Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Computer Science 16 (2013) 668 – 677

Procedia Computer Science

Conference on Systems Engineering Research (CSER'13)
Eds.: C.J.J. Paredis, C. Bishop, D. Bodner, Georgia Institute of Technology, Atlanta, GA, March 19-22, 2013.

# Living Labs, Innovation Districts and Information Marketplaces: A Systems Approach for Smart Cities

Ellie Cosgrave[ab]*, Kate Arbuthnot[b], Theo Tryfonas[b]

[a]*Arup, 13 Fitzroy Street, London W1T 4BQ, United Kingdom*
[b]*University of Bristol, Senate House, Tyndall Avenue, Bristol, BS8 1TH, United Kingdom*

**Abstract**

In the past few years many groundbreaking promises have been made about the potential of the Smart City. The future of cities relies perceivably on ubiquitous sensing, and anytime-anywhere information access and control. However, city leaders are still struggling to identify the quantifiable sources of value that novel ICT can generate. Current Smart City investment is characterized by relatively small demonstrators that often lack the scalability to have real and long lasting impacts on the economy. In this paper we adopt the view of a Smart City as an information marketplace and look at how we might use existing and tested concepts of fostering technology innovation to support city leaders in navigating this unknown territory. In particular we use systems thinking to scope how the concepts of the 'Living Lab' and the 'Innovation District' can work together in a complementary fashion to create a candidate model for the implementation of the Smart City.



Keywords: Smart City; Innovation District; Living Lab; Value Chain.

## 1. Introduction

In the past few years we have been inundated by the promise of the Smart City. The future of cities relies perceivably on ubiquitous sensing, and anytime anywhere access and control. These ideas have 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. Large technology companies have driven this debate and have forced city leaders and academics alike to explore what the implications might be for the future of our economy, welfare and quality of life in our cities.

* Corresponding author. Tel.: +44 20 7755 6534; fax: +4420 7755 2211.
*E-mail address*: ellie.cosgrave@arup.com


doi:10.1016/j.procs.2013.01.070

However, city leaders are still struggling to identify the quantifiable sources of value that novel ICT can generate. Governments are struggling to realize the opportunities offered by ubiquitous information, 'smart' technologies, social media, and anytime, anywhere access. They are finding it difficult to transform the higher-level concepts found in the Smart City literature into actionable and effective policies, projects and programs that deliver measureable value to citizens [1].

There are many reasons why effective 'Smart City' implementation models are yet to be realized. These include:

- Concepts are still in their infancy, and the discussion has previously focused on the technology rather than the conceptual grounding or implementation methods.
- The complex nature of the city itself, which is "an enormously complex and open-ended system, with many intertwining force fields influencing its form simultaneously" [2].
- There are multiple unknowns when dealing with the future.
- Funding mechanisms have restricted investment capability.
- The long term implications are still unknown.

Leading Smart City consultancies have been attempting to characterize the problem. Arup define a Smart City as a city in "which the seams and structures of the various urban systems are made clear, simple, responsive and even malleable via contemporary technology and design. Citizens are not only engaged and informed in the relationship between their activities, their neighborhoods, and the wider urban ecosystems, but are actively encouraged to see the city itself as something they can collectively tune, such that it is efficient, interactive, engaging, adaptive and flexible […]."[3]

Working within this complex domain, city leaders still have a responsibility to take action. In this paper we look at how we may use the existing and tested concepts of the 'Living Lab' and the 'Innovation District' to support city leaders in navigating this unknown territory. We use systems theory to delineate how these two complimentary concepts can work together to create a model for the development of the Smart City, hoping to shed some light on the new, unchartered and unknown features of the Smart City, and highlight what the stakeholder implications for implementation might be.

## 2. Smart Cities as Information Marketplaces

The concept of the 'Smart City' has gained traction in recent years and although it has been coined for a variety of purposes, it broadly refers to a city that is using new ICTs innovatively and strategically to achieve its aims. Smart City investment might include, for example, implementing a network of sensors in the city. The highly instrumented city, it is claimed, will better manage and control city systems by collating ever-detailed information about real time functioning, and be able to optimize decision making in the immediate, short and long term. But many believe that there is more to the story.

The Smart City should not necessarily be interpreted as top-down vision delivered solely through government investment. Quite the opposite, the 'Smart City' is largely an organic 'system of systems' [4], which comprises an ecosystem of products, services, companies, people and society that are working together creatively to foster innovation within the city. As Haque describes, "Smart cities cannot be defined by one application, or central organizing body, that sets pre-programmed limits. They will be defined by individual citizens, who are anxious to collaborate with each other… to create devices and applications that solve specific problems. Smart cities will be places that foster creativity, where citizens are generators of ideas, services and solutions, rather than passive recipients of them" [5]. In that sense, city leaders need to nurture and harness bottom-up development as well as directing investment towards achieving their strategic priorities.

Models for the development of the Smart City, and the information marketplace are in their infancy and city leadership is only just beginning to get to grips with this problem. Action has been spurred through national and international investments such as the Technology Strategy Board's (TSB) 'future cities demonstrator' project and 'Catapult' in the UK, and various Framework Programmed 7 EU-funded research projects. These are still in their early stages and are often small-scale, thus longer term impact has not been identified.

Nevertheless, data from 'smart' investments are already transforming our economy, the way that products and services are delivered and the everyday experience of citizens. A good example of this is in San Francisco (SF Park), where citizens' wait for a parking space has been minimized thanks to the smart sensors feeding timely information to the users [6]. It is claimed that the networked information environment has dramatically transformed the economic marketplace, creating opportunities for new business models, and affecting how we produce and consume information [7]. This new marketplace has been dubbed the 'information marketplace' by Mulligan et al. [8].

In the report 'Information Marketplaces: The New Economics of Cities' they claim that cities wishing to understand how to obtain full value from their ICT investments need to address Smart City technology from a total value chain perspective. This is to say that 'information products' (such as apps, city dashboards or optimization algorithms for city services) are actually formed at the end of a chain of definable inputs, such as devices and sensors, raw data etc. If we can understand and articulate this value chain, city leaders can begin to manage it to support positive economic and social development. Figure 1 shows the value chain derived in the report, which links data input devices to 'information products'.

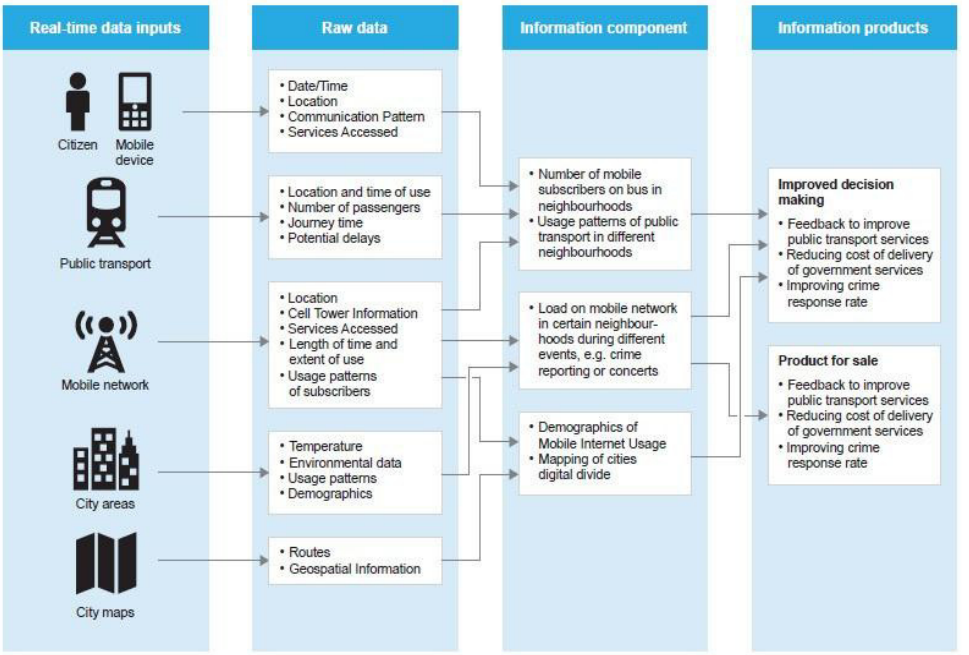


Fig. 1. Information Marketplaces Value Chains

This value chain depicts data as the new raw material, and shows that the market develops that data into information, and then to information products and services. But understanding this value chain and moving away from treating 'Smart City' investments as stand-alone ICT projects is only the first step. City leaders now need to understand what types of investment will nurture this value chain to deliver on their policy goals. In

this paper we use this total value chain approach as a starting point to understand the information marketplace, and explore how city leadership might begin to invest appropriately to get value from the 'Smart City'.

## 3. Means of Facilitating Technology Innovation in Urban Environments

### *3.1. Living Labs*

The premise of the Living Lab is that the city can be used as a real-world testing ground for new ideas and technologies. A vast array of sensors in the urban realm can facilitate the testing of products and services on a real world platform, Schumacher and Feurstein [9] define it as a research methodology for sensing, validating and refining complex solutions in multiple and evolving real life contexts.

Over the years, the concept of the Living Lab has evolved from observing the living patterns of users in a smart/future home to larger scale projects that enhance innovation, inclusion, usefulness and usability of ICT and its applications in society [10, p. 5]. Living Labs are now seen as places that can drive innovations. Vinnova [11] claims for example, that it is a structure and a long-term societal resource rather than related to a certain project. Within this structural framework, experiences, routines and conditions are built to develop ideas into innovations.

#### *3.1.1. Technical Infrastructure*

The Living Lab uses a variety of technology from real time feedback sensors to the latest networks (wireless or alternative). These are a crucial component of the testing; the Living Lab concept has its foundation in the experimentation with technology together with users. Having access to state-of-the-art technology in network access, service platforms, terminal and user interfaces, etc. is therefore key, to be able to optimize the results generated [12].

To set up a Living Lab typical instruments required include; Sensors to gather the data and data transmitter devices, wireless networks and the software to manage the data. The transmitter devices can be larger devices that send information directly to the central data store, or more commonly used (e.g. in Smart Santander, a European research initiative) many smaller devices with shorter transmission ranges that transmit data to each other (M2M) and then eventually onto a central data store.

Wireless networks are used to transmit the data (Santander uses Digimesh, 802.15.4 [13]). Software controls the sensors; this is a principal element to the whole system. A good example of a platform currently under development is the Living Plan IT Urban Operating System [14] (UOS). The UOS is a platform to combine different software (Greenwich Peninsula boasts software from McLaren, Cisco and Living Plan IT) to control the multiple functions in a building/ Living Lab environment. This is particularly novel as it is all integrated onto a single platform.

#### *3.1.2. Living Lab Operation and Ownership*

Typically Living Lab projects are led by local governments or private firms with the aim of driving innovation or new product development. As part of this, they often have pre-defined project boundaries, outcomes, stakeholders and targets. Usually Living Labs are heavily subsidized by government or international grants, and supported theoretically by academics and companies with specific interests. Stakeholder interests and contributions vary throughout the value chain.

Living Labs may be influenced by university research and government initiatives, and other foreign investment can also direct the types of experiments coordinated. Companies also have an interest although are often not equipped with the funds to support the project. In Smart Santander, companies were offered a competitive grant to try out their middleware platforms on the Living Lab [15].

The main launch phases of a typical lab are; funding is sourced, aims are developed, and technical equipment is sourced, implemented into infrastructure and tested.

*3.1.3. Stakeholder Roles for Successful Living Labs*

Living Labs become an innovation area where users co-create with developers and researchers. Various sources postulate that they are the first attempt to structure and provide governance to user involvement in a way that can be addressed by companies, research institutions, public organizations and policy makers (as in e.g. [16]). Particular roles for these groups include:

*Universities*
- Initial research of the technical infrastructure/ implementation of the Living Lab (e.g. types of sensors, types of software and networks to be employed)
- Collaboration with government regarding funding
- Development of services/ products to be tested on the Living Lab

*Private Sector*
- Collaboration with government regarding funding of projects
- Commercialization of product/ service
- Collaboration with Universities and Government regarding research required

*Public Sector*
- Initial funding to establish Living Lab infrastructure
- On-going funding to stimulate innovation and testing on the Living Lab (e.g. Smart Santander 'open calls' previously mentioned).

*3.2. Innovation Districts*

Innovation Districts are small pockets of growth in a town of city, which can be stimulated by a variety of factors. The districts often form organically (East London Tech cluster is a good example of this) and are usually made up of mostly start-up companies, creative industries and inter firm collaborations, these firms "tend to cluster in large, skilled, economically diverse, well-connected urban environments" [17]. Innovation Districts are thought to stimulate stable growth, and as such, cities have been known to try to stimulate the development of Innovation Districts. They have achieved this through the implementation of policies such as tax incentives, or providing services such as communications infrastructure, housing or transportation. A good example of this bottom up approach is Skolkovo in Russia.

In particular Innovation Districts companies form in geographical proximate locations due to cheap rent, similar start-ups in the area, good place to live and good transport networks. Clark and Feldman confirm "it has become foundational in economic geography that firms co-locate in order to share common infrastructure and labor markets, to take advantage of locally-embedded technologies, production processes, and institutions, and to reduce transportation and transaction costs" [18]. Also to note is that this is not a new concept, companies have been thought to cluster as described by Porter in [19], when a geographically proximate group of companies and associated institutions in a particular field, linked by commonalities and complementarities.

*3.2.1. Stakeholder Roles*

Innovation Districts have a number of different stakeholders including;
- Government
- University / research institutes
- Industry and research Labs
- Startups / SMEs
- Landlords and developers within the district

Also to note is the importance of the impact of the triple helix on Innovation Districts. The triple helix is the link between the universities, government and industry, and the innovation that is stimulated from this relationship. The triple helix has been claimed to develop a fluid exchange of ideas and technologies, with fewer barriers between academia and industry for information flow [20].

*Government*

Innovation Districts are often supported and stimulated by government policy. RAO [20] claims that the best practices in Europe are those with government input. Public authorities have a vested interest to try and encourage the innovation to lead to stable growth and higher employment. The government incentives take on a variety of forms from financing specific projects (such as the post WW2 projects that helped stimulate Silicon Valley) to more general approaches such as tax and buildings relief or facilitating networking between firms in an Innovation District.

*Universities*

Increasingly universities have been collaborating with industry experts and producing entrepreneurial graduates; "A survey of MIT alumni in 2003 revealed, that 33,600 companies were founded by MIT graduates employing 3.3 million people and generating $2 trillion revenues annually." [21] This is becoming a key factor for innovation development and for future growth. The National Innovation Council enumerates four primary areas of focus for
University led innovation clusters (UInC): Incubation or promoting entrepreneurship, Collaborations, Research and Development, Continuous evolution of curriculum and teaching-learning methods [22].

*Private Sector*

Firms striving for innovation today have some power to control the type of innovation, method in which it is cultivated and the impact it has on the market. Sternberg et al. (2000) states that the core stimulants for innovation are; industry position of the company, investment in R&D, staff competencies, organizational culture, financial resources, innovation networks.

Also to note is the impact of quality of employees. Innovation Districts are reliant on highly skilled employees, often educated in universities. As suggested by Hart [23], the employees in these firms are not simply highly skilled, a substantial portion are highly educated scientifically and technologically. He interprets this observation as that the private sector innovation is heavily dependent on the output of universities.

## 4. A Candidate Implementation Model for Smart Cities

We note from the previous discussion that the ideas behind the Living Labs and the Innovation Districts are complementary. They both advocate the importance of research, and have innovation at their core. For each, key stakeholders are the triple helix players (Universities, Private Sector and Government) who work together to ensure success. Table 1 highlights the relationship between the two concepts.

| Living Lab | Innovation District |
|---|---|
| Predefined institutions and aims | Emergent institutions and aims |
| Product development focus | Market creation focus |
| Creates and uses data to drive innovation | Develops and uses |
| information to drive innovation Research and development and innovation key Research and development and innovation key | |
| Relies on infrastructure networks | Relies on market networks |

Table 1 Living Lab and Innovation District Comparison

Clearly both of these concepts, if properly implemented, could support cities in becoming 'Smart', but their purpose, focus and boundaries are distinct. While Living Lab are often pre-planned, structured, with clear aims and focused on product development, Innovation Districts are much more emergent and focused on market development. Far from making the two ideas mismatched, these distinctions are actually what make them so compatible, especially as we refer back to the total value chain described in figure 1.

Living Lab and Innovation Districts each play important roles in supporting the information value chain. On the left hand side of it, Living Lab infrastructure has a key role to play in feeding in vast amounts of data as inputs into this new value chain. It also supports the development of that data into useful information through its links to industry and research and development.

As we move along the value chain, the contribution of the Living Lab begins to recede and the role of Innovation Districts comes more into play. Whilst Living Labs are more product-focused, Innovation Districts are focused on market creation. Innovation Districts therefore have a clear role in transforming products that come out of the Living Lab into marketable, appropriate and useful assets for citizens. It also ensures that the firms involved can adopt sustainable business models.

Together then, Living Labs and Innovation Districts can support the whole information value chain (Fig. 2). Living Labs provide raw data and information components, and Innovation Districts ensure that new products and services devised, and the companies that create them, thrive. This not only ensures that citizens get the best, new, innovative products and services, but that the new Smart City economy is sustainable.

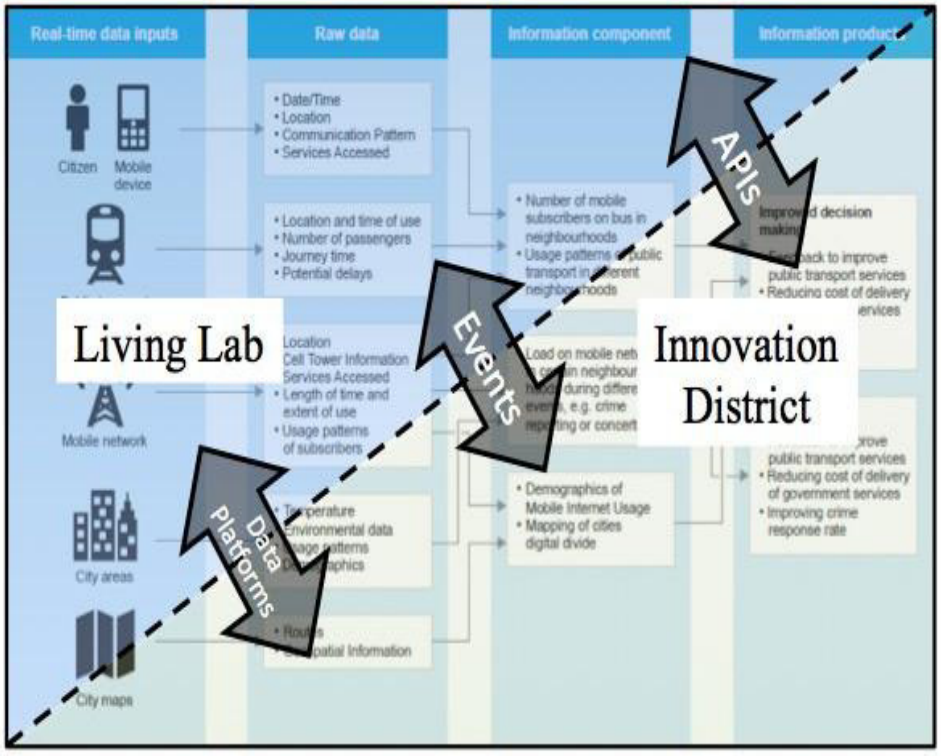


Fig. 2. Living Labs and Innovation Districts used to identify the scope of implementation for Smart Cities value chains.

It is not enough however, to focus on developing Living Labs and Innovation Districts as separate entities, as they are interconnected and reliant on one another for success.

City stakeholders therefore need to investigate mechanisms that support the translation of value between the two entities. The core assets that need to be free to migrate between the Living Lab and the Innovation District include:

- Knowledge (i.e. from research in the Living Lab or industry knowledge in the Innovation District)
- Data
- Ideas/ trends
- Expertise

Therefore, on top of developing Living Labs and Innovation Districts, city leaders need to develop opportunities for this flow to happen. This might include the creation of open APIs, open data platforms, city dashboards, hackathons, networking events, competitions etc. to support successful and sustainable implementation, and creation of an innovation ecosystem that creates value for citizens.

Bristol City Council has already attempted to achieve this in recent years. They have focused on developing an enterprise zone by investing in state of the art infrastructure, creating events such as the iShed, and areas for SME collaboration like the Watershed. They have invested in a Living Lab in a socially deprived area of the city, and have made plans to expand upon this and connect them together in their bid for the TSB Future Cities Demonstrator Competition [24].

As Niitamo et al. [25] claim, the ability to include a large variety of companies and organizations, in many segments of the society, is crucial in order to reach the necessary impact. The Helsinki Virtual Village in Arabianranta has a strong setup involving the full participation and also including actual service delivery within a part of Helsinki. Testbed Botnia and Crossroads Copenhagen have established co-operation networks in certain application areas. In this way, a network of companies supports the sustainability of the information marketplace.

The above model synthesizes product-driven innovation that is based on live data, with market-led innovation that is based on information. Although as a bottom up and top down model correspondingly they at first seem distinct and potentially incompatible, the view of a Smart City as an information marketplace provides the canvas for their integration. Using the existing concepts of the Living Lab and Innovation District in this way, much of the uncertainties introduced by the, otherwise fuzzy, ideas of smart cities could be hopefully mitigated.

## 5. Conclusions and Further Work

Exciting developments in the field of information and communication technologies provide a glimpse of the future of urban life and call for engagement of city leadership with a prospective better, more sustainable future. But the promise of smart technology could remain in the sphere of wishful thinking if engineers fail to convince city leaders of its value. To be effective and deliver on these promises, technology innovation must be delivered in ways that create positive impact in the urban environment and provide convincing evidence of the value of its application.

In this paper we argue that a view of the Smart City as an emerging information marketplace documented elsewhere, can provide the bond to integrate effectively tested innovation models that literature suggests that city leaders understand better and may be willing to engage with. We combine the bottom up concept of the Living Lab and the top down idea of the Innovation District to provide the implementation framework of a Smart City as an information value chain. Such a model is able to capture richly all aspects of the grand vision of meaningfully linking the small enterprise that captures energy usage live data with a city council's ambitions for meeting CO2 emission targets – i.e. linking developments at different levels in the currently fuzzy and ever-developing area of smart cities, under a common purpose. As the information linkages between the interested

stakeholders become explicit, we are able to shape pathways both from the prescribed and specific (live data on movement, energy use etc.) towards the more descriptive and generic (policy supported by information, intention to meet targets etc.).

In the near future, we intend to deploy our approach as an implementation model across a small number of UK cities that have engaged with the future cities catapult demonstrator program. This will provide us with a credible dataset that will enable us to refine our idea at subsequent levels. By adopting a case study research approach we will evaluate the effectiveness of the information marketplace view as an implementation model, based on Living Labs and Innovation Districts.

## Acknowledgements

This work has been supported by the Industrial Doctorate Centre in Systems (EPSRC Grant EP/G037353/1) and Arup.

## References

1. Cosgrave, E. and Tryfonas, T. Exploring the Relationship Between Smart City Policy and Implementation, *Smart Systems, Devices and Technologies (SMART 2012)*, pp. 79-82. Stuttgart, Germany, 27 May - 1 Jun 2012.
2. Sevtsuk, A. Beinart, J. The effects of ICT on City Form. MIT School of Architecture and Planning, Cambridge, 2005.
3. ARUP, "Smart Cities: Transforming the 21st century city via the creative use of technology"
4. Harrison, C. Abbott Donnelly, I. A Theory of Smart Cities, Proceedings of the 55th Annual Meeting of the ISSS, Held at University of Hull Business School, UK, July 17-22, 2011
5. Haque, U. Surely there's a smarter approach to smart cities? April 2012. Available at <http://blog.pachube.com/2012/04/surely-theres- smarter-approach-to-smart.html>
6. SFMTA, SF Park implementation and Lessons Learnt, 2011
7. Kazman, R. and Chen, H. The metropolis model: a new logic for development of corwdsourced systems, Communications of The ACM, 2009.
8. The Climate Group, Arup, Accenture et al. Information Marketplaces, The New Economics of Cities, 2011
9. Jens Schumacher, Karin Feurstein, Living Labs – the user as co-creator, 2007
10. Bergvall-kåreborn, B., & Box, P. O. (n.d.). A Milieu for Innovation – Defining Living Labs Carina Ihlström Eriksson Anna Ståhlbröst Jesper Svensson, 2009
11. Vinnova 2009
12. Niitamo, V., Kulkki, S., Eriksson, M., & Hribernik, K. A. (n.d.). State-of-the-Art and Good Practice in the Field of Living Labs.
13. Details of Smart Santander can be found at http://www.smartsantander.eu/index.php/testbeds/item/132-santander-summary
14. Details of the Urban Operating System can be found at <http://living-planit.com/UOS_overview.htm>
15. SmartSantander-2-Open-Call, 2012 can be found at <http://www.smartsantander.eu/index.php/open-calls/second-open-call>
16. The Electronic Journal for Virtual Organizations and Networks
17. Nathan, Vandorem Whitehead, A Tale of Tech city; The future of inner East London's digital economy, 2012
18. Clark, G. L., M. P. Feldman, et al. The Oxford handbook of economic geography. Oxford; New York, Oxford University Press, 2000
19. Porter, "Location, Competition, and Economic Development: Local Clusters in a Global Economy," *Economic Development Quarterly* 14(1): 15-34, 2004
20. Etzkowitz, H. The Triple Helix of University - Industry – Government Implications for Policy and Evaluation. Science Policy Institute Working Paper, 2002-2011. Available from: http://www.sister.nu/pdf/wp_11.pdf
21. Rao, A,S. White spaces in building innovation clusters. Working paper for discussion in the conference Goa, India, November 18-20, 2011
22. Rao, A,S. White spaces in building innovation clusters. Working paper for discussion in the conference Goa, India, November 18-20, 2011
23. Hart, D, A. Innovation clusters: key concepts. 2000
24. Connect Bristol Feasibility Study available at <https://connect.innovateuk.org/c/document_library/get_file?uuid=e8c43604-1cdc- 4ed3-b1be-0aad2740a835&groupId=6764506>
25. Niitamo, V., Kulkki, S., Eriksson, M., & Hribernik, K. A. (n.d.). State-of-the-Art and Good Practice in the Field of Living Labs.