encourages citizens' participation through open innovation methodologies, which is led by the City Council and a public entity called Ruta N.

Seoul and Amsterdam are leaders in the sharing society movement, addressing urban problems through sharing and citizens' engagement. Since the declaration of Seoul as a Sharing City in 2012, the city has been supporting several sharing organisations and businesses creating the institutional foundations for realising this ambition. Due to these efforts, Seoul was awarded (special mention) by Metropolis in 2014 as one of the world's sharing capitals.

According to Kitchin (2014), there is a "tension within smart cities between serving global mobile capital and stationary ordinary citizens; attracting and retaining an elite creative class and serving other classes; and top-down, corporatized, centralized development and bottom-up, grassroots, decentralized and diffused approach".

Between these two opposite visions, in our opinion technologies are enablers oriented to promote economic development and innovation, to assure sustainable growth, and to improve citizens' quality of life. We tend to agree with Caraglin et al. (2009) when they postulate "we believe a city to be smart when investments in human and social capital, and transport and ICT communications infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance". It is necessary a balance of power between the use of IT by business, government, communities and ordinary people (Hollands 2008).

Despite the necessary holistic view of a smart city, several authors have been separating the concept into several dimensions, facilitating the operational implementation of smart city solutions.

Some literature identifies only the hard domains associated to smart cities, such as energy, mobility, water management, waste management, logistics and so on, where ICT can play a decisive role in the function of the systems (Albino et al. 2015). This is the case of a vast amount of reports produced by multinationals. For example, IBM considers five city domains: water management, public safety, traffic, buildings and energy (IBM 2011).

However, soft domains should be considered, such as education, culture, governance, social inclusion and so on (Albino et al. 2015). In the same vein, management and organisations, technology, governance, policy context, people and communities, economy, built infrastructure and natural environment are the domains proposed by Chourabi et al. (2012).

We support the categorisation suggested by the report "Smart Cities: Ranking of European Medium-sized Cities", in which six characteristics of smart cities were presented: Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment and Smart Living. Smart Economy comprises factors associated to economic competitiveness, such as innovation, entrepreneurship and internationalisation. In sequence, Smart People includes the level of qualification of the citizens, the quality of social interactions and openness. Political participation, the functioning of the administration and public services integrate the Smart Governance dimension. Smart Mobility refers to local and international accessibility, the availability of information and communication technologies and transport systems. Smart Environment includes aspects such as natural conditions, pollution, resource management and environmental protection. Finally, Smart Living includes quality of life (culture, safety, housing, tourism, etc.) (Vienna University of Technology et al. 2007).

However, in practice there aren't "one-size fits all" solutions. All cities differ in their historical, economic, social, cultural and institutional features. Lee and Hancock (2012) identified 143 smart city projects in the world in 2013. North America had 35 projects; Asia 50; Europe 47; South America 10; and the Middle East and Africa 10. Diversity and heterogeneity characterise this smart city movement in the world.

In fact, smart city initiatives have different motivations, promoters, governance structures, business models and financing sources. Alcatel Lucent (2012) analysis refers that there are three motivations behind smart city projects: the economic motivator, the eco-sustainability motivator and the social motivator, which are not exclusive from each other. The majority of the initiatives are promoted by governments (Birmingham Smart City), while

others are led by private companies (Songdo Smart City in Korea). Partnerships (governments, academia and industry) are also common, being the example of "Smart Amsterdam" a well-known case study. In coherence, for some projects governments are responsible for the most important part of the funding, while in others private developers provide investments and capital.

8.2.2 Quadruple Helix Innovation Systems Conceptual Framework and Smart Cities

A city is not smart when it does not include all its stakeholders neither in the decision- and policy-making processes nor in the urban innovation processes. Smart city is based on knowledge sharing and collaboration across all levels of society.

This idea is conceptually linked to the Quadruple Helix Innovation Systems Conceptual Framework[1] (e.g., Liljemark 2004), a development of the Triple Helix Innovation Systems Conceptual Framework (Etzkowitz and Leydesdoff 2000). The Triple Helix Innovation Systems Conceptual Framework postulates a strong cooperation between academia (universities), industry (business) and state (government) in the knowledge production and innovation processes. It focuses on how innovative companies obtain support from state authorities, universities and R&D institutions. Government may be represented by any of the three levels as national, regional and local (Afonso et al. 2010).

The Quadruple Helix Innovation Systems Conceptual Framework introduces one additional actor in the innovation process—the civil society (and media and culture-based public). It can be described as "an innovation cooperation model or an innovation environment in which users, firms, universities, and public authorities cooperate to produce innovations (...) these innovations can be (...) technological, social, product, service, commercial or non-commercial innovations" (Arnkil et al. 2010). Moreover, innovation is now considered transdisciplinary, non-linear, hybrid, open and user-oriented (Chesbrough 2003; Von Hippel 1988).

In our approach, the Quadruple Helix Innovation Systems Conceptual Framework is spatially specific corresponding to a territorial (urban) innovation ecosystem, where cities take the leading role working closely with universities, industries and the civil society. The output is materialised in policy knowledge and innovative solutions oriented to solve urban problems and answer to the challenges cities are facing.

Establishing strategic vision, creating smart city strategies, defining regulation, providing public services, investing in networked infrastructure and making open data available are key roles of local governments. Companies are providers of products, services, platforms and urban solutions, or investors in smart city projects and programmes. They use urban spaces to test their smart city solutions in real-life environments. Universities and R&D centres develop fundamental and applied knowledge and partner with municipalities and industry in the conception and implementation of smart city projects. Technology transfer is another function of academic R&D centres. Finally, citizens demand for goods and services, co-create public services and urban solutions, enhance social capital, assure digital inclusion and develop civic initiatives.

These four actors have different objectives and priorities and potential conflicts of interests may emerge. Thus, it is necessary to break out the silos of knowledge through cross-sectoral collaboration towards a more integrated and holistic approach to city governance (Copenhagen Cleantech Cluster 2012).

From the QH perspective living labs could be considered to be an interesting innovation approach as they are related to the development of cities and regions. According to ENoLL—The European Network of Living Labs "living labs are defined as user-centered, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real-life communities and settings (...) living labs place the citizen at the center of innovation". "The aim is (...) harmonizing the innovation process among four main stakeholders: companies, users, public organizations and researchers" (Ståhlbröst and Holst 2012) (Table 8.1).

8.3   Smart City Actors and Collaborative Dynamics

8.3.1   Collaborative Platforms and Networks

Based on the referred theoretical models, and on the analysis of different international policy cases and practices, the collaboration among smart city actors within local, regional and national innovation ecosystems enhances the development of policy knowledge, urban data and information, and innovative urban solutions.

In this context, the creation of collaborative platforms and networks is an emerging phenomenon. Smart cities networks are integrated by several

Table 8.1 Smart city actors and roles

Actors	Roles
Governments	Establishing strategic vision and strategy, defining regulation, provision of public services, networked infrastructure investment, funding, new policy instruments, open data, solutions to societal challenges
Industry (companies, entrepreneurs)	Providers of smart solutions and platforms, know-how and investment
Universities and R&D Centres	Undertake R&D and supply technical products and services, knowledge transfer
Civil Society	Co-production of public services, building social capital, and assuring digital inclusion, society initiatives, demand for goods and services

municipalities and are being created in some countries, such as Spain (RECI—Spanish Smart Cities Network) and Brazil (Brazilian Human and Smart Cities Network). Cross-sectoral cooperation is a characteristic of local, regional and national platforms created to induce the collaboration among different smart city players. The Technology Platform "Smart Cities Austria", the "Smart Cities Mediterranean Cluster" and the "Tartu Smart City Lab" are some examples.

These platforms are very diverse in terms of conceptual background (labs, clusters, platforms, networks, associations, etc.), geographical level, key actors and intervention areas (Table 8.2).

8.3.2   Local Governments

Municipalities strive to deliver high-quality services for the benefit of citizens, so they are at the forefront the smart city movement. However, to work in the area of smart cities they have to break down silos between departments and knowledge areas approaching cities holistically as complex systems. With this objective, smart city departments and Chief Information Officers are being integrated in governments' organisational structures.

According to Robinson (2016), smart cities are an economic and political challenge, not a technology trend. Thus, political leaders have to be involved because "without them developments and investments in new technology and infrastructure will not create ubiquitously beneficial outcomes (...) historically, there is plenty of evidence that investments in

Table 8.2 Smart city platforms and networks

International platforms and networks	Geographical level	Key actors	Intervention areas
Smart City Lab—Cluster of smart e- and m-city solutions	Tartu, Estonia (local level)	Companies, citizens, public authorities, R&D institutes, innovation centres	Intelligent transports, networks and infrastructures, tourism, digital services, governance
Smart Cities—The Mediterranean Cluster	Mediterranean area (regional level)	Innovation centres, industry, civil society, other stakeholders	ICT, mobility, energy
Fondazione Cluster Smart Cities & Communities	Lombardi, Italy (regional level)	Companies, R&D sectors, other stakeholders	Energy efficiency and renewable energies, mobility, safety, health, e-government, education, tourism, cultural heritage
Cluster Andalusia Smart City	Andalusia, Spain (regional level)	Universities, sectoral associations	Smart society, technology, governance, energy, mobility
EMOCITY—Cluster for E-mobility and Smart City	Slovakia (national level)	Universities, R&D centres, municipalities, industry	ICT, mobility, energy, smart grids, R&D
Technology Platform Smart Cities Austria	Austria (national level)	Industry, cities, R&D centres, other stakeholders	Buildings, networks and infrastructures, energy, mobility
Smart Cities Association	India (national level)	Think tanks, businesses, public service providers, other institutions	Transportation, health care, energy, safety, home automation, water, telecommunications, utilities, data management, analytics

technology and infrastructure can create great harm if market forces alone are left to shape them".

Data collection, analysis and integration are supporting evidence-based policy- and decision-making processes, improving urban efficiency and sustainability. For example, data are helping to predict floods, avoid water shortages and reduce water management costs by 15 % in the Netherlands. In India, real-time adaptive traffic control systems are resulting in a 12 % reduction in average traffic time (Shadi et al. 2015).

■ 2015 ■ 2014
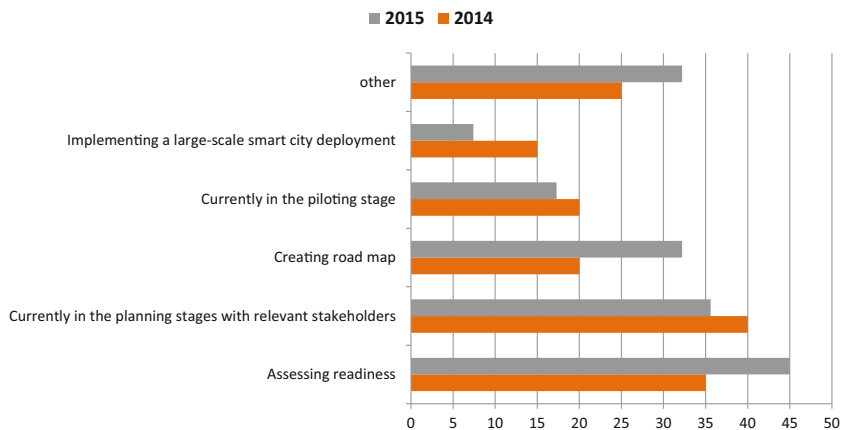
Graphic 8.1 Smart city initiatives in which municipalities are participating in (in %) (*Source*: Black and Veatch 2016)

Moreover, open data promotes citizens' engagement and stimulates the innovation process. "Open Data Barcelona" (hopendata.bcn.cat/opendata/es) and "NYC Open Data" (nycopendata.socrata.com/) are some well-known examples. In this framework, top-down actions co-exist with bottom-up initiatives, since governance and citizens can join together to co-create strategies, civic infrastructures, public spaces, transportation and so on.

Several governments around the world are creating smart city strategies and action plans in collaboration with stakeholders. The "Strategic Directions: Smart City Report" (Black and Veatch 2016) points out that the majority of smart city activities that are being developed by municipalities are centred on "assessing readiness", "planning stages with relevant stakeholders" and "creating roadmaps" (Graphic 8.1).

For example, Birmingham City Council published its "Smart City Vision Statement" (2013), which was followed by the production of "The Roadmap to a Smarter Birmingham" (2014). This roadmap sets out a "framework for the Birmingham's economic, community and third sector leaders, and Birmingham City Council, to come together and address the city's challenges of today—with the clear goal of building a more resilient and adaptable city for the future" (Birmingham Smart City Commission 2014).

The Roadmap has been developed by the Birmingham Smart City Commission, a body created by the City Council which includes key players from

the business, academic and public sectors. "The role of the Commission is to provide thought leadership, set the standards for a smarter Birmingham and embed the core values of being visionary, open and collaborative, inclusive and people-centric across all city actions" (Birmingham Smart City Commission 2014).

Another interesting example is the "Smart City Wien—Framework Strategy" (2014), which is a long-term umbrella strategy to 2050 covering all areas of life, work and leisure activities, and including everything from infrastructure, energy and mobility to all aspects of urban development. The strategy was developed with strong stakeholders' involvement. In fact, the Smart City Wien Agency has organised several thematic forums attended by the city administration, business, science and civil society.

Local authorities have also to collaborate with national governments and European institutions in a perspective of multilevel governance.

Some countries are launching "Smart City National Plans". The Spanish government published its action plan in 2015 corresponding to a global budget of 152.9 million Euros (METI 2015). A Smart Cities Council was also created integrating ETSI, Re.es, IDEA, EOI, local entities and companies under the coordination of the Ministry of Industry, Energy and Tourism. Moreover, the Spanish Smart Cities Standardization Committee is developing specific technical norms in the area of smart cities.

National policies also have to create a favourable regulation framework for the implementation of smart city projects. For example, the UK launched the "Code of practice for testing of automated vehicle technologies" to provide guidance to anyone wishing to conduct testing of automated vehicle technologies on public roads or in other public places in the country (Department for Transport 2015).

After launching Europe 2020 strategy towards smart, sustainable and inclusive growth, the European Commission created the "Smart Cities and Communities European Innovation Partnership" (EIP). The initiative aims to accelerate the market uptake of smart city solutions integrating technologies from Energy, Transport and Information and Communication Technologies (ICT). The experimentation of these innovative solutions in real urban conditions with a view to their replication and full deployment in other European and worldwide cities is also a requisite of the initiative.

Under this framework, Horizon 2020 is financing large-scale lighthouse projects to be developed by partnerships between industry and local authorities under a "new cooperative working environment". "Public authorities need to act as a partner with industry, service providers, financiers, and end users to build the smart city" (Smart Cities Stakeholder Platform 2013).

Horizontal measures are also being supported in order to enhance market demand in the following domains: business models, standardisation, metrics, public procurement, regulations, stakeholders' engagement and so on.

8.3.3 Companies and Entrepreneurs

Smart cities offer a huge market opportunity to companies and entrepreneurs. This business sector comprises systems integrators, services providers, telecommunications companies, infrastructure suppliers, utilities, apps providers, construction companies and so on.

According to ABI Research Institute (2011), the market for technologies that feed into and support smart city programmes and projects is expected to grow on a global basis from 6.4 billion euros in 2010 to exceed 31 billion euros in 2016, accounting for 92 billion euros in cumulative spending during the period. Moreover, Pike Research estimates that the next ten years will see over $100 billion spent on technologies to support smart city development worldwide. By 2020, the annual spend on these core technologies will be almost $16 billion. Governance, buildings and mobility solutions are considered the main areas of growth (Pike Research 2011) (Graphic 8.2).

A report published by Arup in 2011 centred on the 36 members of the C40 network gives a good indication of the areas of focus in the implementation of smart city solutions. Smart energy metering, smart transport cards, electric vehicles and real-time transport information are the solutions with a higher level of implementation (Graphic 8.3).

Several national governments are aware of this opportunity with a view to promote competitiveness, create new jobs and enhance internationalisation.

For example, the study "The Smart City Market: Opportunities for the UK" (DBIS 2013) identifies global market opportunities for the UK industry in smart city technology, exploring its market structure and size. In July 2014, a similar document was launched by Arup and Future Cities Catapult describing UK capabilities for urban innovation and documenting the wide range of UK industry, research and civic capabilities relevant for driving innovation for the world's future cities. The report recognises that "companies, researchers and institutions that can provide the innovations that solve complex city problems will enjoy a sizeable and growing market for their skills, products and services" (Arup 2014).

Future Cities Catapult, one of nine Catapults established by Innovate UK, the UK Government's innovation agency, is oriented to strengthen the
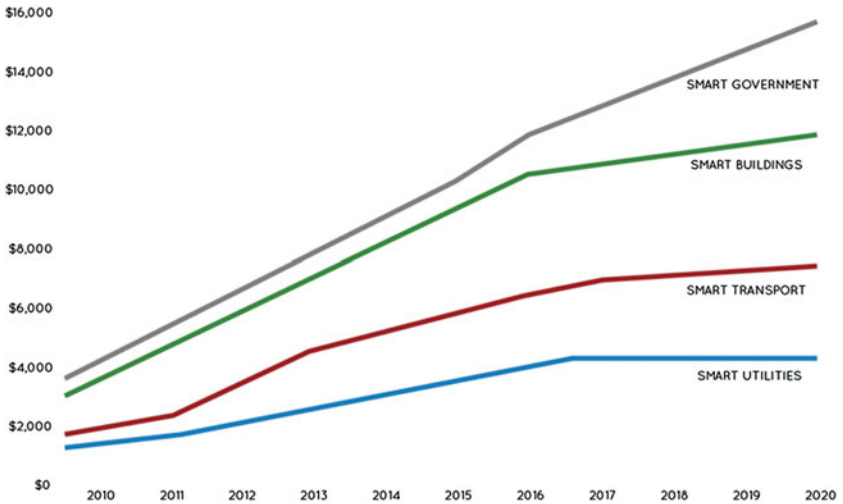
Graphic 8.2   Smart city and smart infrastructure investment by industry, World Markets, 2010–2020 (*Source*: Pike Research 2011— $million)
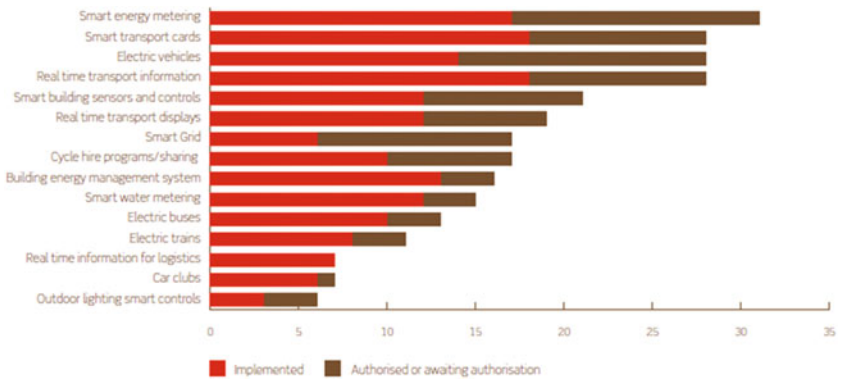
Graphic 8.3   Smart city solutions in 36 member cities of the C40 network (*Source*: Arup 2011)

UK's ability to turn urban innovations into commercial reality. It provides world-class facilities and expertise to support the development of new products and services, as well as opportunities to collaborate with others, test ideas and develop business models. The Catapult helps "innovators turn

ingenious ideas into working prototypes that can be tested in real urban settings (...) then, once they're proven, (it) helps spread them to cities across the world to improve quality of life, strengthen economies and protect the environment" (futurecities.catapult.org.uk).

The report "Danish Smart Cities: Sustainable Living in an Urban World" published by the Copenhagen Cleantech Cluster (2012) provides an overview of Danish smart city competencies and strengths, and some general recommendations to foreign companies and stakeholders who wish to enter the Danish smart city market. A list of smart city companies working in Denmark is also delivered. According to this document "we expect significant growth within the smart city market and a big part of this growth will be activated through the use of data and data management".

Large companies such as IBM, Cisco and Microsoft are strongly involved in the smart city market providing smart solutions and platforms, know-how and investment. The technological component is the key factor of their conceptions of smart cities. These technology providers are partnering with cities in the implementation of smart city projects. For example, the Spanish company Indra is collaborating with the Municipality of Coruña within the "Coruña Smart City" project, implementing an urban management platform which integrates all the city's smart services and solutions in the domains of environment, energy, mobility, safety, tourism and e-government.

Entrepreneurs and start-ups are also developing smart solutions and applications oriented to solve urban problems and answer to city's future challenges, using open data systems. These micro-businesses are being supported by public and private initiatives such as apps contests, hackatons, incubators, co-working spaces, funding programmes and so on. Lisbon is considered one of the best cities for entrepreneurs and start-ups, providing a network of incubators, creative spaces, fab labs and so on that constitutes a powerful innovation ecosystem. In the same vein, Amsterdam was elected the European Capital of Innovation 2016 (iCapital) for embracing a bottom-up approach based on smart growth, start-ups, livability and digital social innovation.

8.3.4   Universities and R&D Centres

Universities and knowledge centres are also involved in the smart city movement, working within research areas relevant to smart cities.

Besides capabilities across business, the referred reports "Danish Smart Cities: Sustainable Living in an Urban World" (Copenhagen Cleantech Cluster 2012) and "Future Cities: UK Capabilities for Urban Innovation" (Arup 2014) provide a list of universities and knowledge institutions developing research in the smart city domain in order to structure national research capabilities.

Several universities are creating urban-focused multidisciplinary research centres, recognising that working beyond single disciplines is the only way to approach smart city research. Moreover, universities are collaborating with other partners to apply research in real-world contexts and for demonstrating and testing urban innovations. One relevant example of collaboration between cities and universities in smart city projects is the MetroLab Network (metrolab.heinz.cmu.edu/). This initiative is aimed at improving American cities through university-city partnerships. It is part of a programme financed by the USA government to boost creative collaborations, new technology and solid data.

Under this scope, urban science centres are emerging in universities around the world, being urban science defined "as an emerging domain of research at the intersection of science and design, drawing on new disciplines in the natural and informational sciences, that seeks to exploit the growing abundance of computation and data" (Townsend 2015a). According to the author, by 2030 $2.5 billion will be invested in urban science and informatics research (Fig. 8.1).

New organisations are outpacing traditional ones. The "Centre for Urban Science and Progress" (New York University) and the "Amsterdam
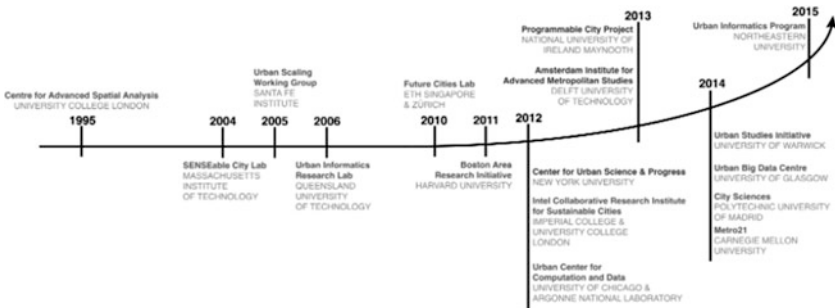

Fig. 8.1   Timeline of urban science institutions (*Source*: Townsend 2015b)

Institute for Advanced Metropolitan Solutions" are recent and well-known initiatives. CUSP is focused on the collection, integration and analysis of data to understand and improve urban systems and quality of life, using New York City as a living lab. Its anchor project is the Urban Observatory which intends to analyse the huge amount of data in cities and develop new scientific instruments to collect novel urban data.

The Amsterdam's institute resulted from the collaboration between the Delft University of Technology, Wageningen University and MIT's Centre for Advanced Urbanism. It was the winning proposal of a call launched by the Municipality to create a new applied technology research institute. In the institute "science, education, government, business partners and societal organizations are working tightly together to create solutions for the complex challenges a metropolitan region like Amsterdam is facing now and in the future" (www.ams-institute.org).

In the education field, several smart city masters and doctorates courses are being launched by universities. UCL is developing a Master of Smart Cities and Urban Analytics and CUSP grants a Masters in Applied Urban Science and Informatics.

8.3.5   Civil Society

Citizens are key actors in smart city planning and implementation. Civil society should be involved in the policy- and decision-making process, in the urban innovation process and in the collection and analysis of urban data and information. "Open data invites cross-sector, trans-departmental participation and cooperation (...) it allows citizens to engage more seriously with city government, not just offering comments and critiques, but in providing their own data and innovative ideas" (Bollier 2016).

Fix my Street platform (UK) was one of the first initiatives designed to promote the participation of citizens in reporting and discussing local problems (like graffiti, broken paving slabs or street lighting). Change by us (New York) invites citizens to propose ideas to make the city a greener and greater place to live. Starting with the Amstel 3D Pilot, Amstel3City is a smart city initiative for real-time master planning in implementation within the Smart City Amsterdam programme. It is an online urban transformation dashboard, which integrates visual storytelling, data-sharing, co-creation, participatory democracy, crowdsourcing and crowdfunding. Citizens, businesses, knowledge centres and the government "can exchange information

and ideas and collectively plan, make and own their city or neighborhood" (amsterdamsmartcity.com/).

The involvement of users in the urban innovation process can be illustrated by the RIO+ initiative launched by the social company Benfeitoria. It is a collaborative creative platform oriented to collect ideas to the city's problems proposed by the community. The solutions are selected through online public voting and are implemented in the urban space with the support from the City Council (riomais.benfeitoria.com/).

Smart society initiatives are also emerging from the ground, often using low cost and publicly available ICT platforms and solutions. Urban action forums, social network platforms, social innovation incubators, carpooling networks and volunteering networks are some recognised examples (Ovum 2011).

Finally, citizens are increasingly involved in the collection of data and information, namely related to environmental issues such as carbon emissions, energy consumption and air quality. These initiatives contribute to accelerate the adoption of technologies by the society, and provide knowledge to the decision-making processes. For example, the Amsterdam Smart Citizens Lab promoted by the City and Waag Society stimulates citizens to collect and analyse data and information through smartphones, smart watches, Do-it-Yourself sensors and so on. A Smart Citizens Kit, an open source device that monitors the environment was experimented, which helped people to understand the possibilities of citizen science.

The sharing economy is also a trend that contributes to the improvement of collaboration within communities. It includes the "shared creation, production, distribution, trade and consumption of goods and services by different people and organizations" (Matofska 2016). Car-sharing, bike-sharing, co-housing and co-working spaces are some examples of this phenomenon. The sharing economy is strongly linked to smart cities, since cities are increasingly supporting the sharing movement. Amsterdam, Milan and Seoul are world-class case studies.

8.4   CASE-STUDY: SMART CITIES PLATFORM IN PORTUGAL

8.4.1   Overview

In Portugal there is no national strategy towards smart cities. However, recent policy documents make reference to living labs and smart cities. "Portuguese Reform Program" and "Startup Portugal" are relevant

examples. Regional authorities (CCDR—Regional Coordination and Development Commissions) do not have political legitimacy, but they are the entities responsible for managing "Regional Operational Programs".

Local dynamics are leading the smart city movement in Portugal. Several cities are defining strategies, policy tools and collaborative approaches to deal with this ambition. Global technology providers are trying to sell their products to municipalities, and start-ups and urban entrepreneurs are increasingly emerging. Universities and R&D centres are wakening for the phenomenon, recognising the need to multidisciplinarity in smart city research. Finally, the involvement of citizens and communities in the urban innovation and policy-making process is still in infancy. However, some grassroots and civic movements are arising.

Informal cooperation networks are being formed, namely the Portuguese Smart Cities Network (RENER) and the Smart Cities Portugal platform. The former aggregates several municipalities who want to develop and implement smart city strategies, and the last one intends to become a collaborative platform integrated by cities, companies, universities and R&D centres, and users. The aim of these initiatives is to promote partnerships within and among the four helices of the Quadruple Helix Innovation Systems Conceptual Framework.

8.4.2 Smart Cities Portugal Platform

Smart Cities Portugal is a collaborative platform integrated by companies, R&D centres, universities, technology infrastructures, associations and municipalities, founded in 2013. At the moment 50 organisations are part of the network. It intends to create synergies among the different players operating in the smart city market, enhancing the roll-out of integrated and scalable creative solutions to solve urban problems.

The platform aims at positioning Portugal as a developer and provider of technologies, products and high value-added systems for smart cities at global level, promoting companies' competitiveness, innovation capabilities and internationalisation. The country could be considered as a living laboratory for the development and testing of innovative urban solutions in real-life context, attracting foreign direct investment. In fact, smart city solutions tested in Portuguese cities can be replicated in other urban spaces around the world.

The Smart Cities Platform intends to act as an intelligence, advocacy, awareness and accelerator alliance, contributing to a better understanding

of the smart city sector in Portugal in order to support decision- and policy-making processes.

The general objectives of this initiative are:

- Promote the development of smart city pilot projects in cooperation among cities, R&D centres and companies, with a view to improving citizens' quality of life;
- Stimulate the scaling up of innovative urban solutions, replicating worldwide the smart city projects tested in Portuguese cities;
- Promote the participation of Portuguese players in lighthouse European projects in the area of smart cities;
- Promote the internationalisation of Portuguese companies working in the smart city market;
- Enhance the creation of new companies in the smart city market, supporting urban entrepreneurship;
- Evaluate the impact of smart city projects on wealth creation, jobs generation, environment quality and citizens' quality of life, through the use of specific metrics and key performance indicators;
- Contribute to increase the local content of foreign direct investment projects linked to smart growth;
- Increase the participation of Portuguese cities and companies in international territorial, knowledge and commercial networks.

Internationalisation, R&D and innovation, entrepreneurship, funding and regulation are the strategic areas of intervention of the Smart Cities Portugal platform, centred on the following domains: energy, mobility, environment, economy, governance and quality of life.

Internationalisation Creating favourable conditions to promote the internationalisation of Portuguese companies operating in the smart city market. The cooperation between companies oriented to the development of integrated solutions across energy, mobility, ICT and so on enhances their participation in global value chains. Intelligence exercises will help the identification of business opportunities and collaboration possibilities related to smart city projects.

R&D and Innovation Stimulating the development of integrated, innovative and sustainable solutions for smart cities, using the competencies of

universities, R&D centres and technology infrastructures. Providing information and knowledge about smart cities to companies' employees and municipal staff is also important, in areas such as business models, financial mechanisms, partnerships, case studies and so on.

Entrepreneurship Promoting urban entrepreneurship, supporting the development of innovative ideas, applications and solutions oriented to answer to the challenges cities are facing, in the areas of mobility, energy, governance, tourism, health and so on. Launching start-ups in these areas enhances wealth growth and job creation, contributing simultaneously for solving urban problems. Open data, apps contests and incubator spaces facilitate entrepreneurship and the creation of new businesses.

Funding Creating favourable conditions to facilitate the access to funding by companies, municipalities and R&D centres, namely within the European programming period 2014–2020. The "Smart Cities and Communities European Innovation Partnership" (EIP) is coordinating smart city research and innovation projects, which could be supported by Horizon 2020, COSME, LIFE + and Cohesion funds. The cooperation between cities and industry is an added-value when applying for lighthouse smart city projects.

Regulation Participating in international forums on smart city standardisation and normalisation, and contributing to the elimination of legislation barriers to the development and implementation of smart city projects. The provision of interoperable systems is one of the most important issues in this debate. ISO—International Organisation for Standardisation, CEN—European Committee for Standardisation, City Protocol Society, and specific national organisms are already working in this field.

Under the framework of the Smart Cities Portugal platform, a study has been developed in order to identify and analyse smart city business and research capabilities in Portugal—"Smart Cities Portugal Roadmap" (INTELI 2014).

Hundred entities (companies and R&D organisations) were inquired; 78 % of these organisations consider "very important" and 22 %
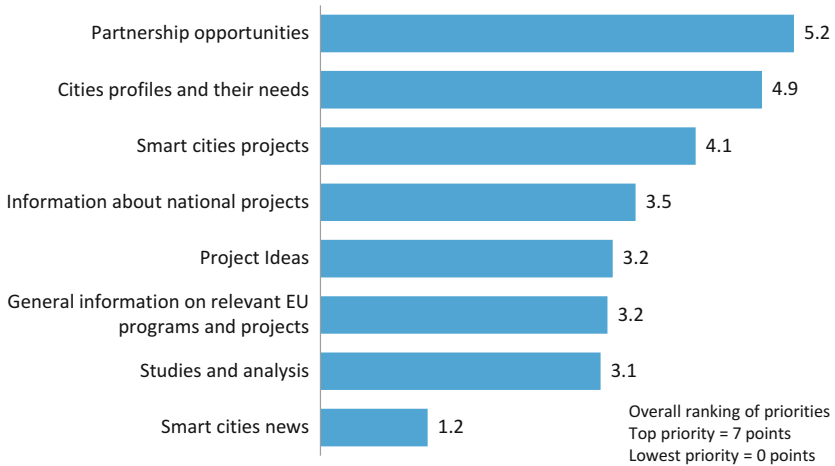
Graphic 8.4 Access to information needs of smart city companies (*Source*: INTELI 2014)

"important" the launching of this platform. None of them referred the network as "non-important" or "irrelevant".

Around 60 % consider "difficult" or "very difficult" the access to information about the smart city market. Information about partnership opportunities and cities' profiles and needs are the priorities identified by companies (Graphic 8.4).

However, in the opinion of the inquired entities the identification of business opportunities is the most relevant advantage of participating in the Smart Cities Portugal initiative.

8.4.3   *Local Governments*

Local authorities are the leaders in the development of the smart city movement in Portugal. Some of them are starting with the definition and implementation of a strategic framework to guide major urban development projects; others are developing specific, distributed interventions in buildings, open data or mobility, before trying to connect these dimensions (Arup 2010). However, the majority of the municipalities lack integrated strategies and roadmaps.

Some good practices that are being developed by national cities were awarded with the "Smart Project for Smart Cities" Label, promoted by INTELI. The bike-sharing system of Torres Vedras, the intelligent public lighting system of Águeda, the environmental information system of Matosinhos, the digital urbanism platform of Vila Nova de Gaia, and the smart waste management system of Cascais were some of the distinguished projects in 2015.

Bigger cities such as Lisbon and Oporto are integrated in European consortiums in the area of smart cities. Oporto is follower city in the "Grow Smarter" lighthouse project. Lisbon is partnering with London, Milan and other stakeholders in the "Sharing Cities" project, supported by Horizon 2020—"Smart Cities and Communities". The objective is to integrate and demonstrate smart city solutions crossing energy, mobility and ICT in urban districts. Within this project, Lisbon will launch an Integrated Operations Centre with the aim of collecting, analysing and integrating real-time data and information about cities' services and operations to support decision-making processes. "Lisboa Aberta" (Open Lisboa) is the city's open data portal, one of the first initiatives in Portugal in this area.

However, cities are represented in the Smart Cities platform through RENER—Portuguese Smart Cities Network, and not in an isolated manner.

RENER was created under the Portuguese Electric Mobility Program, as a pilot network for the introduction of the electric vehicle in the country. Several charging points and other related technologies were tested in these urban spaces by large international manufacturers such as Renault, Nissan, Mitsubishi and Peugeot. National technology solutions are being exported to the USA, Asia and several European countries. In 2013, RENER extended its intervention field integrating other urban domains, such as energy, buildings, environment, governance, social innovation and so on.

At the moment, RENER is composed of 46 municipalities, representing 45 % of national population and 19 % of the territory. It is a space for development, testing and experimentation of smart urban solutions in real-world context, under the concepts of open innovation and co-creation with the involvement of end users. It is also a space for sharing best practices and innovative experiences capable of replication, as well as for the incubation of local solutions with potential for internationalisation. Managed by INTELI, RENER is a member of ENoLL—The European Network of Living Labs.

Several join projects are emerging within the network due to the work of the municipalities in five thematic groups: governance; energy and environment; mobility; society and quality of life; economy and innovation. Cities offer their territories to companies and entrepreneurs who want to test, experiment and validate smart solutions in real-life context.

In 2013, RENER established a cooperation agreement with RECI— Spanish Smart Cities Network, composed of around 70 municipalities. Some projects have been developed in partnership, such as Startup4cities Iberia in the area of urban entrepreneurship. Several contacts are also being established with Brazilian cities and institutions.

8.4.4   Companies and Entrepreneurs

The referred "Smart Cities Portugal Roadmap" (INTELI 2014) has identified the characteristics of the smart city industry in Portugal.

Among the companies inquired 75 % are classified as small- and medium-sized enterprises. Only 14 % have a share of foreign capital in their equity capital, and have decision centres located outside the country.

The Lisbon and Oporto Metropolitan Areas are the main locations of these organisations, followed by the municipalities of Coimbra, Aveiro and Braga/ Guimarães where well-known universities are sited. The agglomeration effect in the coastal area is also a reality.

Among the respondents, 35 % have already created organisational departments to deal with smart city issues, demonstrating the importance that these entities are giving to this new market.

Of the total human resources working in these companies, 70 % have graduate and 1 % PhD levels of qualification. The high level of graduates in the workforce reveals a knowledge and technology-intensive smart city sector. Moreover, R&D investment corresponds to 13 % of global turnover, which is a significant amount compared to the average Portuguese companies' R&D investment.

According to the information available, governance, mobility and energy, followed by buildings and environment are the areas in which these companies are developing smart city solutions (Graphic 8.5).

E-government solutions, municipal portals, management systems (ERP, AIRC) and public procurement tools are the principal products and services provided in the governance area. Mobility products and services are mainly linked to electric mobility (charging points, electric bike-sharing, electric car-sharing), parking management and integrated ticketing. Intelligent
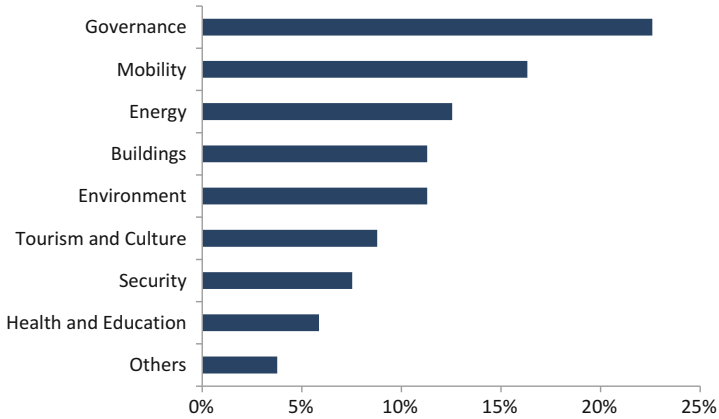
Graphic 8.5 Smart city solutions developed by Portuguese companies (*Source*: INTELI 2014)

lighting systems, PV panels and integration of renewable energy solutions are some of the products offered in the energy area. There were also identified some solutions in the field of waste management, such as intelligent containers, contributing to cost reduction and efficiency gains in cities. Systems integrators, mainly multinationals are developing smart city platforms, with the aim of providing real-time information to services' operators and local authorities.

Twenty-seven per cent of the respondents have registered patents related to smart city products, which is a relevant number compared to the Portuguese average.

Twenty-eight per cent of the companies exports smart city products and solutions. Their markets are mainly located in Europe (Spain, France, Turkey, Switzerland and Ireland), Africa (Angola, Mozambique) and Latin America (Brazil). Moreover, 10 % of the smart city turnover is exported, with a specific emphasis in the areas of energy and mobility. It is worthy of notice that when companies were asked about their future target markets, the scenario is slightly different, due to the growing opportunities identified in Latin America and also in Asia and Middle East.

Smart city market is not yet in a mature stage of development. To accelerate the transition towards a renovated urban development paradigm, it will be needed to strengthen enablers and removing market barriers. Overcoming these barriers will enhance the adoption of innovations, the

deployment of smart city solutions and the enlargement of the market. The perception of respondents resulted in the systematisation of the following barriers:

- Lack of integrated and coherent public policies;
- Weak culture of urban planning and city management;
- Resistance to change and innovation by local authorities;
- Lack of coordination between departments, infrastructures and urban functions;
- Ambiguity and vagueness of the smart city concept;
- Fragmented vision of what is a smart city;
- Lack of information and knowledge related to the smart city market;
- Absence of demonstration projects to show the benefits of smart city solutions;
- Market with a high diversity and heterogeneity of players;
- Domination of global companies in the smart city market;
- Lack of integrated solutions and competencies;
- Difficulty in launching interfirm and interinstitutional cooperation processes;
- Absence of standards and interoperability;
- Problems with legislation and regulation;
- Economic crisis and lack of funding sources.

Twenty-nine per cent of the respondents have already participated in large-scale smart city projects, with a great relevance of mobility and energy as application areas. These projects were mainly funded by national and European programmes, such as 7th Framework Programme, Competitiveness and Innovation Framework Programme and Horizon 2020.

8.4.5   *Universities and R&D Centres*

Beyond the traditional urban studies, Portuguese universities and knowledge organisations are increasingly involved in smart city research. Energy, mobility and buildings are their main areas of intervention (INTELI 2014) (Graphic 8.6).

However, universities are recognising the need to cooperate with cities in the development of R&D and demonstration projects. For example, the University of Minho launched the "UMCidades" (UMCities) initiative. It intends to fill the gap between knowledge and policy in the field of urban
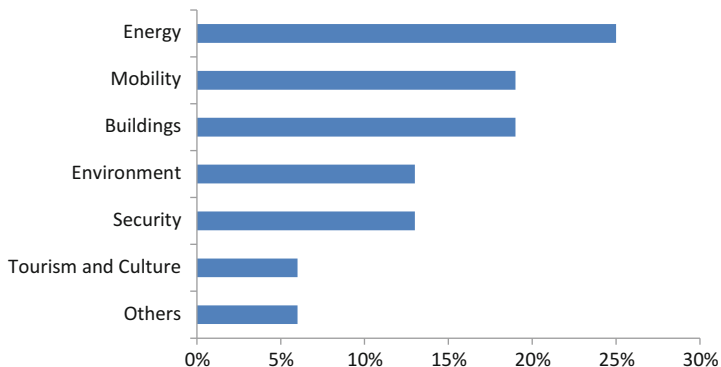
Graphic 8.6 Smart city areas in universities and R&D centres (*Source*: INTELI 2014)

studies. Improving the debate among knowledge organisations and policy-makers is also an objective of "UMCidades". One of its anchor projects is the "City of the Year" award, which aims to distinguish good practices and projects under development by Portuguese municipalities.

Moreover, universities are becoming aware of the need to break down the silos of knowledge. A multidisciplinary methodology is needed to approach the smart city research field. The University of Oporto—Faculty of Engineering launched the "Centro de Competências para as Cidades do Futuro" (Centre of Competencies on Future Cities). "It is focused on bringing together, developing and applying knowledge, skills and compe-tences of multidisciplinary nature in order to promote economic develop-ment and social inclusion in urban environments". The centre concentrates the expertise of University of Oporto in areas such as communication technologies, services, models and instruments of intervention to the urban and metropolitan scales, simulation, construction, operation and management of environmentally sustainable cities.

They want "to turn Porto into a smart city, a living lab, by providing it with a wide range of sensors and communication equipment, thus creating the conditions for future research and development using advanced tech-nologies for data collection through mobile platforms, wireless communi-cation and large-scale information processing" (futurecities.up.pt/site/build-research-capacity/).

Moreover, some masters and training courses are being launched in the area of smart cities. The Nova University of Lisbon is beginning a postgraduate programme in smart cities which "is aimed at managers, technical staff in public or private sectors, and other professionals that wish to acquire skills and knowledge in information systems for smart cities, using the most advanced technologies, data collection, analysis, and processing methods" (www.novaims.unl.pt/sc).

These initiatives are recent but have a great potential for replication in other universities and R&D centres.

8.4.6   Civil Society

Civil society is not formally represented in the Smart Cities Portugal platform. The same happens with arts, media and culture organisations, considered also as the "fourth helix" in some authors' approaches to the Quadruple Helix Innovation Systems Conceptual Framework.

However, some municipalities are trying to involve citizens in the policy and decision-making processes. Several Portuguese cities are using participatory budgeting as a policy tool, in which ordinary people decide how to allocate parts of municipal budgets. There are reported 158 on-going experiences of participatory budgeting in Portugal (www.portugalparticipa.pt).

Methodologies similar to UK "Fix my Street" are being implemented by a small number of local governments. Fix Cascais (Cascais), AlertaTVedras (Torres Vedras) and "A Minha Rua" (My Street) (Lisbon) are some examples. Crowdsourcing platforms are not generalised, and initiatives related to collective data collection and analysis were not identified.

One case study is the on-going initiative "Desafios Porto" (Oporto Challenges), a project that allows the public to contribute actively to the resolution of the problems that the city lives every day by presenting challenges. In order to participate citizens have only to identify a challenge experienced by the city of Oporto in one of the four categories—Health and Wellness; Energy; Digital City; Mobility and Environment. Sixteen challenges were selected through public voting and local entrepreneurs and companies have been called to propose technological and innovative solutions to solve these challenges. At the end the elected solutions will be implemented in the city of Oporto with the support from the Municipality and some sponsors.

In Aveiro several civic movements are emerging. VivaCidade Aveiro, Vivó Bairro and Ciclaveiro are some relevant examples. VivaCidade aims

at identifying and intervening in "empty spaces" in the city, acting the citizens as actors of urban change. Vivó Bairro intends to promote the sense of community in historic neighbourhoods through the organisation of several join activities (urban art, civic workshops, etc.). Finally, Ciclaveiro is coordinated by a group of citizens who want to promote the use of bicycle as an alternative transport mode.

8.4.7 Collaborative Dynamics

The smart city sector in Portugal is still in an emergent stage of development. Besides the creation of informal platforms and networks, there is a need to increase the collaborative dynamics within and among the different helices of the Quadruple Helix Innovation Systems Conceptual Framework: local authorities, companies, universities and the civil society.

Since the 1980s, industry-university partnerships have been promoted within the national innovation policy. Specific policy instruments used for achieving this objective were science and technology parks, technological infrastructures, incubators and join projects funded by European, national and regional sources. Since 2007, these partnerships are also being supported by international programmes established between Portuguese universities and the Massachusetts Institute of Technology, Carnegie-Mellon University, University of Texas at Austin and the Fraunhofer-Gesellschaft.

City-industry collaboration is essentially focused on traditional commercial relationships, being necessary a "new cooperative working environment". Pre-commercial public procurement of innovation, green public procurement, tax incentives and specific regulations are some of the policy tools that can be used to facilitate this interaction. These partnerships are being enhanced by European lighthouse projects in the area of smart cities and communities. In this process, cities are offering their territories as living labs for companies who want to test innovative technologies and solutions in real-life environments.

Moreover, Portuguese companies are facing several market barriers when they approach the smart city market, namely the vagueness of the concept, the lack of information, the absence of standards and the dominance of global technology providers. This market has specific characteristics when compared to other traditional commodities markets. New governance models, new business models and new funding schemes are needed.

Municipality–university relationships are more recent. Universities are looking for a "new" role in society beyond education and research. They want to improve their connections within the urban innovation ecosystem, contributing for solving city's problems. Due to the reinvention of "urban science", several research centres are being created within universities in order to promote interdisciplinary smart city research. Data management and analytics are disciplines that are being applied for collecting and integrating urban data and for studying urban metabolism. Moreover, knowledge centres are also using cities for testing and validating their ideas and conceptions.

Citizens are the "silent actors" in this collaborative dynamics. Besides some isolated examples, the majority of the cooperation projects do not integrate the user side. The adoption of technologies is harmed by the lack of user involvement in the innovation process. And the lack of community participation in solving urban problems induces the application of technologies not compatible with people's needs.

This situation reveals the dominance of an embryonic Triple Helix Innovation Systems Conceptual Framework. Collaboration among municipalities, companies and universities is increasing but it is not in mature stage of development. However, some isolated national and local projects are being or were developed according to the Quadruple Helix Innovation Systems Conceptual Framework, such as "Future Cities" initiative (2011–2015).

8.5   Conclusions

Smart cities are emerging as a new urban development model, responding to the economic importance of cities, to the process of urbanisation and to the demand for a post-carbon model. Besides the diversity of the phenomenon, a smart city is a territory where the investments in human and social capital, and ICT infrastructures and networks promote economic development, environmental sustainability and a high quality of life, through participatory governance.

A city is not smart when it does not include all its stakeholders in the urban innovation process. Smart city is based on knowledge sharing and collaboration across all levels of society.

In this framework, the creation of collaborative platforms and networks is an emerging phenomenon in the smart city arena. Promoting the interaction among the four helices of the Quadruple Helix Innovation Systems Conceptual Framework, municipalities, companies, universities and the civil

society is the aim of these initiatives. QH is considered an urban innovation environment oriented to the co-creation of creative solutions to solve urban problems and to answer to the city's future challenges.

In Portugal, the smart city context is characterised by an embryonic Triple Helix Innovation Systems Conceptual Framework, besides the existence of some informal platforms like RENER—Portuguese Smart Cities Network and Smart Cities Portugal platform. To increase the collaboration between smart city actors and to include the civil society in the urban innovation process are needed to build an attractive, sustainable and inclusive innovation ecosystem.

Future research will be dedicated to the quantitative analysis of the smart city actors' collaboration.

NOTE

1. This approach is theoretically linked to the interactive model of innovation (Kline and Rosenberg 1986), Mode 3 of knowledge production model (Gibbons et al. 1994), national innovation systems theory (Lundvall 1988; Nelson 1993) and clusters thinking (Porter 1990).

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