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REVISTING THE RELATIONSHIPS BETWEEN BROADBAND DIFFUSION AND REGIONAL SYSTEM DEVELOPMENT: A PRIMER

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REVISTING THE RELATIONSHIPS BETWEEN BROADBAND DIFFUSION AND REGIONAL SYSTEM DEVELOPMENT: A PRIMER

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ABSTRACT

As they create generative conditions for socioeconomic development ICTs and broadband technology, can be understood as an innovation kernel for system evolution. Whereas for a regional system (a local area), technological progress may at certain times be regarded as exogenous, information endowments and expected level of functionalities are not. An innovation kernel, in fact, cannot exist outside the organization of the regional/local system which it belongs to. To grow and deploy its potentials, a fertile environment capable to adapt pro-actively to the changes it produces is needed.

In this paper the conceptual underpinnings of an innovation kernel are overviewed and their relationships with those conventionally addressed in regional science studies briefly discussed.

Bbuilding upon the IRES research undertaken as a part of the Piedmont ICT Observatory activities, an effort is made to pinpoint the determinants and processes of regional development on which an innovation kernel would encroach. A conceptual framework is outlined which makes it possible to elicit some main relationships between ICTs, broadband and developmental processes in a regional system.

Key words: information wired environment, reflexivity, co-evolution, regional development.

1 Introduction

The economic literature of the last decades offered several contributions concerning ICT based innovative processes, their origins and conditions for their occurrence¹. Recently, the relevance of ICT technologies has been also acknowledged in the formulation and enforcement of European, national and regional policies (Commission of the European Communities, 2006, European Commission and DG Enterprise & Industry 2008; European Commission and e-Business W@tch, 2008, European Commission 2010).

Among ICTs, broadband technology plays a crucial role as it affects both ICTs developmental paths and the strength of their societal impact. Furthermore, because of the range of novel functionalities, broadband is not only an innovation in itself but it creates the conditions necessary to develop further innovations.

Several arguments have been put forward to support these arguments.

¹ See for example: Avgerou and La Rovere (2003), Barrios and Navajas Cawood (2008), Batten et. Al (2000), Jorgenson (2001), Louis Lengrand & Associés (2002), Lucas and Sands (2009), OECD (2002, (2006), (2010), Oliner and Sichel (2000), McKinsey Global Institute (2010), Schreyer, (2000), Vicente and Suire (2007).

From the point of view of economic development, for example, it has been emphasized that a number of advantages coming through broadband are due to the fact that the continuous progress in broadband technologies prompts competitive mechanisms, thus spurring ICT suppliers to adequate their strategies which would also benefit the final consumers. Broadband effects on firm and sector productivity have also been pointed out, although the final impact on the overall economy is still far from being clearly ascertained (Atkinsons, 2007, Broadband Stakehold Group, 2004, Lehr et. al, 2005, Fornefeld et. al, 2008, OECD, 2008, Preston and Cawley, 2008).

Also from the organizational point of view, several positive effects have been identified, as a result of the diffusion and use of the broadband services among firms, citizens and local governments (Atkinsons and McKay, 2007).

Finally, a number of recent empirical studies provided evidence that positive outcomes are achieved in the areas where broadband development takes place (Atkinson, 2009, Susiluoto, 2003, Van Gassbeck, 2008).

The type of improvements produced by broadband are not limited to economic gains and organizational upgrading. Broadband innovative potential, in fact, forms a basis for engendering further innovative, not necessarily ICT based, processes and products. In this sense, ICTs and broadband constitute an innovation kernel in that they create generative conditions for socioeconomic development (Pollone and Occelli, 2005, Occelli, 2008).

Interesting questions that arise in the study of broadband diffusion within national and regional systems is, on the one hand, how the above mentioned generative conditions encroach on existing socioeconomic conditions (David, 2007) and, on the other one, how they can help overcoming uneven developmental opportunities.

These issues are not only theoretically challenging (Bargero, Donato and Occelli, 2007; Choudrie and Dwivedi, 2006; Dwivedi and Irani, 2009), but also relevant also from the policy-making point of view, due to the fact that broadband is also credited as a main factor for boosting competitiveness and sustain growth at a regional and country level (Cawley and Preston, 2007, Pupillo, 2009, Rintels, 2008).

This study aims to offer a contribution in this direction. An effort is made to develop a framework of analysis for accommodating the role of Innovation and Communication Technologies (ICTs) and of broadband among the determinants and processes of regional development.

A core idea of the present analysis is based on the aforementioned notion of innovation kernel, according to which ICTs and broadband can be understood as a kind of generator of local system development. As such, innovative kernel can be assimilated with the notion of economic multiplier, whose functions, however, considerably extend those attributed to the latter.

Whereas, for a regional system (a local area), technological progress may at certain times be regarded as exogenous, on the contrary, information endowments and expected level of functionalities are not. These are rooted in the overall socioeconomic conditions existing in an area as well as in the agents' willingness to engage in the broadband usages. An innovation kernel, therefore, cannot exist outside the organization of the regional/local system which it belongs to (Ocelli, 2008). The strength of its development depends on the agents' awareness about the benefits likely to be accrued in their everyday life, in health, education, employment access and economic competitiveness.

The work is organized as follows. First, building upon the IRES research undertaken as a part of the Piedmont ICT Observatory activities², the notion of innovation kernel is recalled.

Then, an effort is made to pinpoint the determinants and processes of regional development on which ICTs and broadband encroach. The designed conceptual framework serves as a reference for leveraging the ICTs' generative role in fostering regional innovation paths.

Finally, some challenges for future research are proposed.

2. Leveraging the innovation kernel in a regional system: a conceptual approach

2.1 Innovation kernel and regional development

Underlying the concept of innovation kernel are three interlinked elements:

- Information and Communication Technologies (ICTs), which consist of the set of artefacts brought into existence by the technological progress (computers, telecommunication networks, cellular phones and the hybrids resulting from the convergences of the former).
- Information, broadly understood here as the whole continuum of transferable knowledge which can be conveyed by means of ICTs.

² For an overlook of the activities of Piedmont ICT Observatory, see www.sistemapiemonte.it/innovazionetecnologia/osservatorioICT.

- Functionality, here defined as the operating activities making it possible the working of an organization, which is supported and/or enabled by the coupling of ICTs and of Information.

But innovation is not simply something that happens to occur in a certain place, at a certain time, because of certain conditions. It is strongly inherent to the evolution of human organizations (Read, Lane, van der Leeuw, 2009). Moreover, innovation also happens to be sought for, despite of its costly investment. In this regard, positive expectations about new functionalities of innovation are recognized as major drivers of this complex process (Witt, 2004).

In the current debate on the relationships between ICTs and the evolution of urban regional socio-economic systems, in particular, three steps have been emphasized, and namely (Graham, 2000):

1. substitution, according to which ICT applications are mainly aimed at replacements in order to improve efficiency;
2. co-evolution, according to which as a result of ICT increasing spreading, production of virtual action spaces would occur together with physical counterparts in socio-economic and spatial organizations;
3. recombination, according to which ICTs introduce a further relational-based dimension which adds up to the already existing social, economic, spatial and institutional ones. Actually, the technological dimension does not simply introduce an additional layer, but turns out to be generative of new ways of dealing with those relational dimensions (Dodge and Kitchin, 2004).

Whereas the availability of ICTs is a necessary condition for the innovation kernel to develop, agents, as represented by individuals, organizations and institutions, as well as the spatial environment are the essential means through which innovation potentials are shaped and deployed in a certain area. In this respect, both agents' ability to take advantages of ICTs and the characteristics of the recipient social, cultural and territorial environment, are fundamental in ICTs diffusion. The links between interacting individuals, supposed to act not as blind avatars, but as aware and cognitive agents, and the range of ICTs expected outcomes at the collective level are therefore a challenging issue on both a theoretical and operational ground (Occelli, 2006b, 2008).

Some of the effects likely to be determined by the realization of the innovation kernel in the economy, society, environment and human settlements have already been gauged by the literature and are briefly recalled in Tab.1.

Table 1- Main types of effects associated with the application of innovation kernels (adapted from Haglund and Nevalainen, 2004).

	<i>Substitution First order effects</i>	<i>Co-evolution Second order effects</i>	<i>Recombination Third order effects</i>
	The impacts and opportunities created by the physical existence of ICTs	The impacts and opportunities created by the ongoing use of ICTs	The impacts and opportunities created by the overall effects of many agents using ICTs
Economy	Growth of ICT sector and market Growth of ICT investments within firms Ongoing investment in ICT R&D Spurs to organizational change in private and governmental companies Market volatility	Opportunities for new efficiencies in business New markets and more efficient production for SMEs Expansion and new financial markets Modifications in the business-market relationships	ICTs as a new paradigm of growth (sustainable developments) Risk of reinforcement of uneven pattern of wealth New solutions for sharing economic benefits (exclusion vs. inclusion)
Society	Jobs created as a result of the expansion of ICT sector Access to on-line information: health, government, education, transport, leisure, etc. Digital divide: discrepancies of access to ICTs	Access to better services: e-health, e-government, e-learning, Tele-work, e-commerce Creation of new types of communities Security challenge	Balancing cultural homogeneity and diversity Establishing co-operative communities Encouraging citizen participation in community affairs
Environment and human settlements	Design and production of more energy- efficient equipments ICT sectors as lightweight industry Problems of old ICTs equipment disposal	Increase and decrease in transport (increase of home delivery as a result of e-commerce, reduction of travel miles by tele-work and traffic externality effects) Virtualization of material products Extension of product lifetimes and reduction of product development cycles Enhanced use of GIS information	Possibilities of de-coupling economic growth and environmental impacts (i.e. energy consumption and carbon emissions) Changes in settlements: risks of increasing environmental pressure on local areas

2.2 *Local area as a HCAS*

The fact that socio-economic development is a localized phenomenon is a core notion in the regional science literature.

When enquiring the features affecting the competitiveness of a production system, for example, a local area can be understood as a bearer of static and dynamic advantages for local

enterprises, (Capello, 1995, Cusinato and Gibin, 2008, MacKinnon, Cumbers and Chapman, 2002)³.

Environmental factors, as well as the knowledge assets (Bruzzo and Occelli, 2005, Camagni and Capello, 2002, Bramanti and Salone, 2009, Nahapiet and Ghoshal, 1998) are additional determinants having a main role in the development of an area.

Finally, the concept of local governance system should be also taken into account (see Friend, Jessop, 1969). This relates to a human activity system, referring to a spatially delimited and historically established territory having a commitment to make plans to sustain and foster its evolution.

More recently, the system overall capability to steer and manage its economic, social and environmental dynamics, has been given increasing attention for the viability of the development of a local area. In this respect, the notion of local governance has been extended to give a greater emphasis to the reflexive dimension in planning activity (Occelli, 2006b).

On the conceptual ground, the notion of (Human) Complex Adaptive System, recently introduced in the complexity science literature (see Holland, 2006) provides a further powerful metaphor.

A local area, in fact, can be conceived as a Human Complex Adaptive System (HCAS), thus possessing the features recalled in Tab.2.

Table 2 – Comparison of the main features of Human and Non-human CAS

Descriptive keys	Non-human CAS	Human CAS
1. Variables	Few components and relationships	Many components (individuals and organizations) interacting simultaneously at different levels
2. Relations with the external environment	Closure	Openness
3. Purpose of regulation	Returning to some predetermined stable state	Adaptation and evolution. Changes that improve performances (credit assignment and rule discovery)
4. Forms of regulation	Only error-controlled regulation	Actions upon signals, formation of subroutines, deliberation

According to the first descriptive key listed in the table, therefore, a territorial system consists of a large number of individual and collective agents (individuals, enterprises, institutions, local governmental bodies) continuously interacting with one another and exchanging both tangible and intangible (information) goods. Several network relationships exist, allowing agents to interact both in within an area, and outside its boundaries, at different spatial levels.

³ These advantages would stem from (Capello and Fratesi, 2009): a) the external context, providing tangible and intangible factors feeding enterprise productivity and innovation; b) the governance system bringing together private actors and local institutions; c) the social and economic relational system underpinning the social capital of a specific geographical context.

The fact that a CAS has the ability “to ‘coarse grain’ and ‘chunk’ information about itself and its environment” (Coward and Pines, 1994, P.711) is an additional distinctive feature, which is particularly important in developing the reflexive capabilities of human organizations (Ocelli, Staricco, 2005).

As already pointed out more than three decades ago, in fact, the phenomenon of reflexivity of social processes, requires acknowledging (Muller, 1975): a) the embedding of the individual, who observes, describes and influences any social event, into a network of social processes that contains these events and b) the intelligent reactions of individuals to the activities of others.

What this reflexive dimension also entails is that “In many fields of social action behaviour and strategy cannot be distinguished. Especially when humans begin to live in a more and more intensive manner in artificial, i.e. social contexts, they influence and sometimes construct such contexts on which, in turn, their behaviour depends” (Muller, 1975, p.16)⁴.

Actually, this property of self-steering is associated with the so-called deliberative consciousness and distinguishes the *homo sapiens* as well as all kind of human organizations (families, communities, nations) (see Donnadieu and Karski, 2002)⁵.

What the above arguments point out is that for a CAS to exist, the context, (the system external environment) is not only part of the system but is also a component of the system having the (ontological) properties of an agent. Of course, in a CAS the behaviour of the context-agent will depend on the overall functioning of the system, i.e. the instantiations of the descriptive keys in Tab. 1, and ultimately on the type of CAS analysts are interested in.

The scheme shown in Fig. 1 can be of assistance for designing a range of possibilities (Ocelli, 2010). The scheme identifies four main blocks derived from the joint articulation of the two dimensions conventionally retained in dealing with CAS: that related to the micro-macro level distinction and to the property-phenomena articulation. Within each block the main descriptive categories are also mentioned.

In both cases, then, context makes it possible to inscribe the outcomes of agents’ behaviour. The encoded marks, then, would subsequently affect agents’ actions. Depending on the

⁴ Actually, it is worth recalling that the point of view by means of which an observer constructs a model of other systems, while recognizing these systems as agents in their own right (thus interacting also with the observer) has been a issue of enquire in second-order cybernetics (Heylighen and Joslyn, 2001).

⁵ Such property, in fact, is inherently rooted in the ways organizations structure themselves at the different levels and see to their management over time (Lane *et al*, 2009). To some extent, it is also at the basis of what some authors call as enculturation a process by means human species acquired the ability to “decouple societal organization from biological kinship” (Read, Lane and van der Leeuw, 2009, p.44).

type/intensity of information associated with them, in fact, context can be viewed as an agent type likely to possess certain features of human “intelligence”.

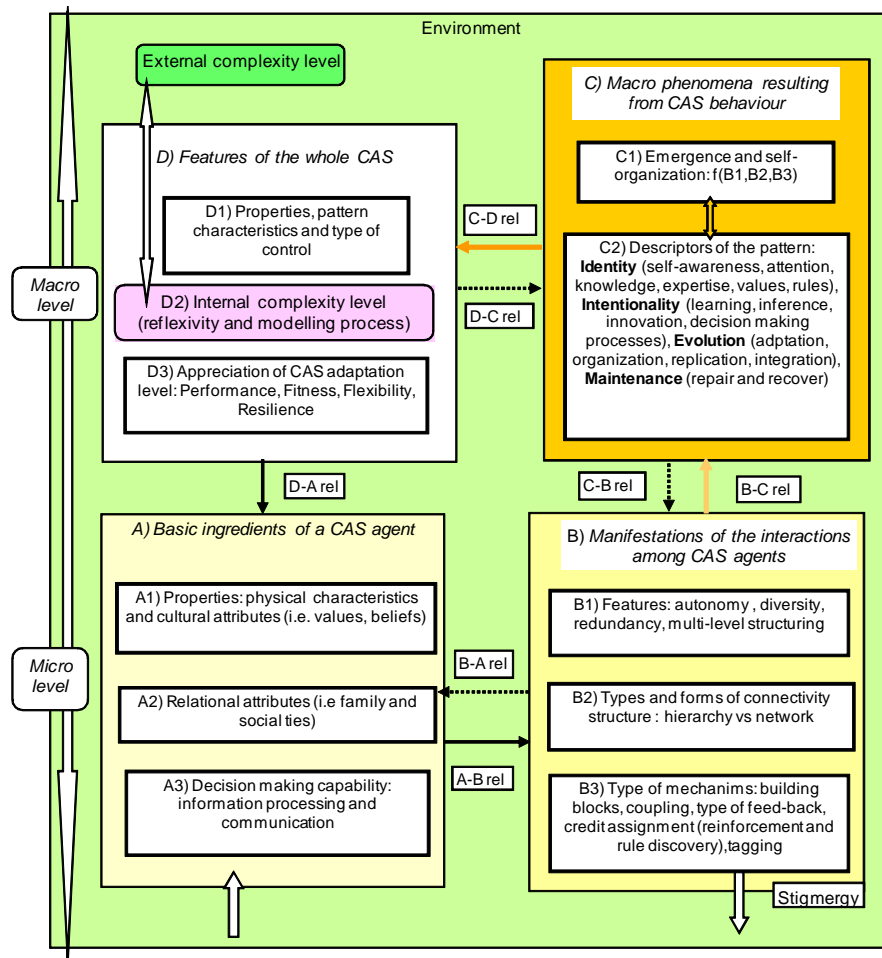


Figure 1 - An outline of HCAS (developed upon Couture, 2007)

A last aspect of the scheme deserving attention relates to the type of relationships among the different blocks. Although the suggested distinction among the four blocks is mainly a descriptive expedient, (a CAS in fact is a holon having the properties of both a part and a whole) it makes it possible to highlight that different type of relationships exist: a) instantiation-type relationships, as those labelled as D-A rel; b) types of interactions among agents (those labelled as A-B rel); c) generative-type relationships such as shown by the B-C rel label; d) encoding relationships⁶ (those labelled as C-D rel); e) relationships associated with feed-back loops, such as those indicated as B-A, C-B and D-C rel⁷.

⁶ These encoding relationships would result from an evaluative process which a human CAS is supposed to undertake because of his endogenous reflexivity endeavour.

⁷ A further point to note here is that the ways these relationships are activated and applied affect the formation and evolution of the context-agent. By means of them, a local area, then, can also create through search,

3. Determinants of regional development and the role of ICTs

In the following, a conceptual framework of local development is outlined in which the capability of self-steering is addressed. A claim is made that ICTs, and more specifically the leveraging of the innovation kernel, have a major role to play in supporting this capability.

Discussion proceeds by successive steps.

First, building upon the cybernetic approach, a functional scheme of HCAS (herein also indicated as a local area) is provided, which distinguishes between what has the responsibility to manage or guide the system from what makes the system functioning (par. 3.1).

Then, the scheme is detailed by accounting for a set of determinants of regional development already well known in the literature (par. 3.2).

The enriched scheme turns out to be useful for instantiating the notion of innovation kernel and this is carried out in the last step of the discussion (par.3.3).

3.1 *A functional scheme of local development*

Considering a local area as a HCAS means that the importance given to those factors conventionally viewed as determinants for development, such as territorial capital, specialization, and evolutionary learning, would also depend on the ways through which they support its self-steering capability.

To account for that it can be helpful, to have a functional description of HCAS and distinguish two main subsystems, the so called OPERATING and GUIDING SYSTEM, see Fig. 2.

The OPERATING SYSTEM (OS) deals with those processes (and patterns) involved in the working of a local area and supporting its maintenance and transformations over time (see A1, A2, B1, B2 in Fig.1). A number of well known concepts in the regional science literature are pertinent in this respect:

- *agglomeration*. It relates to the urbanization processes and the formation of settlement structures as they are progressively created by the concentration in an area of (material and immaterial) resources and activities interacting both functionally and spatially;
- *accessibility*. It underpins the relationships between the need to partake in certain activities (access some resources), typically located in certain areas, and the efforts involved to reach them (typically time and transport costs);

exchange, interaction and evolutionary learning processes, what some authors (see Girardot, 2009) have recently called *a territorial intelligence*, understood as “a mean for the researchers, actors and territorial community to acquire a better knowledge of the territory but also to better handle its development”.

- *generative mechanisms*. The notion encompasses a whole range of socioeconomic, cultural and institutional processes which over time are responsible of the formation of agglomeration and accessibility (Camagni and Capello, 2002). They are also a source of the competitive advantages of an area and at the same time create the conditions for its further evolution (David, 2007).

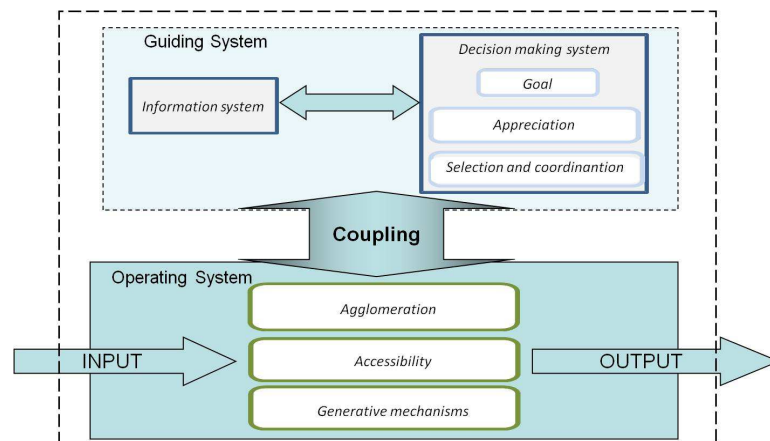


Figure 2 - A functional description of a local area

The GUIDING SYSTEM (GS) encompasses those processes involved in steering the operations performed by a local area (what in Fig. 1 is represented by the connection between external and internal complexity levels). It is associated with the human reflexivity dimension and modelling capability and stems from two main motivations: a) a need of acting without delay for achieving a certain goal and b) a quest for understanding a situation better that is for dealing with the uncertainties about the consequences of alternative actions. The GS then includes functions such as those related to gathering and processing information. It also sees to decision making and more specifically to the use of knowledge resources provided by both the information system and the system's own capability to leverage them as well, in order to comply with the system motivations and needs (see Landini and Occelli, 2010). Relevant aspects involved in this regard are (see Fig.1):

- the definition of the system goals as these stem from a value laden evaluation of the system state and motivations for its changes (see blocks D2 and D3);
- the appreciation of the state of the system (as underlying, for example, the type of descriptors shown in C2);
- selection and coordination activities (which underpin the processes in blocks A3 and B3).

To support the existence of the local area over time two main requisites (at least) are necessary:

- that both the OPERATING and GUIDING SYSTEMS have an adequate level of functionality;
- that there exist a set of conditions/processes allowing for convenient couplings between the two systems.

3.2 *Detailing the subsystems: determinants and relationships*

Several studies in the regional science literature have identified in the *territoriality* of the local area the main source for its development. The features, determinants and processes underlying the concept of *territoriality* are manifold. In the following, an effort is made to recall some of them as they are at the basis of what have been identified above as OPERATING and GUIDING SYSTEM. For the sake of the discussion, here, they are distinguished in two main groups, labelled as:

- a) I LEVEL DETERMINANTS: they relate to the socio economic, spatial, environmental and institutional features of the local area (system). Their presence are at the basis of the working of the OPERATING SYSTEM. These determinants have their roots in well-known (although ontologically heterogeneous) notions such as: specialization/diversification, territorial capital, openness, inclusion/exclusion, sustainability, Infrastructure development, skill and education.
- b) II LEVEL DETERMINANTS: they include a set of process determinants, some of which also stem from the encoding in the system of agents' activities, which affect the behaviors of the individual agents and organizations, and underpin the ways the I LEVEL DETERMINANTS are geared (see the D-A rel in Fig.1). They have a main influence on the type of control, which both at individual (see level B3 in Fig.1) and collective levels, (see C2 in Fig.1) the local area would adopt for overseeing its management and evolution. To provide examples of these determinants we can mention: pro-activity as an attitude which make agents act in anticipatory and change-oriented ways; social and evolutionary learning; capability; citizen participation in development processes; I° order reflexivity (willingness of a system/individual to extract information from the environment in order to sustain itself); affordance (a potential for an agent to extract information through an interaction process among individual agents or between an agent and a context).

To support the determinants of the OPERATING and GUIDING SYSTEM, and the viability of the local area over time, an adequate level of self-steering capability is necessary. This means that besides the need of conveniently coupling the two systems, a higher-level reflexive ability

(herein labelled as *II order reflexivity*) is necessary to see to the transformations of the system over time. To some extent, this ability can be associated with the notion of “organizational thinking”, by which territorial systems would “...represent their context by modelling them...” (Lane et al 2009b, p.35).

Examples of outcomes of II order reflexivity processes are:

- governance: here broadly understood as “the whole of interactions taken to solve societal problems and to create societal opportunities; including the formulation and application of principles guiding those interactions and care for institutions that enable and control them”, (Kooiman et al. 2005);
- upgrading in the ways activities are performed in the system, thus making it available new attributes of system functionality. It would endow agents with new ways of dealing with choice, information and action, and ultimately empower their participation in local area’s change trajectories.

For the sake of the present discussion, the scheme in Fig. 3 shows the relationships among the determinants and how they affect the OPERATING and GUIDING SYSTEM.

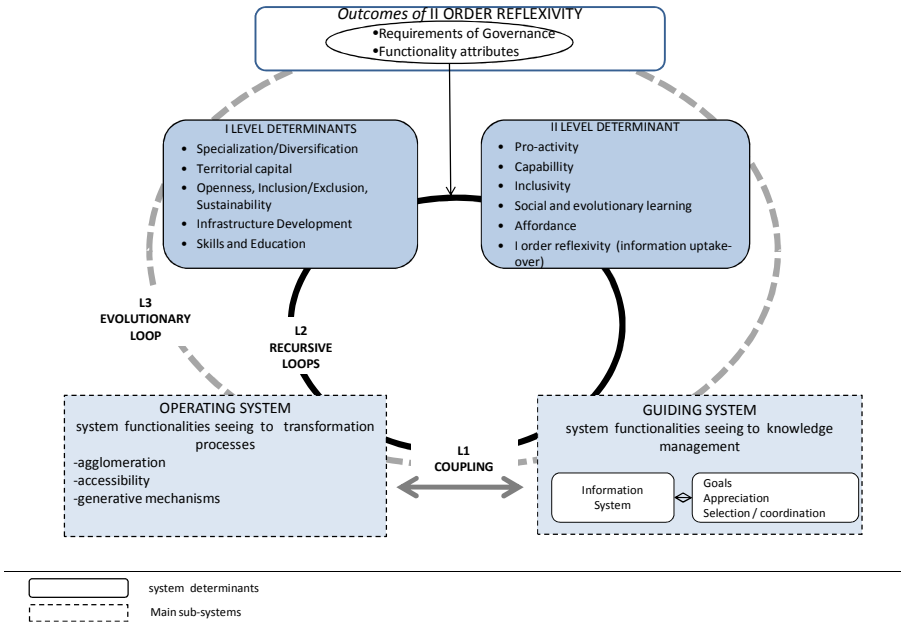


Figure 3 – System functionalities and determinants of regional development

Three main types of loops are emphasized in the scheme:

- L1: the *coupling (horizontal) loop*, which, over short time ranges, within a certain governance regime and given a certain level of functionality attributes in the system,

makes it possible to align the OPERATING and GUIDING SYSTEM. By means of this loop the system would leverage I and II LEVEL DETERMINANTS and undertake the adjustments necessary to continuously adapt to the many impulses produced by a changing environment;

- L2: *recursive loops* which, as a result of L1 processes, and given a certain form of governance and functionality attributes, see to the upgrading and modifications in both the I and II LEVEL DETERMINANTS over the medium time range;
- L3: a so-called *evolutionary loop* which building upon the outcomes of L1 and L2 processes is responsible for changing the system functionalities and governance regime, over the medium-long run.

3.3 ICTs and regional development: instantiating the Innovation Kernel

To accommodate the concept of Innovation Kernel (IK) within the above scheme, Table 2 recalls its constitutive elements (Pollone and Occelli, 2005) and mentions the types of evolution process they would likely to support.

Table 2 – Development of the Innovation Kernel and likely effects

Elements of the IK	Evolution process	Examples of economic and societal outcomes
1. ICTs component	substitution	<i>first order effects: they are produced by the physical availability of ICTs</i> economy: growth of ICT investment; ongoing investment in R&D, spurs to organizational changes society: access to on-line information, reduction of digital divide
2. Information component	co-evolution	<i>second order effects: they stem from the increasing use of ICTs</i> economy: higher productivity, market diversification and more efficient production, new in market relationships society: improved access to better services, new types of community
3. New functionalities	recombination	<i>third order effects: they result from the combined effects of ICT usages by a great number of agents</i> economy: ICTs support a more sustainable paradigm of growth and new solutions for sharing economic benefits society: balancing cultural homogeneity and diversity, co-operative communities, improved citizen participation

The descriptive keys listed in the table indicate that the components of an innovation kernel can themselves be included among the determinants of the local system (for example, broadband infrastructure belongs to the I LEVEL DETERMINANTS, and Internet based information systems to the II LEVEL DETERMINANTS).

For the sake of the discussion, the table also gives some examples of the outcomes, that over time, are likely to be observed in a local area as a result of the activation of the innovation kernel.

They are meant to emphasize the fact that the deployment of the innovation kernel takes place in place and over time. Its different outcomes in fact depend on the agents' capabilities to get hold of ICTs and on local area overall readiness to nurture the growth of the innovation kernel as well.

As observed in the spreading of innovations (Brown, 1981), one can also assume that the deployment process of the innovation kernel would progress by successive steps, and its outcomes be associated with what in Tab. 2 is called first, second and third order effects.

A description of the mechanisms by means of which the innovation kernel would leverage the determinants of a local area and support its evolution over time is graphical offered in the scheme of Fig. 4.

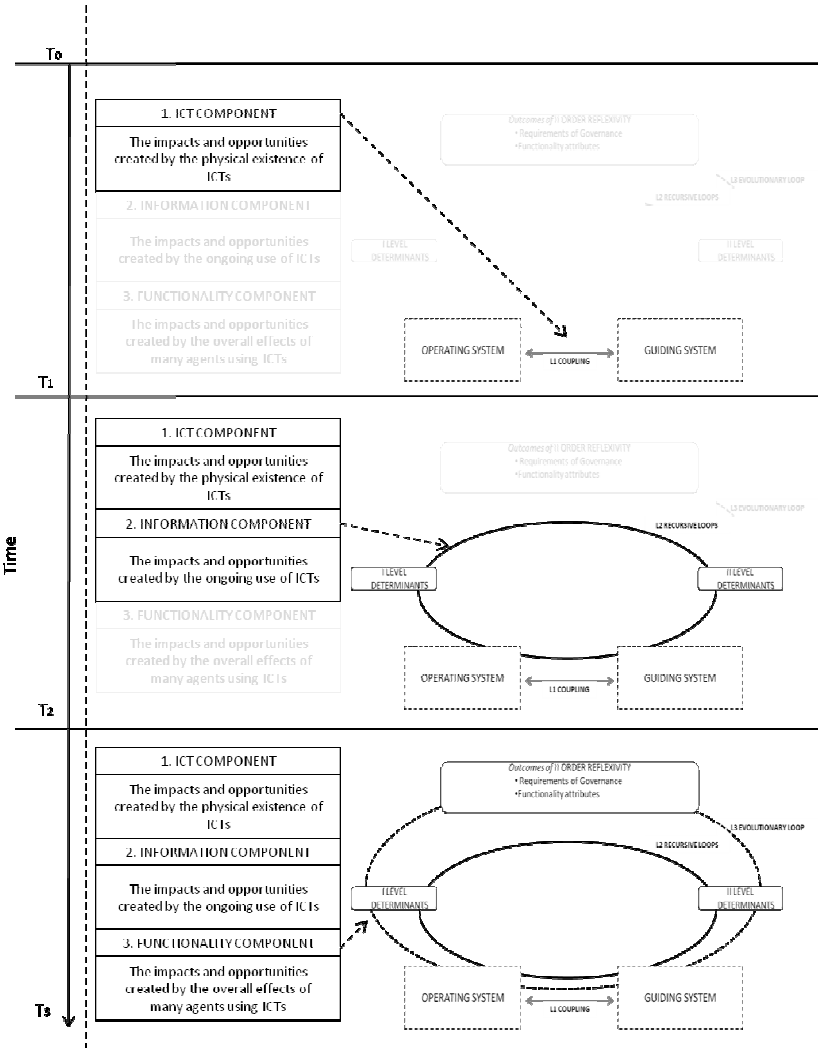


Figure 4 – The Innovation Kernel in action

Although overly simplistic the sketch provides a reference framework for the arguments discussed so far. It is hoped that it might also serve as a basis for policy oriented investigations in real systems.

The scheme depicts an idealized account of the deployment process of the innovation kernel, although it is also inspired by the results of the empirical investigations carried by the Piedmont Observatory over the last years.

It assumes that when, at a certain time (say t_0) the innovation kernel appears in a local area, the ICT component is then leveraged firstly, at time t_1 . As it mainly affects the communication relationships, it is supposed that this component would primarily improve the alignment between the OPERATING and GUIDING SYSTEM, i.e. by shortening the time necessary to their coupling and/or by overcoming the friction imposed by the distance which can exist between the two systems. On-line access to services by citizens, firms and local governments are examples of this improved alignment.

Then, as the ICT component is progressively appropriated by the different agents, the information component becomes increasingly apparent (at time t_2). Together the ICT and information components, can modify the ways the relationships among the system agents are established, thus changing the patterns of system relationships. As a result, a cascade of changes are triggered (by means of the recursive loop mentioned above) which involve both I and II LEVEL DETERMINANTS. Examples of the effects produced by this stage of development of the innovation kernel are manifold and can be found in all the societal organizations; they include changes in firms' supply chains, on-line interactions with local governments by citizens and firms, and the formation of on-line communities.

It is at this developmental stage that the transformations in I and II LEVEL DETERMINANTS yield those traits likely to generate novel socio-technical networks.

These entities can be understood as an organisational and cultural paradigm which, through technology, bring functional and relational elements together, making way for a plurality of organisations of social networks. They form comprehensive systems encompassing human and technological elements, interacting together by means of various social and technical relationships (Berra, 2007). No supremacy exists by one type of network over the other in shaping the resulting socio-technical system, although each one can play a specific role as the whole network is progressively established and changed over time (Berra and Occelli, 2008).

Finally, at time 3, as these (ICT-based) networks expand and progressively consolidate, new attributes of system functioning can appear. In so far as these networks would prompt and

reinforce learning processes, while allowing more effective and educated, participation, self-steering capability (II order reflexivity) of the local area may be improved.

As a result new governance requirements can be established and set the context for growing another innovation kernel.

4. Concluding remarks

The role of broadband in contributing to the local performance and growth has a relevant place in the theoretical and empirical discussions. However, the majority of the studies undertaken so far concentrated on the process of broadband implementation, without addressing the potential benefits that its usages may accrue to the overall system. In particular, the generative conditions that broadband might create in a local area, while boosting innovative developmental paths are still overlooked.

The present study made an attempt to address these issues.

It outlined a framework of analysis for accommodating the role of Innovation and Communication Technologies (ICTs) and of broadband among the determinants and processes of regional development. The concept of a regional system as a Human Complex Adaptive System was put forward and developed to account for ICTs as enabling factors in regional evolution. In this context a view that ICTs can be understood as an innovation kernel, was also put forward and a stylized account of its developmental process in a regional system suggested.

Although still far from being definitive, the discussion exposed a number of aspects, and namely those related to the role of reflexivity and of ICT based socio-technical networks, which should be given deeper attention in future research⁸.

For example, referring to the innovative role of ICTs, questions are raised about how to better account for the impact of broadband in sustaining not only other ICT based innovations, but also the associated network externalities (Atkinson, 2007) which, locally, may be leveraged for innovative developmental path. The analysis of the diffusion of innovations should also be extended to consider the expected beneficial impact that ICT based socio-technical networks can produce in improving social practices and creating more socially robust community

⁸ Actually this is the realm of complexity science and its contribution can be substantial (for a review, see Rullani, 2003 and 2009, Bertuglia and Vaio, 2009).

A further concern is how to better take into account the normative/behavioral aspects that underpin every social practice and modulate the acceptance of novel ICTs based usages.

Finally, a challenging research topic is related to the learning capability of the overall system in seeing to its evolution over time. A point to note here is that usages of ICT artefacts and collaborative socio-technical networks can have a crucial role in this regard, in particular in supporting the co-evolution between the OPERATING and GUIDING SYSTEM. In fact, for certain services. For certain collective services, the knowledge leveraged by the ICT systems embedded in these networks, can increase the quality (and value) of the delivered services and raise users' perception of their public value, while helping to establish new forms of democracy (Coleman, 2001). It might also spur, by means of trust enhancing socio-technical networks, actors' contributions to collective goods (Castells, 2004, Kahan, 2002).

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