

A Smart City Initiative: the Case of Barcelona

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Abstract Information and communication technology is changing the way in which cities organise policymaking and urban growth. Smart Cities base their strategy on the use of information and communication technologies in several fields such as economy, environment, mobility and governance to transform the city infrastructure and services. This paper draws on the city of Barcelona and intends to analyse its transformation from a traditional agglomeration to a twenty-first century metropolis. The case of Barcelona is of special interest due to its apparent desire, reflected by its current policies regarding urban planning, to be considered as a leading metropolis in Europe. Hence, an assessment of the Smart City initiative will cast light on the current status of Barcelona's urban policy and its urban policy of Barcelona and its future directions. This article analyses Barcelona's transformation in the areas of Smart City management; drivers, bottlenecks, conditions and assets. First, it presents the existing literature on Barcelona's Smart City initiative. Then, the case study analysis is presented with the Barcelona Smart City model. After describing this model, we further explore the main components of the Smart City strategy of Barcelona in terms of Smart districts, living labs, initiatives, e-Services, infrastructures and Open Data. This paper also reveals certain benefits and challenges related to this initiative and its future directions. The results of the case study analysis indicate that Barcelona has been effectively implementing the Smart City strategy with an aim to be a Smart City model for the world.

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Introduction

Recently, there has been a growing interest in the Smart City concept by policy-makers across Europe following USA. Information and communication technologies (ICT), as the new economic force for urban growth, change the way cities compete. Across the world, municipalities challenge to compete to be the best models of sustainable urban development.

In 2010, 50% of the world's population lived in urban areas and this figure is forecast to rise to 75% by 2050 [29]. Due to this escalating population, governments are required to figure out how to create future spaces for the citizens. This is why they base their economic development policies on building advanced infrastructures to keep up with competition. Not only are policymakers involved in this initiative but also citizens are engaged in the project, as their future quality of life is at stake.

Today, international competitiveness is driven by the innovativeness of cities. To achieve that, cities are undergoing fundamental transformations. With rapid industrialization, small towns turn into metropolises with major installations of ICT infrastructures and can reposition themselves on the global stage. These cities also provide new locations for businesses and clusters.

Barcelona is considered as a success story in urban development across Europe. Despite the downturn in 2008, Barcelona managed to maintain its position among top European cities. As the second largest city of Spain, Barcelona has been growing and transforming itself to be a knowledge-intensive city. As well as being a tourist spot and a main port, it is also a foremost example of industry clusters. In 2009, Barcelona was positioned fourth in the ranking of Europe's best cities for locating business [7]. Possessing an extensive industrial foundation and an entrepreneurial structure facilitated Barcelona to reach a position of being a knowledge-intensive economy. As a city, Barcelona utilises knowledge as an engine for economic growth to support production and the generation of talent. Today, Barcelona has more than 400 research centres for the creation, dissemination and use of knowledge. However, more importantly, Barcelona is a pioneer in being a Smart City, with various initiatives in the industrial area 22@Barcelona district.

To transform itself into a Smart City, Barcelona has undertaken significant reforms. Further, the Barcelona case has a special significance due to its apparent tendency in its urban policies and reforms to become a leading Smart City among European cities. Hence, an assessment of the Smart City initiative will cast light on current urban policies of Barcelona and future directions. This is why it is an excellent case to explore.

Briefly, a Smart City should be able to actively generate smart ideas in an open environment through fostering clusters or Open Data or developing proper living labs while directly involving citizens in the co-creation process of products or services. This is what the Barcelona Smart City initiative aims to accomplish. In this paper, we attempt to shed light on issues like Smart City initiative management, drivers,

challenges and conditions that define the transformation of a city with an in-depth case analysis.

This paper investigates how Barcelona has been implementing technological systems to transform itself into a Smart City and compete in the global knowledge-based economy. This paper aims to explore and demonstrate the transformation of a city into a Smart City while addressing the following research questions: (1) How does city hall manage transformation? (2) What are the underlying drivers and bottlenecks for the transformation? (3) What are the main obstacles faced by the city hall? (4) What are the necessary conditions to be established for the transformation? (5) What are the assets/infrastructures required to become be a Smart City?

Here, the intention of conducting this research is to illustrate a Smart City in a real context while examining its transformation. To achieve this objective, the case study method is employed. The case study method involves a variety of interviews and analyses of sites while acquiring insights from interviews and observations [28, 31]. A variety of data were collected through structured in-depth interviews with five leading members of the Barcelona City Council, such as Joan Batlle, the head of International Cooperation in eGovernment and Innovation in Barcelona City Council, Julia Lopez Ventura, also working for International Cooperation in eGovernment and Innovation in Barcelona City Council, Anna Majo, the director of Strategic Sectors and Innovation department and two members of Barcelona Activa—Maria Vila and Isabel Ponti, non-participant observations in the 22@Barcelona district, as well as presentations and informal talks. Further, we used secondary data such as international comparisons of urban policies, clusters, economic indicators and demographics. Below, the Barcelona case will be illustrated in relation to their management of Smart City initiative, main drivers and challenges, and also, in terms of infrastructures.

In order to attain the stated objectives, the present article will have the following structure. First, we will present the existing research on Smart Cities. It will proceed with a description of the case study analysis. Here, the main components of the Smart City strategy of Barcelona will be explored. Then, the benefits and challenges of the Smart City initiative and its future directions will be described. The paper will conclude with the insights generated from the case analysis.

Literature Review

In recent years, Smart Cities have attracted significant interest by governments in their research and development projects around the world. Although there is no apparent description about what Smart Cities are, they can be briefly explained as those cities that utilise information and communication technologies with the aim to increase the life quality of their inhabitants while providing sustainable development. Through implementing information and communication technologies into municipal services, cities turn into being more intelligent in their management of resources. Those new types of cities with new technological applications create new business opportunities and a hub for research. Thus, they attract companies, entrepreneurs and research institutes.

In the literature, the ‘Smart City’ concept is referred to as the safe, secure, environmental and efficient urban centre of the future with advanced infrastructures such as sensors, electronic devices and networks to stimulate sustainable economic growth and a high quality of life [6, 17]. Currently, most of the cities across Europe and USA have already initiated or are about to initiate the Smart City approach due to its effect on amplified urban growth [8, 27].

Smart City is described as a concept in various ways but a general definition involves implementation and deployment of information and communication technology infrastructures to support social and urban growth through improving the economy, citizens’ involvement and governmental efficiency [18]. Other research suggests that initiatives should be implemented in the fields of mobility economy, environment, living, people and governance to achieve a complete Smart City initiative [14]. A few researchers point out that there can be few negative aspects in the Smart City approaches [16, 18]. Despite this growing body of literature on Smart Cities, the literature lacks a detailed analysis of the management of Smart City initiatives as well as descriptions of the underlying drivers and challenges faced.

Barcelona City Hall has been well known across Europe for its ambitious programmes of urban planning and regeneration. What distinguishes Barcelona is its unique approach to urban governance. This is why the urban policy of Barcelona has been analysed from various dimensions—housing [13, 24], urban policy [11, 15, 20–23, 26], environment [9, 30], employment [12] and knowledge economy [19].

Whilst some of the dimensions of change have been fully described, Smart City initiatives have been analysed rather less and partially. Regarding urban regeneration, Leon [20] examined Barcelona while only focusing on 22@Barcelona district and the internationalisation of Barcelona business. Similarly, Barber and Eastaway [3] examined challenges of policymakers in the creation of 22@Barcelona district together with Eastside (Birmingham). This research of Barber and Eastaway [3] provides documents, presentations and reports about the Smart City project in Barcelona that have been published by the city hall itself. Mazzoleni [25] focused on the reconstruction experiments of Barcelona in the final decades of the twentieth century but just briefly mentioned the 22@Barcelona district and defined it as a different form of reconstruction. Most of the above materials focus on the urban regeneration of Barcelona but an overall assessment of Smart City initiative of Barcelona is required. Nevertheless, these documents provide an initial description of Barcelona as a Smart City to initiate this research paper.

Smart City Initiative of Barcelona: an Integrated Urban Development Model

The urban transformation of Barcelona dates back to 1980s. It changed from being in a deep economic crisis and having a serious infrastructure deficit, to becoming a leading metropolis [22]. Barcelona has distinctive characteristics that impact its urbanisation plan. It has been highly urban, densely constructed, with very close collaboration between politicians and companies [10]. Marshall [22] concluded that earlier urban planning of the city had been relatively weak; for instance, the period of the 1992 Olympics was mainly about internal infrastructure for urban planning. Thus,

the Smart City initiative was necessary because there were obvious deficiencies in the previous strategic planning regarding housing, environmental issues, water, transportation and energy. To achieve a change in these areas while implementing the use of ICT, city hall recognised that a common action from all the elements of city was required. This is why the city authorities together with the other organisations and institutions organised the Smart City strategic plan in 1990s with the aim of placing Barcelona in a leading position for being a Smart City across Europe.

The conceptualization of the Smart City by Barcelona is quite extensive. For Barcelona, Smart City implies a high-tech intensive and an advanced city that connects people, information and city elements using new technologies in order to create a sustainable, greener city, competitive and innovative commerce and a recuperating life quality with a straightforward administration and a good maintenance system. More importantly, Smart City Barcelona is a collaborative movement among its corporations (retail), academic institutions, government authorities and the residents of Barcelona, aimed at becoming a reference programme for economic engines and urban development. Together, they are developing smart projects to foster the competitive profile of city.

The general objective of the Smart City model in Barcelona is to use ICT in order to transform the business processes of public administration both internally and externally to be more accessible, efficient, effective and transparent. For instance, through providing Smart Services, Barcelona aims to boost cooperation between the council, civil stratum and the professional arena.

There are various drivers for the Smart City model in Barcelona, but among all, fostering competitiveness of the city is the leading one. Smart City was initiated to promote innovation, create new channels of communication, facilitate access to information both locally and internationally and improve the efficiency of public services.

The Smart City initiative is just one part of an advanced conceptual model of Barcelona (Fig. 1). Smart City is the physical environment that provides the infrastructure and town planning based on historical patrimony. A knowledge economy is built with an industrial network and clusters in this physical area. This creates a relationship space, social network between companies, institutions and city hall and citizens. This interaction of the citizens with this area and companies eventually creates a knowledge society.

The main assets of Barcelona Smart City model are summarised in Fig. 2 based on the interviews with leading members of the Barcelona City Council. These initiatives are grouped under four main topics: Smart Governance, Smart Economy, Smart Living and Smart People. Other than tools such as kiosks and maps, Smart Governance involves a major initiative such as Open Data. However, all mainly aim to provide a better access to government information. Smart Economy involves the creation of innovation clusters and a triple helix concept where companies, faculties and citizens can interact and collaborate. So that innovation can be fostered through these networks, the initiatives under Smart Living is mainly targeting new technology adoptions that are mainly initiated by municipal police and tool developments for public transport. Finally, Smart People mainly involves training programmes for digital literacy of the Barcelona City Hall. To support these initiatives, Barcelona have built and/or use existing or new infrastructures—the 22@Barcelona innovation

Fig. 1 Conceptual model of Barcelona [1]



district, corporate fibre optical network, Wi-Fi mesh network, sensors network and public Wi-Fi network (Fig. 2).

To accomplish the initiated objectives, the Barcelona Smart City model foundations lay on three pillars, namely these are ubiquitous infrastructures, information and human capital. In terms of ubiquitous infrastructures, the city needs to be equipped with advanced infrastructures to evolve the Smart City concept from pure theory to reality, providing citizens and enterprises with a powerful platform to connect city elements and let them interact effortlessly with each other and with their administration through electronic means. Stable sturdy infrastructures, from optical fibre networks covering the city acting as a backbone to the installation of sensors, are the key for the development of intelligent solutions in cities.

In terms of information, it is the raw material to fuel innovation factories. Information coming from daily activity in the city is an invaluable asset that needs to be collected and interpreted, creating a Smart City information space that acts as the basis to deliver smart-tailored services and better city management. Several sources have been identified as being the following the most important ones to construct the concept of the Smart City. There are two main information sources: (1) information coming from the city that involves sensors and city elements and Open Data (public sector information) and (2) information coming from the citizens as digital footprint, social media and crowd sourcing.

Finally, in terms of human capital, actors actively participating in the daily activity of the city are the ones that potentially could make a city smarter. The implementation of the Smart City is not only a concern of public administration but also it should involve the population, innovation centres, companies and entrepreneurs.

Faculties and society are knowledge producers, while companies and entrepreneurs generate new business opportunities. Moreover, public administration can

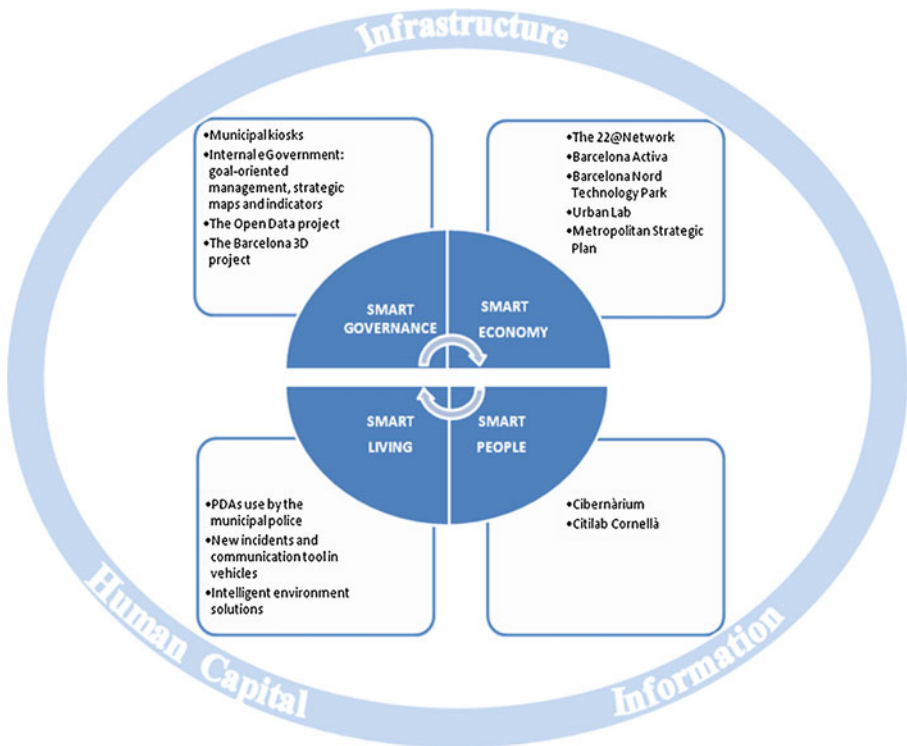


Fig. 2 The main assets of Barcelona Smart City initiative model generated from [1, 4, 5]

generate growing environments that should push a growing, sustainable and progressive dynamic. In this sense, cooperation between these actors seems to be the key for the development of a suitable environment for talent development.

The Main Components of the Smart City Strategy of Barcelona

Smart Districts

In certain districts, Barcelona has pushed the limits toward an effective and sustainable city by transforming itself from an industrial area into a home of new innovative companies. This, specifically, is the 22@Barcelona district project, but that is just one of many projects within the Barcelona Smart City plan. The 22@Barcelona has a model of knowledge city that covers Smart City standards with economics, green infrastructure, inclusiveness, science and tech, housing, mobility, quality of life and identity. The 22@Barcelona district supports a series of projects that will add value to companies and cities. Among these projects, Barcelona Urban Innovation Lab & Dev (BUILD) programme exists as a mixed sphere in the Smart City model development [2, 5]. Based on the Smart City model, this programme aims to foster the participation of the private sector in the development of innovative products and services related to improvements in the urban space management. This creates two types of relationships between the city council and organisations—urban research and urban lab.

The 22@Barcelona district supports the formation of urban research and facilitates a new working space among the Barcelona City Hall, companies and institutes. This space is intended to foster research activities about the smart management of the urban space and e-Services. To achieve successful outcomes, the city council supports this urban research through providing human resources and tools depending on the subject, size and proposal relevance. Thus, the main objective is to sustain an area for the collaboration with companies and institutes for new product developments while improving the urban management.

As a district, 22@Barcelona also creates a space of personal relationships. It constructs an affiliation sensation to the community of 22@Barcelona and this also encourages feelings such as pride to live and work in 22@Barcelona district. To develop and sustain this space, a number of programmes such as agora programme, relationship spaces and 22@Barcelona Network have been implemented by the city hall for the professionals. For the residents in that district, other kinds of programmes used such as digital district programmes, support the initiatives of the district and actions of direct communication.

Living Labs Initiatives

As mentioned above, 22@Barcelona, also referred as 22@Urban Lab, is another component of the BUILD programme. The BUILD programme uses 22@ district as a leading living lab for new infrastructures and services, inspiring companies to test and develop innovative solutions as products or services in any field: sensorization, urban planning, mobility, education, etc.

Living labs are used as tools and processes for the creation of user innovation cooperatively in real-life environments. It is employed for learning, conducting tests and research for the implementation of new technologies and services of organisations in large-scale real-life environments. As a promising method, living labs not only provide benefits like product improvements but also foster innovation and give insights for future markets while lowering risks. This is why living lab applications have been accelerated tremendously in the recent years across Europe. Other than 22@Urban Lab, Barcelona has numerous living labs such as LIVE, BDigital Custer TIC Living Lab, i2Cat LivingLab (related to UPC), FABLab (linked to IAAC), HANGAR and CITILAB–CORNELLÀ.

In the case of 22@Urban Lab, the experimentations of new products and services that are at pre-commercial stages ease the market access for companies, while boosting competitiveness in their sectors. Thus, 22@Urban Lab is used as a tool to bring the latest products and services closer to the city hall services. The district already has a collection of about 14 pilots in various domains such as environment, mobility and telecom. Projects in the neighbourhood began in 2001 and have run for over 10 years in the district. It involves projects aimed at creating sustainable living, working and mobility with advanced infrastructures. Some pilots include the implementation of 12 outdoor public street-lighting points, Eco Digital with LED technology that includes sensors of vibration, temperature, humidity, sound and pollution as well as GSM aerials, Wi-Fi Mesh access point and webcams for video surveillance functions. Another trial was about the implementation of charging points for electric cars and the management and analysis of the system from a centralised control point

in Barcelona City Council. This district embraces clusters of ICT, media, energy, design and biomedical with a triple helix case [2, 5]. Here, new business culture is promoted based on collaboration between companies, universities and the public sector for innovation (Fig. 3).

Infrastructures

Since the 1990s, Barcelona has been planning and investing in order to be a leading metropolitan city and to achieve that it has been building new motorways, train services and infrastructures. Defining Barcelona's future as a Smart City, the government has embarked on a massive model to build up the necessary infrastructure. However, the aim is not just evolving Barcelona from its strong industrial legacy to a productive and profitable knowledge-based economy but an improvement of the quality of life for its citizens. It would also allow better delivery of public services from transportation to education and healthcare.

To achieve the objectives of the Smart City model, the traditional infrastructures are redesigned to ease the integration of ICT at all levels. This can take place either as a minor road renewal or a whole transformation of a major district such as 22@Barcelona or Sagrera for a model of territory adaption to the new needs. This major transformation involves infrastructures such as companies, institutions, specific spaces, universities, technological centres, incubators, residences, dissemination, entrepreneurs and other services. The backbone of the Smart City involves special public property infrastructure plans. This involves Wi-Fi and optic fibre, a new mobility plan, new heating and cooling systems, new energy networks and underground galleries. For instance, the communication infrastructure optical fibre project was initiated in 1994, and today, it covers 325 km for the development of city services [5].

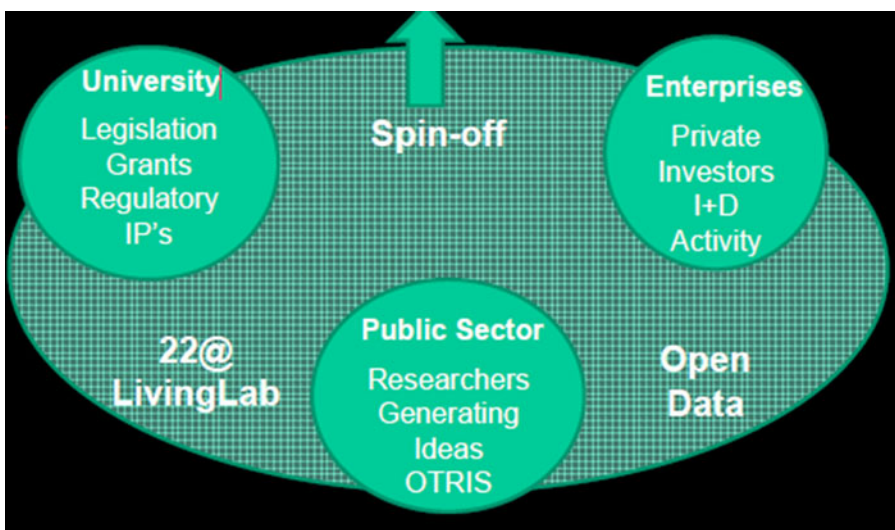


Fig. 3 Triple helix model of Barcelona [4]

New Services for the Citizen

The Smart City model of Barcelona provides various new services: a corporate fibre optical network to connect the main municipal buildings; a Wi-Fi mesh network to provide wireless connection to those municipal services and employees working at street level; sensor networks to manage a multivendor, multipurpose sensors network configured to be used by several providers; and a public Wi-Fi network.

The foremost result of the Smart City model in Barcelona, Smart Services, is grouped according to the target and producer. The first one is the internal government services. These services aim at making public workers' tasks easier and giving useful information to city managers that can help them take better management decisions and evaluate policies. These services boost the cooperation between the several strata of public workers in order to acquire efficiency and efficacy.

Secondly, there are services aimed at making the citizens' daily life easier and more comfortable, by offering more and better services, offering updated information in a proactive way and fostering citizens' participation in the city management daily life. These are grouped under government to Citizen/Business services.

Finally, services created by citizens for the citizens, including also the professional arena, boosting cooperation between the several elements of civil life are grouped under Citizen to Citizen services. These services are based on public Open Data, representing the real social innovation and the real openness of a city.

Open Data

Recently, the Barcelona City Hall became involved in the Open Data movement with the Open Data project, whose objective is the opening up of government information to public access. These data involve territory, population, management and procedure indicators, urban environment and documental data. It is society's right to use this data, whether to brief themselves or for creating new services, increasing social value and perhaps also commercial value. The underlying objectives for the Open Data initiative are as follows: (1) design and validate a network management platform and sensor data that can become a reference for other cities, (2) create a communications network of sensors that allows communication between many of the sensors developed across Catalonia, (3) identify a framework based on open standards, (4) develop a platform that is completely applicable for any city of any size and (5) explore and implement the appropriate services for public management enhancement [5].

Management of Smart City Initiative

In order to achieve the objectives of the Open Data initiative, Barcelona City Hall has to take certain actions. First, it needs to develop the platform of network management and sensor data while considering that the system should allow the integration of other types of communications at the network level sensor. Secondly, a development of a proof of concept of the platform with the deployment of the developed systems is needed that will interact with the existing sensor infrastructure as well as new ones.

Eventually, all these initiatives and projects for Smart City model aim to foster innovation and increase the efficiency of public services while providing more information access and communication channels.

Accordingly, the management of the Barcelona Smart City initiative is composed of various organisations and departments. These mainly involve the 22@Barcelona agency which was responsible for urban planning, setting up new infrastructures and refurbishing pre-existent ones. Together with the 22@Barcelona agency, Promoció Econòmica (Economic Promotion) was responsible for attracting economic capital to the region. There are two governmental departments that are also involved in the management of Barcelona Smart City model. These are the mobility department, that is responsible for the mobility plan of public and private transport, and the control and environment department that is in charge of environmental issues. Finally, Institut Municipal d'Informàtica (Municipal Institute of Information Technologies) that provides IT services to the city hall is also involved in the management process. Thus, all these organisations work and collaborate together in order to run the Smart City model successfully in Barcelona.

Main Benefits and Challenges

The Smart City model promotes both public and private sectors in various ways. Public benefits involve free cession of land in terms of facilities, green areas and subsidised housing and financing a part of the special infrastructure plan. It has enhanced public services, access to knowledge and fostered networking systems while taking notice of its citizens' demands to meet their needs. For instance, with the 22@Barcelona District, the city hall created new employment opportunities, moved universities to the area, provided social housing, urbanised green areas and provided more efficient public services. It has created more than 4,000 units of new housing with 25% at minimum rental, 55,000 jobs with over 1,500 new companies and new institutions, mainly in information and communication technologies and media industries. It has ten universities and 12 R&D centres [5].

Similarly, private organisations gained from the use of leading-edge infrastructures, higher density of collaboration and networking. For instance, through the 22@Urban Lab, new products and patents could be generated from commercial products that have been tested and validated at least in one city. This assures the viability of their solutions in a real environment while fostering innovation. Hence, the Smart City model provides a higher rate of innovation, creativity and cohesion for both parties.

Nevertheless as in any other city, Barcelona faced certain challenges such as providing exact and appropriate infrastructure, deployment and management of wireless networks, creation of triple helix, networks, clusters and collaborations. In the case of 22@Barcelona district, the research of Leon [20] highlighted five major challenges that city hall faced: (1) the skilled human capital level was not enough to satisfy the needs of industry clusters, (2) the level of local entrepreneurship was lower compared to any other country in Europe, (3) venture capital funding was not sufficient to attract firms and finance start ups, (4) the number of large firms to lead innovation was low and (5) in the business context, global connectivity of Barcelona was poorer compared to other European cities.

In this paper, we explored the key challenges faced by Barcelona in its transformation journey to become a Smart City. As Barber and Eastaway [3] also showed, we observed a top-down approach in leadership. Further, local engagement and collaboration across departments could be challenging sometimes. The planning and use of new products and services should be well integrated with the social and economic programmes of the city; otherwise, it would not provide a real test environment. Creating a cross-departmental cooperation and clear definition of roles and responsibilities is also quite challenging and this is why intermediary organisations to facilitate the collaborations were used.

The future also holds some important challenges for Barcelona due to the Spain's current economic situation. This could affect public funding and projects. The question is how to combine urban growth with sustainable development and provide effective governance actions in the case of budget restrictions. However, city hall must continue to invest and focus on Smart City initiatives for the future which are based on creativity, knowledge and innovation.

Despite the recent financial crisis, Barcelona still maintains its international position and it is successfully moving towards to becoming a leading Smart City. Among the various future plans to support this aim, Barcelona will launch a pilot programme with Cisco for being the leading place in sustainable urban development by 2020 while reducing the capital costs and providing operational savings.

Also the first congress of Smart City Expo & World Congress was planned to be held in Barcelona to bring together key speakers and representatives of the leading organisations with the most innovative ideas in the world in November 2011 [2]. Thus, Barcelona is going ahead with the Smart City concept with various future projects and collaborations.

To sum up, the Smart City Barcelona initiative generates and supports the development of innovation, urban growth and its citizens' quality of life. It has established various services as conditions, while collaborating together with universities and companies. Initiated for various motives, Barcelona City Hall effectively transformed the city to become a Smart City despite the challenges that they faced. Thus, this analysis can provide guidance to practitioners and policymakers of other cities that intend to be Smart while providing a contemporary vision of the Barcelona Smart City model.

Conclusions

The analysis we have undertaken indicates that Barcelona and other cities need to proactively engage and collaborate with public and private organisations as well as with knowledge institutions. Cities should base their Smart City models on three main pillars—infrastructure, human capital and information—while the Smart City initiative should be a composition of various organisations and departments. If we look more broadly at the progress of the Smart City initiative, it has not been too hard for Barcelona to transform itself into a leading Smart City despite all the obstacles that it has faced, such as the management of the initiative, providing necessary infrastructures and creation of collaborative networks. Further, both public and private sectors benefited from this initiative in terms of enhanced public services,

innovation, business developments and a more collaborative system. More importantly, we explored the Barcelona Smart City model and the main components of the Smart City strategy such as Smart districts, living labs, initiatives, e-Services, infrastructures and Open Data.

The Smart City concept in Barcelona is used as a strategic tool to encompass modern urban production factors in a common framework and foster competitiveness of the city. As the main outputs of the Smart City model, Smart Services have been successfully implemented to boost cooperation, innovation and development. Barcelona initiated the Smart City model in the expectation that it would result in effective urban management, a requirement of any growing city. To sustain an effective urban management system, intelligent network technologies are required to drive economic growth, to support a sustainable green city and to provide a better quality of public services. The flourishing outcomes of this transformation into a Smart City in Barcelona can be clearly observed, such as in the 22@ district or successful implementations of other projects. Based on this research, it is observed that the overall transformation of Barcelona into a Smart City is progressing successfully and it is already widely recognised as a leading city in Smart City initiatives all over Europe.

References

1. Ajuntament de Barcelona: 22@Barcelona, the innovation district (2010) May, Ajuntament de Barcelona
2. Ajuntament de Barcelona: The City of Barcelona, Barcelona (2011) Ajuntament de Barcelona
3. Barber A, Eastaway MP (2010) Leadership challenges in the inner city: planning for sustainable regeneration in Birmingham and Barcelona. *Policy Stud* 31(4):393
4. Batlle J (2010) Barcelona Smart City: paving the way, Ajuntament de Barcelona
5. Batlle J, Majó A, Ventura JL, Vila M, Ponti I (2011). Interviews, Barcelona City Council
6. Caragliu A, Bo C, Nijkamp P (2009) Smart cities in Europe. Research memorandum, 48
7. Cushman and Wakefield (2009) European city monitor
8. Davis K (2010) The rise of the smart city. POWERGRID International. <http://www.renewableenergyworld.com/rea/blog/post/2010/01/the-rise-of-the-smart-city>. Accessed 10 May 2011
9. Domènech L, Saurí DA (2011) Comparative appraisal of the use of rainwater harvesting in single and multi-family buildings of the metropolitan area of Barcelona (Spain): social experience, drinking water savings and economic costs. *J Clean Prod* 19(6–7):598–608
10. Ferrer A, Pic R, Nello O (1997) Els 20 anys del Pla General Metropolita de Barcelona, Papers 28, Regio Metropolitana de Barcelona
11. Garcia B (2004) Urban regeneration, arts programming and major events: Glasgow 1990, Sydney 2000 and Barcelona 2004. *Int J Cult Policy* 10(1):103–118
12. Garcia-López MÀ, Muñiz I (2010) Employment decentralisation: polycentricity or scatteration? The case of Barcelona. *Urban Studies* 47(14):3035–3056
13. Garcia J, Raya JM (2011) Price and income elasticities of demand for housing characteristics in the city of Barcelona. *Reg Stud* 45(5):597–608
14. Giffinger R, Fertner C, Kramar H, Kalasek R, Pichler-Milanovic N, Meijers E (2007) Smart cities: ranking of European medium-sized cities. Vienna: Centre of Regional Science. http://www.smart-cities.eu/download/smart_cities_final_report.pdf. Accessed 20 May 2011
15. González S (2011) Bilbao and Barcelona ‘in motion’. How urban regeneration ‘models’ travel and mutate in the global flows of policy tourism. *Urban Stud* 48(7):1397–1418
16. Graham S, Marvin S (2001) Splintering urbanism: networked infrastructures, technological mobilities and the urban condition. Routledge, London
17. Hall RE (2000) The vision of a smart city. (Brookhaven National Laboratory, USA), 2nd International Life Extension Technology Workshop, Paris, 28 September
18. Hollands RG (2008) Will the real smart city please stand up? *City* 12(3):303–320

19. Hospers GJ (2003) Creative cities in Europe: urban competitiveness in the knowledge economy. *Intereconomics* 38(5):260–269
20. Leon N (2008) Attract and connect: the 22@Barcelona innovation district and the internationalization of Barcelona business. *Innovation: Manag Policy Pract* 10:235–246
21. Majoor STJ (2009) The disconnected innovation of new urbanity in Zuidas Amsterdam, Ørestad Copenhagen and Forum Barcelona. *Eur Plan Stud* 17(9)
22. Marshall T (2000) Urban planning and governance: is there a Barcelona model? *Int Plan Stud* 5(3):299
23. Marshall T (2004) Transforming Barcelona: the renewal of a European metropolis. Routledge, London, p 288
24. Mascaro J (2002) Two low income social housings: a comparative study of the environmental behaviour. *Manag Environ Qual* 13(4):357–365
25. Mazzoleni C (2010) Space of the city in reconstruction: the lawscapes of Barcelona and Berlin. *Int J Law Context, Suppl Law, Mov, Space* 6(3):199–242
26. McCrone D (2000) Urban change and the European left: tales from the new Barcelona. *Urban Stud* 37(8):1461
27. O'Connell L (2008) Exploring the social roots of smart growth policy adoption. *Soc Sci Q* 89(5):1356–1372
28. Stern BB (1998) Representing consumers: voices, views and visions. Routledge, New York
29. UN (2008) World urbanization prospects: the 2007 revision population database
30. Villalba G, Gemechu ED (2011) Estimating GHG emissions of marine ports—the case of Barcelona. *Energy Policy* 39(3):1363–1368
31. Yin RK (2003) Case study research: design and methods, 3rd edn. Sage, London