Intelligent cities: towards interactive and global innovation environments

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Abstract: Intelligent cities (communities, clusters, districts, multi-cluster territories) outline a new planning paradigm pertinent for urban-regional development and innovation management. This paper attributes the rise of intelligent cities in the globalisation of innovation networks, which appears in multiple forms in global technology markets, innovation and R&D offshoring, global technology transfer, new product co-development and the subsequent needs for online environments of global collaboration. By developing sector-focused, cluster-based or more complex intelligent city strategies, territories can set in motion innovation mechanisms of global dimensions and enhance substantially their innovation systems. Within these environments, new knowledge functions and business models appear relying on collective intelligence, technology transfer and collaborative innovation outspread globally. However, in developing augmented innovation environments, organisational issues of innovation management prevail over the technological ones of virtual communication. ICT is just the facilitator for creating this new type of innovation environment, which requires the balanced development of human creative skills, innovation institutions, broadband networks and virtual collaborative spaces to succeed.

Keywords: intelligent cities; innovation networks; global innovation environment; strategic intelligence; collaborative innovation; regional innovation.

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1 Introduction

Intelligent cities constitute a new planning paradigm pertinent for both the fields of urban-regional development and innovation management. In the field of urban-regional development, intelligent cities sustain the rise of the knowledge-based local and regional economies. In the field of innovation management, they sustain the globalisation of innovation networks and the consequent opening up of innovation systems on a global scale. Bridging local resources, innovation institutions and broadband networks, intelligent cities can address the challenges of global competition faced by cities and regions for knowledge and innovation.

The literature on intelligent cities reflects the gradual shaping of this planning paradigm and the way its technological base (telecoms and virtuality) was enriched with various forms of networking and social intelligence and an innovative functionality allowing the space produced to be characterised as intelligent.

Mitchell (2007) argues that the new intelligence of cities resides in the increasingly effective combination of digital telecommunication networks, ubiquitously embedded intelligence, sensors and tags, and knowledge management software. This technological construction did not appear all at once, but came through continuous evolution starting with the development of the theory of digital interaction, the invention of packet switching, the Arpanet, Ethernet, the internet and the World Wide Web, the rapid expansion of wired and wireless communications, the appearance of laptop computers and other end-user communication devices, mobile phones, blackberries and ipods, tiny embedded microprocessors, digital sensors and tags, minuscule digital cameras and microphones, RFID tags, GPS and other positioning devices. The fact that digital intelligence is now ubiquitously present throughout urban environments makes the old metaphors of cyberspace and virtual worlds quite outmoded. Then, large-scale software appeared, like Google which ties all these pieces together and social media (MySpace and YouTube) that enable and sustain social and cultural connections through the operation of software. This narration of evolution towards intelligent cities incorporates and updates older arguments about telecoms in the city, cybercities and digital cities (Graham, 2003; Graham and Marvin, 1996; Horan, 2000; Ishida and Isbister, 2000; Besselaar and Koizumi, 2005) taking into account the recent contributions from the field of intelligent environments, social media and ambient intelligence. However, the intelligence of this world of devices and 'internet of things' is limited by the artificial intelligence available, neglecting that the strengths and wealth of cities have always been in two other forms of intelligence, human and collective, stemming from the skills of the population and the social institutions of cooperation.

In contrast to the previous understanding is the work of social scientists which places intelligent cities in the context of knowledge, creativity and intellectual capital. Florida wrote extensively about creative cities in USA and Europe (Florida, 2002, 2005). The propensity of cities to generate prosperity, he argues, depends on their creative class, knowledge workers, scientists, artists, engineers, lawyers, entrepreneurs and innovators. They produce new ideas, new products, strategies and theories. People and cooperation are the main assets of cities. 'Companies cluster in order to draw from concentrations of talented people who power innovation and economic growth'. However, talent and education that allow knowledge to be transformed into innovation need an appropriate environment of tolerance and experimentation to flourish. Talent, technology and tolerance connected together shape creative environments. 'Cities need a people climate

even more than they need a business climate'. Social capital for cooperation, open societies and free social networks enable cities to address their problems more intelligently. The same importance is attached to people and cooperation by theories on intellectual capital for communities and cities (Edvinsson and Malone, 1997; Bounfour and Edvinsson, 2005; Edvinsson, 2006). Intellectual capital is the set of intangible assets of an organisation, the collective experience and knowledge distributed among in-house employees and external experts, suppliers and customers' confidence. What makes cities more intelligent is the intellectual capital of its organisations; the system of territorial knowledge and creativity is also structured by the same capital.

Within this literature, we also witness the permanent concern to build a bridge between the technological base of intelligent cities and social objectives; innovation objectives in particular. The oldest reference to the concept (Batty, 1990) makes a clear connection between intelligent cities and competitive advantage. Collective intelligence (Lévy, 1997), distributed intelligence and problem solving (Kuhlmann et al., 1999) and regional intelligence (Komninos, 2004) investigate how information technologies and virtual environments organised within communities channel individual practice into social projects addressing the complexity and challenges of modern world (Nouvel, 2004). Bridging innovation and broadband, intelligent cities create multi-level systems of innovation where the knowledge functions of innovation are deployed in physical, institutional and digital spaces. What intelligent cities offer are skills, institutions and virtual spaces of cooperation sustaining the creation of new knowledge (research), monitoring knowledge flows (intelligence), disseminating existing knowledge (technology transfer), applying knowledge (innovation), developing new activities based on knowledge (incubation) and managing knowledge remotely (e-government) (Komninos, 2002, 2008).

In different ways, the link between intelligent cities and innovation is a milestone throughout this literature, though there are diverging views about the type of intelligence (human, organisational, artificial) that drives innovative behaviour. This paper investigates how this relationship is entering a new stage because of the globalisation of innovation and the subsequent need for global innovation environments. An unsophisticated equivalence of intelligent cities and broadband networks has led many cities around the world to invest heavily in communication infrastructure (cable and wireless) assuming that broadband is a sufficient window to globalisation and competitiveness. However, broadband is not enough; intelligent cities are equally about knowledge exchange, human skills and innovation support institutions. Instead of putting ICT first, we argue that intelligent city planning should aim at putting in place new augmented (physico-virtual) innovation environments and mechanisms that manage knowledge networks and resources scattered all over the world.

The first section of the paper discusses trends and causes of the globalisation of innovation. It is a common knowledge now that innovation relies on systemic environments which help transform inputs (funds, ideas, technologies, skills) into marketable innovation outputs (patents, exports, new products, jobs, new companies, profits, etc.). The literature of innovation over the last 25 years, from Nelson and Winters' (1982) evolutionary metaphor has mainly been about the different environments that mediate between innovation inputs and outputs. Various types of innovation environments have been identified and analysed: technological regimes, systems of innovation, technology districts, innovative clusters and innovation poles, etc. Today, the globalisation of innovation networks is changing the existing innovation environments

(clusters, ecosystems of innovation, supply architectures), forging new forms, such as global innovation clusters and i-hubs, intelligent agglomerations, intelligent technology districts and intelligent clusters, living labs (LLs) experimenting with new products and services and others.

Section 2 examines some fundamental profiles of intelligent city strategies applied at the level of different city sectors, at the level of different city districts and at the level of the entire agglomeration with the aim of sustaining global innovation networking. Illustrations of corresponding initiatives are given from the Intelligent Community Forum (ICF) awards, European LLs and some well-known strategies with a clear sectoral focus. Besides this diversity, intelligent cities set in motion a common innovation mechanism sustaining and profiting from the global deployment of innovation networks.

Section 3 refers to the augmented innovation environments created within intelligent cities which relies on a series of advanced knowledge functions, such as: strategic intelligence, technology acquisition, collaborative product development and marketplaces promotion. The new innovation system that emerges from the combination of human creativities, innovation institutions and virtual cooperation has the capacity to integrate knowledge and resources distributed on a global scale (thanks to digital communication) or distributed among the population (thanks to Web 2.0 participatory media). The paper concludes by considering intelligent cities as the next step of regional innovation strategies (RIS), widely applied in the EU over the last ten years, which might lead to the creation of more interactive, efficient and globally open regional systems of innovation, so much needed in EU regions.

2 Globalisation and changing systems of innovation

The globalisation of innovation networks is a new contemporary trend deeply influencing local innovation clusters and regional systems of innovation. The 'intensification of worldwide social relations which link distant localities in such a way that local happenings are shaped by events occurring many miles away and vice versa', that characterises globalisation [Giddens, (1990), p.64] has now extended to an even larger part of activities including R&D and innovation, which have acquired the capacity to coordinate their networks and transactions in real time on a planetary scale [Castells, (2001), p.52]. Decentralising business units and operations to every corner of the world has become a routine practice, but now, companies are also redistributing their product innovation even basic and applied research across global R&D networks (Economist Intelligent Unit, 2004; United Nations, 2005).

The trend is relevant for both large and small innovative companies. Large global corporations are setting up massive innovation facilities and cooperation networks in developing countries of Asia. However, for smaller companies also, innovation offshoring is becoming important. VC funds in Silicon Valley, for instance, require start-ups to plan offshore outsourcing as a precondition for funding, imposing a business model which keeps strategic management functions on site (customer relations, marketing, finance and business development) while moving product development and research work to offshore locations (Ernst, 2006).

Cisco already has R&D facilities in Bangalore, Toyota in Thailand, Nokia operates nine satellite design studios located within targeted nations like India (Bangalore), China (Beijing) and Brazil, where researchers and designers work to customise products to each

market (Business Week, 2007). The *UNCTAD Survey on the Internationalization of R&D* shows that China has become the most attractive destination for non-equity R&D collaboration (United Nations, 2005). The majority of the new R&D centres that multinational companies plan to open during the next years are to be located in India and China. This R&D relocation has taken multiple forms: 'satellite R&D' labs located in developing countries focus on the exploitation and adaptation of home-R&D; they have relatively low strategic importance and are vulnerable to budget cuts decided by headquarters. 'Contract R&D' labs are a pure 'innovation offshoring' form confined to the provision of lower-cost skills, capabilities and infrastructure; knowledge exchange remains very limited in this case also. 'Equal partnership' labs are the most advanced, but also the most limited form and concern those MNC labs that are charged with a regional or global product mandate; knowledge exchange is higher and eventually there is mutual knowledge exchange (Ernst, 2006).

As a result of these trends, innovation spending in Asia is growing at incredible rates; while business R&D expenditure rose by 5.2% in North America, 2.3% in Europe and 3.8% in Japan from 2000 to 2005, it rose by 17% in India and China and by 19.7% in Australia, Brazil, Singapore, South Korea and Taiwan, combined. In the EU, R&D intensity, measured by the R&D-to-GDP ratio has been slowing down since 2000 and grew by 0.2% only in the period of 2002–2003. The opposite is taking place in China, which has lower R&D intensity (1.31% of GDP in 2003), but with a growth rate of about 10% per year between 1997 and 2002. If this trend continues, China will be spending the same as the EU in 2010.

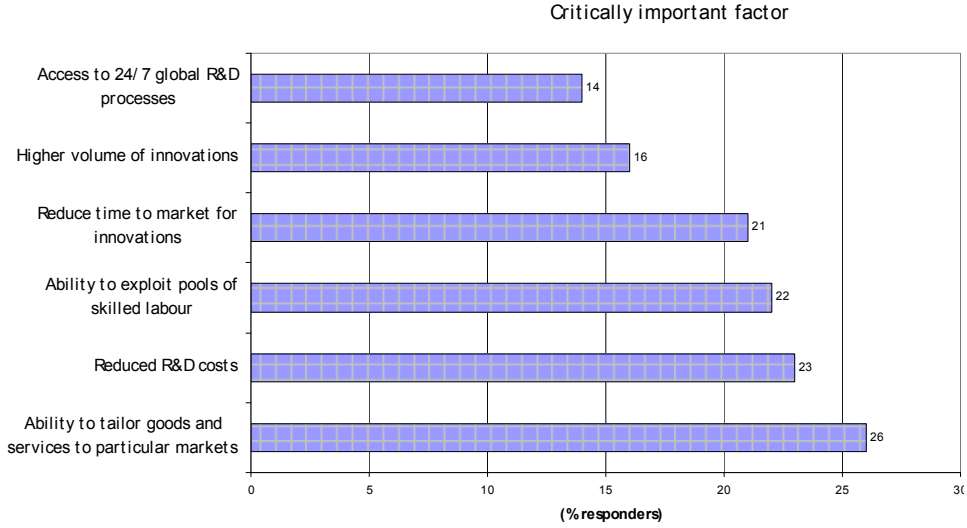
These are just a few facts from a sea of evidence demonstrating the rise of Asia as an important location for R&D and innovation activities. Innovation offshoring follows the intense relocation of production activities to Asia in diverse industry sectors such as textiles and footwear, electronics, automotive components, machine tools, software and IT-based business services. Innovation offshoring goes beyond the relocation of routine activities, such as quality control, call centres and 24/7 business support services. Strong innovation clusters and hubs have emerged all over Asia; for broadband technology in South Korea and Singapore, for mobile communications and digital consumer devices in South Korea, Taiwan and China, and for software engineering in India (Ernst, 2006).

Why is this happening? Why is this transition from global production networks to global innovation networks taking place?

A recent survey conducted by the Economist Intelligence Unit (2004) documents the many reasons that drive the actual relocation of R&D (Figure 1). Reduced R&D costs and the ability to exploit local pools of skilled labour are among the most important delocalisation factors. However, new factors have also appeared alongside the classical factors of FDI attraction (proximity to local markets and bypass of tariff barriers): tapping into pools of local know-how, taking advantage of local creativities, avoiding relocation expenses and shrinking of R&D budgets.

The 'Global Innovation 1000' report of Booz-Allen-Hamilton has also demonstrated that over the period of 2001–2005, the largest R&D spending companies in the world have demonstrated both rising revenues and rising innovation spending. However, the ratio between these two measures (R&D spending per sales) is declining; revenues are rising faster than innovation spending. The authors argue that this trend can be attributed to the increasing globalisation of R&D, which is outsourced to facilities in lower-cost regions of the world (Jaruzelski et al., 2006).

Figure 1 Benefits of globalised R&D as perceived by senior executives (see online version for colours)



Source: Economist Intelligence Unit (2004)

The global decentralisation of R&D and innovation has a direct impact on local and innovation clusters and regional innovation systems as well. Through this impact, it becomes decisive for urban and regional development also.

It is well documented that innovation activities tend to cluster. In Europe, for instance, R&D laboratories and companies active in R&D are concentrated to a great extent in a series of urban islands of innovation and innovative regions in north-west Europe and Scandinavia. This spatial polarisation of innovation is explained by the horizontal and vertical knowledge interaction within the clusters, local knowledge spillovers and the 'embedded tacit knowledge' thesis (Edquist, 1997; Keeble et al., 1998; Malmberg and Maskell, 2002). Since innovation activities rely on tacit knowledge networks, they have location-specific dimensions and tend to cluster; tacit knowledge is spatially 'sticky' and despite the growth of knowledge management tools, it is not easily communicated other than through personal interaction (Morgan, 2001); clustering becomes inevitable in innovation in order to materialise innovative behaviour based on tacit knowledge and cross-science exchanges and spillovers.

Recent evidence, however, maintains that international relationships and global knowledge flows in particular are crucial sources of creativity and innovativeness within local innovation clusters. Successful clusters are building and managing resources from around the globe (Bathelt et al., 2004; Owen-Smith and Powell, 2004). There is a growing evidence that even in the most innovative clusters, an important proportion of their knowledge and customer bases are not local (Gertler and Wolfe, 2005). Local clusters and innovative cities are going global to take advantage of external resources (supply chains and knowledge inputs), market opportunities (suppliers and customers) and the attractiveness of global funds and investments (Uhlmann, 2008). In developing countries, innovation offshoring tends also to cluster. Offshoring takes place in a limited number of cities and regions in India, China, Malaysia and in global city-regions like

Singapore and Hong-Kong, giving birth to agglomerations of high-tech activities and innovative clusters.

The most innovative clusters to be found in Silicon Valley, Seattle, Austin, Raleigh and Boston in the US, Stockholm, Munich and Helsinki in the EU and Bangalore, Beijing, Shanghai, Seoul, Singapore, Taiwan and Tokyo in Asia take on board this new local – global innovation interplay based on IT (Index of Silicon Valley, 2007), with local innovation ecosystems sustained by global innovation networks and supply architectures (Jacobides et al., 2006).

3 Intelligent city strategies: setting global innovation environments

The 'innovation clustering – global innovation networks', geography becomes possible thanks to digital collaborative environments and information communication infrastructure. A new type of urbanity is taking shape as innovative clusters extend their cooperation networks virtually into those of intelligent cities. The development of intelligent cities enables the global functioning of local innovation clusters and regional systems of innovation. Intelligent cities offer the capability of online knowledge processing and exchange: faster and more direct communication, high capacity for information storage and processing, online knowledge management, agent-based knowledge assessment, 24/7 real-time communication, virtual cooperation and so on. Key practices in the overall innovation cycle, such as information provision, technology transfer, product development, partnership and so on can now be performed collaboratively in digital space and be distributed to various localities around the globe.

Most intelligent city strategies document the structural relationship between innovation, digital interaction and the global market. However, all intelligent city strategies are not the same, there are important differences in the way the relationship between locality, innovation and the information society is organised and implemented.

3.1 Sector-driven strategies

In this case, intelligent city strategies aim at transforming specific sectors of a city, either manufacturing or services. The geography of the sector within the city is not a critical factor, compared to its growth and networking with activities outside the city.

A good illustration of this approach is the 'Intelligent Nation 2015' (iN2015), the strategy and programme for turning Singapore into an intelligent island. The strategy is guided by the vision of 'an intelligent island, a global city, powered by Infocomm'. Information and communication technologies will be harnessed to enable the fundamental ingredients of city development: innovation (the capacity to create new products or new ways of doing something), integration (the ability to harness resources and capabilities across diverse organisations and geographies) and internationalisation (the need to be well plugged into the globalised economy) (IDA, 2007).

Implementation of the strategy relies on the transformation of ten key economic sectors of the city: digital media and entertainment (DME), education and learning, financial services, healthcare and biomedical sciences, manufacturing and logistics, tourism, hospitality and retail, government, Infocomm infrastructure and services, enterprise development for Infocomm companies and Infocomm manpower development. In each sector, a planning committee has been set, which in consultation with the public

has elaborated a ten-year plan that reaffirms the strategic role of Infocomm as a differentiator and enabler of innovation and globalisation. The plans foresee the implementation of projects that introduce new products and services in each sector, establishing a pervasive and intelligent infrastructure, going beyond user-inputs with intelligent data collection and mining, offering personal digital assistants to every citizen and advanced services in collaborative product design, intelligent supply chain management, turning companies to 'techno-strategists' that have the ability to combine technical know-how with domain experience for innovative products and solutions.

The central objective of the sector plans is to integrate R&D, commercialisation and IT. The plan for the DME sector, for instance, puts forward a series of resource centres providing DME firms with technology tools and training, the DME technology creation and commercialisation initiative, the digital assets management programme with the digital vault (digital content bank), the digital key (safe trading of content) and the digital courier (end-to-end sales, payment and delivery of digital assets). All in all, these initiatives intend to create a strong sector system of innovation, combining high R&D capacity, product implementation capability and wide marketing and product promotion.

3.2 Cluster or district-focused strategies

LLs highlight another form of intelligent city strategy advancing bonds among localities, innovation and ICTs in selected city districts or clusters. LLs are targeted at city districts or clusters, advancing their telecom infrastructure and digital services in view of becoming significant testing-beds for new products, services and new ideas. The concept is to take advantage of the fundamental qualities of the urban environment (agglomeration, infrastructure and cooperation), moving research out of laboratories into real-life context, allowing citizens to participate in research, product design and product testing. Users are invited to cooperate with researchers, product designers and developers to test and improve innovative ideas and R&D outcomes. Through the LLs, the city infrastructure is improved; public policies are adapted to firm-specific assets, clusters of competencies are maintained and advanced by applied research and experimental development, education and training. The city district becomes a 'living laboratory' for prototyping and testing new technology applications and new methods of generating and fostering innovation.

> "An LL is a city area which operates a full-scale urban laboratory and proving ground for inventing, prototyping and marketing new mobile technology applications. An LL includes interactive testing, but is managed as an innovation environment well beyond the test bed functions. As a city-based innovation resource, the LL can take advantage of the pools of creative talent, the affluence of socio-cultural diversity and the unpredictability of inventiveness and imagination in the urban setting."(Living Labs Europe, 2006)

LLs offer original ways to create clusters developing innovative products for global markets. The cluster-based approach is strong in most ongoing initiatives. For instance:

- The Normandy LL relies on the skills, networks and resources of the secure electronic transactions competitiveness cluster (TES), managed by this cluster (http://www.pole-tes.com). It tests innovative products and services in the fields of m-logistics, m-health, m-tourism, m-marketing and m-citizen, integrating the end user into the innovation/product development process. The Normandy LL combines three operational units: the 'usage observatory' involved in the institutional aspects of secure electronic transactions, the 'innovation institute' elaborating new product concepts and the 'experimental centre' assessing product prototypes with the aid of end users.
- The Forum Virium Helsinki is another LL based on a cooperation cluster developing new customer-driven digital services and content. Many significant companies, R&D organisations and public sector organisations located in the Helsinki region take part. In a series of fields (metropolitan traffic, healthcare, education, retail, digital home and culture), the activities of the LL encompass the typical cluster activities, such as cooperation in new product development, internal and external networking and creation of an environment favourable to innovation and even the development of the region (http://www.forumvirium.fi/).

The LLs initiative appeared at the end of 2006 as part of the official programme of the Finnish Presidency of the EU and the concept has proven to be extremely popular. Within two years and two waves of expansion, the European Network of LLs has 51 members from most EU countries while a new call for the third wave of LLs was opened in April 2008.

3.3 Large-scale, complex intelligent environments

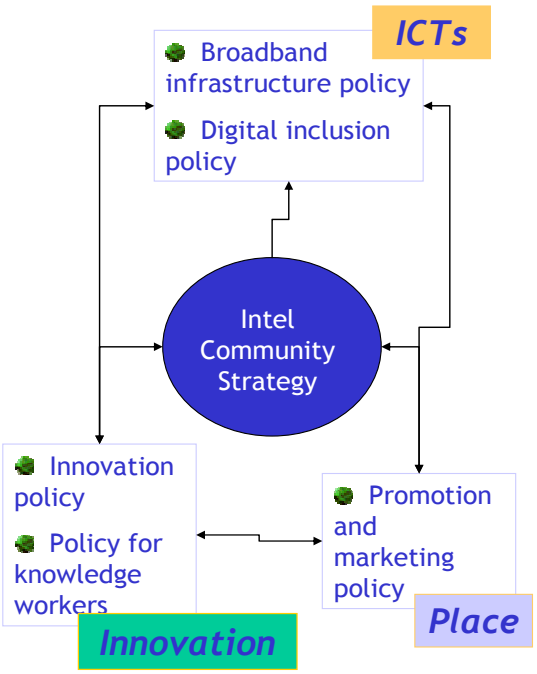
Intelligent city strategies may also affect the entire cities and regions engaging multiple innovation ecosystems, clusters and industry sectors. The environment that emerges is highly complex enabling each company to create its own innovation ecosystem combining elements of the physical, social and virtual space of the city. The movements of smart and intelligent communities highlight some interesting cases of this type.

Launched in 1997, the initiative for 'Smart Communities' (SC) was intended 'to help communities worldwide better understand the important role of technology, economic development and importantly, creativity and innovation to success and survival in the new global economy'. The concept refers to a community that makes an effort to use information technology and change life and work conditions fundamentally; it is an attempt that goes far beyond the mere use of information technology, preparing a community to tackle the challenges of a global, knowledge economy (Smart Communities, 2008). Sharing the concern for innovation, ICT, community and globalisation, SC (Canada) propose a top-down planning procedure covering the entire city. The starting point for setting up an SC is leadership by key individuals or institutions who share authority, risk and responsibility, forming a partnership that guides the strategy and the business plan of the community. This is followed by the setting up of a coalition and development of the SC's vision, undertaking a preliminary assessment of needs and opportunities, developing an action plan, shaping the personality of the community, determining the infrastructures and laying down the rules of governance (Smart Communities, 2002).

Decentralised, bottom-up strategies for innovation development, broadband networks and digital services also lead to high-complex intelligent agglomerations. In this case, a global networked intelligence emerges from local knowledge, skills and competences distributed across many organisations located into the agglomeration. However, the movement from low-level rules to higher-level organisation, which is called 'emergence', cannot be truly described as emergent until the local interactions result in some kind of organised macro-behaviour. The state of emergence commences when a higher-level pattern arises out of interactions between local actors [Johnson, (2004), pp.18–19]. Furthermore, in these systems that learn from the ground level and macro-intelligence and adaptability emerge from local knowledge, Gordon's research has shown that there are five fundamental principles that shape the emerging systemic behaviour: large numbers of operating units are needed, operation rules should be simple enough to avoid misleading, random interactions and encounters are important, individual behaviour should lead to larger patterns and the primary mechanism of the swarm logic is the interaction between neighbours [Gordon cited by Johnson, (2004), pp.78–79].

The ICF has awarded many cities and regions around the world for their combined achievements in innovation, broadband access and digital services deployment. These communities were assessed with respect to public policy achievements (strategy) in five fields (Figure 2): 'broadband infrastructure', enabling the local capacity for digital communication; 'knowledge workforce', which measures the capacity of the population for qualified work in knowledge-intensive activities; 'innovation', which assesses how far communities have gone in creating an innovation-friendly environment; 'digital democracy', which assesses the government and private sector programmes to overcome the digital divide; and 'marketing', which assesses the attractiveness of a community vis-à-vis its competitive cities and regions (ICF, 2006).

Figure 2 ICF awards criteria (see online version for colours)



In 2006, the ICF awarded Taipei as the top intelligent community with a rationale that highlights a bottom-up emergence of intelligent environment, based on the combination of multiple innovative clusters and broadband services. Among the achievements of Taipei, cited by the ICF, were Taipei's 88 technology incubators, which continue to produce new businesses, products and technologies for the global market; its 45 R&D centres and technology parks for software, data communications, mobile communications; the highly-skilled knowledge workers; the large number of spin-offs and start-ups; and the growing capability for ubiquitous broadband, the m-government, the e-government, e-schools and the creation of e-communities initiatives, the equal access to internet services for all, the cyber-city initiative, which are altogether transforming an innovative agglomeration into a 'high-tech city of the digital future' (ICF, 2006).

The above reference to strategies focusing on sectors, clusters and large-scale agglomerations shows that intelligent city strategies combine locality, innovation and the information society in many different and creative ways. What locality has to offer to systems of innovation is the simultaneous presence and operation of all the system's components; external economies of innovation related to the reduction of cooperation costs within the system, tacit knowledge flows and above all the creation of local communities of trust and the social capital needed for innovation. On the other hand, what ICTs have to offer to local systems of innovation is better communication, rapid transmission of explicit knowledge, opening of participative processes and global extension of networking. Forms of e-cooperation, e-technology, e-innovation and e-marketplace offer important enhancement to the local innovation ecosystems.

Critiques of these strategies do not question this effectiveness in transforming local knowledge and innovation activities. On the contrary, what is questioned is the justice in the city they bring. For instance, critiques of Malaysia's multimedia super corridor (MSC) and the Putrajaya and Cyberjaya projects (the flagship intelligent cities in Prime Minister Mahathir's vision to transform Malaysia into a fully developed nation by the year 2020) have shown that such high-tech developments may perpetuate existing patterns of social and spatial inequality if specific action to redistribute wealth is not taken. These large-scale investments in information infrastructure are concentrated in the main city-region of Malaysia and have further polarised the national spatial structure, while marginal groups and individuals are subjected to new forms of social and spatial exclusion because their participation is dependent upon the possession of skills required for an emerging knowledge economy (Bunnell, 2002). Nor, do intelligent city strategies escape the usual financial risks of large-scale urban development projects. The MSC has suffered from Malaysia's economic woes and the lack of interest from foreign corporations, leading the Multimedia Development Corporation into substantial debt (Lombardo, 1999).

4 Augmented innovation environments

A key objective of intelligent communities, LLs and sector-driven strategies is to enhance innovation in their area of reference. They do it by enriching the respective innovation system with interactive virtual spaces which:

1 improve the innovation environment offered in incubators, technology transfer centres, clusters, research institutes and other components of the innovation system

2 enable participatory innovation processes involving customers and end-users

3 open up the system to collaboration with overseas suppliers, researchers and innovators.

Deploying virtual collaboration and e-tools, more people, more suppliers, more customers and consumers can join in innovation activities. Digital interaction extends collaboration networks and the participation of users. These are two novel elements (global innovation networks/user participation in innovation) that broadband communication and digital collaborative spaces can offer to innovation ecosystems. It makes no difference whether their level of implementation is the entire city, a city cluster, a network or a sector of activity.

Among the technologies available for creating intelligent environments (sensors, RFID, embedded systems, actuators, virtual spaces, broadband networks), those of broadband networks and virtual collaboration spaces are crucial. The reason is that they sustain the spatial enlargement of innovation systems and their opening up to global human resources and cooperation more than other technologies. Broadband communication is necessary; however, more important is the content of communication and the services that run over broadband networks. A series of e-tools, digital platforms and Web 2.0 applications have made this virtual innovation environment operational and relatively easy to use. The concept behind it is to create digital collaborative spaces enhancing key innovation processes such as strategic intelligence, new product development and regional markets promotion. For each process, different e-tools and platforms has been created containing information management applications, intelligent agents for alert, search, information classification, processing and dissemination, addressed to global partners and end-users. Applications for virtual networking, virtual clustering, virtual product co-development, virtual technology exchange, virtual order placing, virtual follow-up of processes, etc., have greatly amplified the ability of organisations to cooperate and innovate.

4.1 Strategic collective intelligence

This is a field with enormous potential within intelligent cities and clusters. Strategic collective intelligence (SCI) is about collaboration in gathering and processing available information, not reinventing the wheel, getting a strategic view on markets and technologies. Business intelligence, which has set the stage for SCI, is defined as an activity to overview the internal and external environment of a company, with the intention of finding information that can be incorporated into management processes. It relates to the exploitation of information gathered from suppliers and customers; it uses data from enterprise resource planning (ERP) and customer relationship management (CRM), applies data mining and data compilation techniques and produces reports (OLAP) elucidating hidden aspects of the business environment and activity. Informed corporate action is then taken (Enterweb, 2006).

Digital collaborative spaces and intelligent cities sustain a particular form of collective intelligence, in which information collection, assessment and dissemination rely on the combined action of a group of people, a community, or a network of

companies or organisations. In collective strategic intelligence, data comes from a network of actors that disclose and share information. The network engages in strategic intelligence and produces an information system based on collective wisdom and interaction. The collection of information is distributed within the community, the assessment of information is also distributed and based on agreed criteria and the dissemination of information is customised according to individual interests and needs.

Well-known platforms of this kind concern intelligence in the textile sector (http://www.yarnsandfibers.com) and Decilor (http://www.decilor.org/) offering intelligence in the wood and food industries. They rely on collective intelligence tools like Weblogs, Wikis, social media, RSS and portals. URENIO implemented a similar platform for the ICT sector (http://www.urenio.org/bi). A common characteristic is that they provide intelligence on a sectoral base, which is mainly due to the fact that information collection, analysis and dissemination processes are easier at sectoral level.

Collective strategic intelligence needs three conditions to converge: a network of actors who provide continuous information inputs, an institutional agreement about the rules of cooperation in information collection, analysis and disclosure, and a virtual cooperation space containing the depository of data and the e-tools for analysis and dissemination. The virtual space mediates both global networking and end-user participation. Global information is customised along the needs and perspective of the individual user. The intelligence of the system is both organisational and artificial, enabling the compilation of information from multiple sources, rich data input coming from a large number of participants and adaptation of information to individual profiles and needs.

4.2 Collaborative new product development

A prime objective for intelligent cities, particularly those focused on clusters or sectors, is collaborative innovation, the cooperation of a group of actors in the development of a new product or service. Radjou (2004) described collaborative innovation as a network composed of four types of actors:

1 inventors – creative agents who conduct basic research and design new products and services resulting in the patenting of inventions

2 transformers – multifunction production and marketing services that convert inputs from inventors into new products and sell them to their internal or external customers

3 financiers – funding innovation for intellectual property

4 brokers – market-makers who find and connect service providers with the network, buying or selling services and enriching the capabilities of the network.

Virtual collaboration is a prerequisite for this type of networking. A series of applications, web platforms and e-tools have been developed to facilitate cooperation among spatially distributed organisations.

Innocentive (http://www.innocentive.com), for instance, facilitates cooperative R&D and global networking. It is a virtual network for collaboration between companies, contract research organisations, university labs and freelance scientists; it uses the internet to connect research-driven companies (seekers of know-how) and top scientists (solvers) worldwide. ‘Seeker’ companies anonymously announce scientific problems

(as challenges) and the award that they intend to pay in the case of resolution. 'Solver' scientists are registered scientists and labs that attempt to provide a solution to posted problems. Innocentive is the broker that facilitates the collaboration process, defines the intellectual property rights relating to collaboration and guarantees the payment of the award.

Virtual collaborative environments like 'Crowdspirit' (http://www.crowdspirit.com/) help create web-based product development communities. Crowdspirit operates in four steps:

1 the innovator sends ideas and the contributors' fines tune them and vote for the best one

2 a core team is selected by the innovator to define the product specifications with partners

3 the first prototype is tested and then further improved by the community

4 fans purchase products from the Crowdspirit partners; the community recommends products to new partners.

The application materialises the concept of crowdsourcing 'the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call' (http://www.crowdsourcing.typepad.com/cs/).

Acquisition of state-of-the-art technology is another area that is substantially enhanced by online collaborative spaces and intelligent-city strategies. It is true that global technology e-marketplaces have been in operation for some years now, such as Yet2com (http://www.yet2.com/app/about/home) and Cordis Technology Marketplace (http://www.cordis.europa.eu/marketplace/home.html) offering intellectual property from multinational companies, universities and research centres. In these platforms, technology offers are stored in databases following agreement or by the organisation/individual with the IPR. Data entry follows a typical profile that also includes the conditions of exploitation. Users seeking solutions to their technology needs to search the database and may then contact the technology provider online. The virtual technology marketplace is coupled with other online services related to technology transfer: consultative services assessing a portfolio of intellectual property; evaluation of better solutions to a given problem or need; legal assistance through the deal-making process; and roadmaps and tools for new product development.

The challenge of setting up this virtual collaborative space for technology transfer is more organisational than technological. This is the main lesson we took after a series of applications we ran (see: http://www.vrc.gr/index_en.html and http://www.innovation.duth.gr/duthvrc/index.html). It is highly demanding to sustain a continuous flow of technology offers; avoid discontent from the terms of exploitation; and keep alive a vigorous network of technology providers and users. The virtual space assists technology exchange and builds upon market relations or social networks of trust and cooperation. However, virtuality is not sufficient for or capable of replacing real-world cooperation and exchange. Relations of exchange and trust remain the bottom line of technology acquisition. The virtual space adds content broadness, transparency, systematisation and openness, while making technology producers an active promoters of their intellectual property.

Intelligent cities can offer the framework for developing both the organisational and digital terms of this type of technology transfer. The Madri+d application, (http://www.madrimasd.org/English/default.asp) which received the first IRE award in 2007, is a good example of this type of platform. Developed in the context of EU innovative action programmes, it is a locally-based virtual system of technology promotion and diffusion linked to a network of 42 universities and research institutes in Madrid, managing scientific and technological knowledge at regional level. With respect to global technology marketplaces, the advantage of local platforms is in the post-information stages of technology transfer and absorption. Cooperation between technology providers and users is more easily developed on a regional rather than international scale. Regional technology exploitation networks seem more effective. The reasons are well justified in the literature analysing the geographic scales of technology cooperation and transfer and the problems produced by the geographical, cultural and linguistic distances between technology providers and users.

Intelligent cities target such virtual collaborative environments at local resources, providing the local system of innovation with additional creativity and cooperation capacity. What happens in LLs is in fact crowdsourcing, with the population of the LL taking the role of collective product designer and testing. The advantage of physical-virtual communities of innovation compared to just virtual one is in the stronger social and institutional factors of innovation.

4.3 Promotion of regional marketplaces

The announcement of new products and services, the promotion and delivery of products and services can be considered the last mile of innovation. Virtual environments play an important role in this last mile. E-markets were among the earliest applications of digital technologies to business activities. However, the interest of intelligent cities in this field is more recent and it is expressed with applications for building regional market identity, regional markets promotion, virtual marketplaces and e-services provision (e-government).

City-based virtual marketplaces, e-malls for businesses and online marketing services created within intelligent cities differ substantially from company portals and privately owned e-stores and e-markets. Their distinctive characteristic is collectivity and openness. They do not market products and services from a single organisation, but promote those of the city, the cluster or the community. They create public digital marketplaces in which all interested companies of a community can find a place to 'locate' and offer products and services. They do not operate for the profit of a particular organisation, but they promote the interest of the community or city as a whole.

Many platforms of this type are available (http://www.local.aol.com/aol/localhome; http://www.maps.yahoo.com/; http://www.urenio.org/platforms/dcs.html) combining virtual tours of the city, presenting monuments, arts and crafts, stores and products with the use of digital maps and panoramic photos, virtual marketplaces where companies can place their e-shop with information on products and services, present product offers and carry out e-commerce transactions, and e-government shops with services from the public administration.

5 Post-RIS: regional innovation systems going global

Developing intelligent cities and augmented innovation environments, every district of a city or region, be it a productive cluster, a technology district, a central city area of services, a technology park, an incubator, a university campus, any sector of activity, can improve its innovation capabilities using broadband networks, digital cooperation spaces and online services. The objective is not broadband per se, but the opening up of the cluster/district to extended the collaboration and user participation. Broadband services and virtual environments are the medium for making systems of innovation more open and user responsive.

The intelligent environments that emerge are three-layer systems, with Layer (I) composed of the physical space and the agglomeration of people, innovative clusters and companies; Layer (II) composed of institutional innovation mechanisms and policy instruments for information mastering, technology transfer, product development and innovation; and Layer (III) composed of virtual collaborative spaces and tools, such as portals, agents, content management systems, Web 2.0 platforms, enabling collaboration and user participation (Komninos, 2008).

Deploying such intelligent environments, communities, cities and regions can address the major challenges of contemporary development related to innovation and competitiveness, employment, energy and the environment. The logic for creating the augmented innovation environment is the same, besides the differences from sector to sector. Within these environments, each company can build its specific physico-virtual innovation ecosystem, combining its internal knowledge capabilities with those of other companies and research organisations.

However, beside the need for broadband networks and digital spaces, the objective of intelligent cities is to enhance innovation of the respective city/region/cluster rather than to offer digital services. This is their distinctive attribute with respect to digital cities and cyber spaces. The innovation component allows an environment to be characterised as ‘intelligent’ in a literal rather than in a metaphorical way. Among their two fundamental components (innovation and virtuality), the organisational issues related to the management of innovation prevail over the technological ones of setting up virtual environments and communication.

Because of the concern for innovation, intelligent cities can be viewed as part of the wider movement for RIS that have been intensively developed all over Europe since 1994. RIS offer a rich show case of innovation strategies with the IRE network of 235 members; the three generations of RIS and RITTS projects (1994–2001); RIS-NAC (2001–2004); new RIS (2005–2008); the regional programmes of innovative actions (2000–2006); trans-regional innovation projects (1998–2000); the IRE thematic networks (2001–2004); the regional innovation policy impact assessment and benchmarking projects (2005–2008); and the mutual learning platform (2005–2006). Within this tradition, intelligent cities can pave the way for more global and interactive innovation systems, more sensitive to global cooperation and exchange so needed in EU regions.

The challenge today for Europe and beyond is for globally open systems of innovation; to gather and integrate knowledge from every available source all over the world, in the words of Thomas Friedman [Friedman, (2006), p.393] quoting a saying of the Prophet Mohammed to ‘seek knowledge even unto China’.

References

Bathelt, H., Malmberg, A. and Maskell, P. (2004) 'Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation', *Progress in Human Geography*, Vol. 28, No. 1, pp.31–56.

Batty, M. (1990) 'Intelligent cities: using information networks to gain competitive advantage', *Environment and Planning B: Planning and Design*, Vol. 17, No. 2, pp.247–256.

Besselaar, P. and Koizumi, S. (Eds.) (2005) *Digital Cities III: Information Technologies for Social Capital – Cross-Cultural Perspectives*, pp.66–96, Springer-Verlag, Berlin.

Bounfour, A. and Edvinsson, L. (Eds.) (2005) *Intellectual Capital for Communities: Nations, Regions and Cities*, Elsevier, Butterworth Heinemann, Oxford.

Bunnell, T. (2002) 'Multimedia utopia? A geographical critique of high-tech development in Malaysia's multimedia super corridor', *Antipode*, Vol. 34, No. 2, pp.265–295.

Business Week (2007) 'Inside innovation – special report', *Business Week*, 10 August, available at http://www.businessweek.com/innovate/di_special/20070830insideinnov.htm.

Castells, M. (2001) 'Information technology and global capitalism', in W. Hutton and A. Giddens (Eds.): *On the Edge: Living with Global Capitalism*, Vintage, London.

Economist Intelligence Unit (2004) *Scattering the Seeds of Invention: The Globalization of Research and Development*, available at http://www.graphics.eiu.com/files/ad_pdfs/RnD_GLOBILISATION_WHITEPAPER.pdf.

Edquist, C. (Ed.) (1997) *Systems of Innovation: Technologies, Institutions and Organisations*, Frances Pinter, London.

Edvinsson, L. (2006) 'Aspects on the city as a knowledge tool', *Journal of Knowledge Management*, Special issue on knowledge cities, Vol. 10.5, pp.6–13.

Edvinsson, L. and Malone, M.S. (1997) *Intellectual Capital – Realizing Your Company's True Value by Finding Its Hidden Brainpower*, Harper Business, New York.

Enterweb (2006) *Competitive Intelligence and Strategic Intelligence*, available at http://www.enterweb.org/strategy.htm.

Ernst, D. (2006) *Innovation Offshoring: Asia's Emerging Role in Global Innovation Networks*, East-West Center special reports, East-West Center, No. 10, available at http://www.eastwestcenter.org/fileadmin/stored/pdfs/SR010.pdf.

Florida, R. (2002) *The Rise of the Creative Class and How It's Transforming Work: Leisure, Community and Everyday Life*, Basic Books, New York.

Florida, R. (2005) *The Flight of the Creative Class: The New Global Competition for Talent*, Harper Business, New York.

Friedman, T.L. (2006) *The World is Flat: The Globalized World in the Twenty First Century*, Penguin Books, London.

Gertler, M. and Wolfe, D. (2005) 'Spaces of knowledge flows: clusters in a global context', Paper presented at the *DRUID Tenth Anniversary Summer Conference 2005 on Dynamics of Industry and Innovation: Organizations, Networks and Systems*, Copenhagen, 27–29 June.

Giddens, A. (1990) *The Consequences of Modernity*, Stanford University Press, Stanford.

Graham, S. (Ed.) (2003) *The Cybercities Reader*, Routledge, London.

Graham, S. and Marvin, S. (1996) *Telecommunications and the City: Electronic Space, Urban Places*, Routledge, London.

Horan, T. (2000) *Digital Places: Building Our City of Bits*, ULI – the Urban Land Institute, Washington, D.C.

ICF (2006) *Intelligent Community Awards 2006*, available at http://www.intelligentcommunity.org/displaycommon.cfm?an=1&subarticlenbr=135.

IDA (2007) *Innovation, Integration, Internationalisation – Singapore: An Intelligent Nation, A Global City, Powered by Infocomm, iN2015 Steering Committee*, available at http://www.ida.gov.sg/doc/About%20us/About_Us_Level2/20071005103551/01_iN2015_Main_Report.pdf.

Index of Silicon Valley (2007) available at http://www.jointventure.org/inthenews/pressreleases/2007index.html.

Ishida, T. and Isbister, K. (Eds.) (2000) *Digital Cities: Technologies, Experiences and Future Perspectives*, Springer-Verlag, Berlin.

Jacobides, M.G., Knudsen, T. and Augier, M. (2006) 'Benefiting from innovation: value creation, value appropriation and the role of industry architectures', in David J. Teece (Ed.): *Research Policy, 20th Anniversary Special Issue of the Publication of 'Profiting from Innovation'*.

Jaruzelski, B., Dehoff, K. and Bordia, R. (2006) 'Smart spenders: global innovation 1000', *Strategy and Business Magazine*, Winter, available at http://www.finfacts.ie/biz10/2006BoozAllenGlobalInnovation1000Full%20Report.pdf.

Johnson, S. (2004) *Emergence: The Connected Lives of Ants, Brains, Cities and Software*, Scibner, New York.

Keeble, D., Lawson, C., Moore, B. and Wilkinson, F. (1998) 'Collective learning processes, networking and institutional thickness in the Cambridge region', *Regional Studies*, Vol. 33.4, pp.319–332.

Komninos, N. (2002) *Intelligent Cities: Innovation, Knowledge Systems and Digital Spaces*, Taylor and Francis, Spon Press, London and New York.

Komninos, N. (2004) 'Regional intelligence: distributed localised information systems for innovation and development', *Int. J. Technology Management*, Vol. 28, Nos. 3/4/5/6.

Komninos, N. (2008) *Intelligent Cities and Globalisation of Innovation Networks*, Routledge, London and New York.

Kuhlmann, S., Boekholt, P., Georghiou, L., Gyu, K., Heraud, J., Laredo, P., Lemola, T., Loveridge, D., Luukkonen, T., Polt, W., Rip, A., Sanz-Menendez, L. and Smits, R. (1999) *Improving Distributed Intelligence in Complex Innovation Systems*, Final report, TSER project, Fraunhofer Institute, Systems and Innovation Research, Karlsruhe, available at http://www.isi.fraunhofer.de/p/Final.pdf.

Lévy, P. (1997) *Collective Intelligence: Mankind's Emerging World in Cyberspace*, Perseus Books, Cambridge.

Living Labs Europe (2006) *Living Labs Europe: A New Driver for European Innovation*, available at http://www.livinglabs-europe.com/livinglabs.asp.

Lombardo, H. (1999) 'Mahathir opens intelligent city', *Asia.Internet.Com*, available at http://www.apnic.net/mailing-lists/s-asia-it/archive/1999/07/msg00034.html.

Malmberg, A. and Maskell, P. (2002) 'The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering', *Environment & Planning A*, Vol. 34, pp.429–449.

Mitchell, W. (2007) 'Intelligent cities', *Inaugural Lecture of the UOC 2007–2008 Academic Year*, available at http://www.uoc.edu/uocpapers/5/dt/eng/mitchell.html.

Morgan, K. (2001) 'The exaggerated death of geography: localised learning, innovation and uneven development', Paper presented to *The Future of Innovation Studies Conference*, The Eindhoven Centre for Innovation Studies, Eindhoven University of Technology, September, pp.20–23.

Nelson, R. and Winters, S. (1982) *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge.

Nouvel, J.F. (2004) *Collective Intelligence: The Invisible Revolution*, available at http://www.TheTransitioner.org/ci.

Owen-Smith, J. and Powell, W.W. (2004) 'Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community', *Organisation Science*, Vol. 15, pp.5–21.

Radjou, N. (2004) *Innovation Networks: A New Market Structure Will Revitalise Invention-To-Innovation Cycles*, available at http://www-03.ibm.com/technology/ets/capabilities/others_say/pdf/innovation-networks.pdf.

Smart Communities (2002) *Guide for Creating a Smart Community*, available at http://www.198.103.246.211/documents/SC-Guide.pdf.

Smart Communities (2008) *The Concept of Smart Communities*, available at http://www.smartcommunities.org/concept.php.

Uhlmann, R. (2008) 'Global integration of regional clusters', *IRE Conference*, Rennes, June.

United Nations (2005) *UNCTAD Survey on the Internationalization of R&D*, Occasional note, available at http://www.unctad.org/en/docs/webiteiia200512_en.pdf.