TECHNOLOGICAL CONVERGENCE VS KNOWLEDGE INTEGRATION

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ABSTRACT
Today Information and Communication Technologies (ICT) make it available a novel superimposing environment, i.e. *an information-wired environment*, which concocts innovative system functionalities, i.e. new artifacts, additional capabilities of affordances, new ways to enable reflexive abilities for both individuals and organizations.
Within this environment, also the lines of enquire traditionally adopted in the analysis of urban systems are modified and may play a novel role in supporting agents' decision-making and behaviors. The discussion is laid out as follows. First, in section 2, the major contribution of ICT to the evolution of today urban systems is emphasized. This stems from the intrinsic components of innovativeness underlying ICT, which enables the building of an in*formation-wired environment.* Next, in section 3, the main methods of enquire of urban systems, i.e. models, indicators and spatial representations are briefly recalled. Finally, in section 4, a few implications as far as the modification of the role of existing methodologies are discussed. It is argued that in the information-wired environment created by ICT that role is strengthened, i.e. methods of enquire act as cognitive mediators in that environment. This strengthening, however, does not simply result from technological convergence, which makes methodological approaches easier to integrate. Rather it stems from a deeper integrative process based on knowledge integration, which human agents, - within a reflexive urban system coupled with an enabling *information-wired environment*- would be capable to instanciate.

Key words: Information and Communication Technologies, urban reflexive system, cognitive mediator artifacts,

RÉSUMÉ.
Les nouvelles Technologies de l'Information et de la Communication (TIC) mettent à disposition un nouvel environnement, un *information-wired environnent* qui contient en puissance de nouvelles fonctions systémiques – des artéfacts permettant de nouvelles capacités d'apprentissage par interaction (affordances), de nouvelles capacités réflexives pour les individus et les organisations. Dans cet environnement même les approches d'analyses utilisées dans les études des systèmes urbains sont modifiées et peuvent avoir un nouveau rôle dans la prise de décision et les comportements des agents. Le texte discute d'abord le principal apport des TIC à l'évolution des systèmes urbains. On soutient que celui ci découle de la particularité des TIC ne pas être des innovation comme les autres. Ensuite on rappelle les principales méthodes d'analyse des systèmes urbains, les modèles, les indicateurs et les représentations spatiales (les cartes) et on essaye de montrer comment leur rôle est affecté par les TIC. Une conséquence relève spécifiquement du fait que les méthodes d'analyse seraient des médiateurs cognitifs, qui permettraient aux agents de mieux se rapporter à leur environnement. Cette possibilité néanmoins ne dépend pas seulement de la convergence technologique qui permet aux différentes approches de mieux s'intégrer, mais découlerait d'un processus plus profond d'intégration des connaissances. Celles ci étant mit en œuvre par des agents humains qu'ils sont capables de déployer dans un système urbain réflexif couplé avec un *information-wired environment.*

MOTS-CLÉS : Technologies de l'Information et de la Communication, système urbain refléxif, artéfacts de médiation cognitive

Paper presented a Les Journées Annuelles Transdisciplinaires de réflexion au Moulin d'Andé, Colloques AFSCET, May 13-14, 2006.

1.Introduction

This paper deals with the role of methodologies as a spur to knowledge yielding and learning as a fundamental asset in supporting policies in which human systems are both targets and actors.
Methodologies are here understood in a rather general sense as organizational paths of thinking attitudes whose major advantage ultimately rests on their ability to disentangle coherent features of human endeavors.
The discussion aims to pinpoint some features of this role in an age, widely popularized as the information age (see Castells, 1989), in which economic, cultural and technological changes along with paradigm shifts are the encompassing rules.
It builds upon a few ideas originally put forward in the late nineties (see Occelli, 1998), several of which have been progressively extended in later research works (see Occelli and Rabino, 1999, 2003, Occelli, 2001, 2002, 2003) and still are topics of current investigation (see Occelli, 2005, Occelli and Staricco, 2005).
Underlying the discussion are three main aspects which, to some extent, are different facets of a same bulk of arguments.
The first is the contention that methodological approaches to urban systems should not be considered simply as analytical devices, characterized by various formalization contents and elicited by a restricted number of experts. Rather they should be viewed as knowledge levers, the application of which yields information gain and keeps learning processes going on.
The second alleges that the above argument is related to a complexity perspective insofar, for an information gain to become apparent, both its entity definition, i.e. the identification of the properties of what ultimately makes an information gain be what it is (the ontological definition) and its ways of enquiry (i.e. the epistemological component) are involved.
The third, maintains that such a complexity perspective is human specific as it bears on a distinctive trait of humans which is rooted in their reflexive ability to make sense of their living experience (see Boulding, 1956, Maturana, 2002). Developing methodological approaches to support policy-making, therefore, would not simply reflect a plugged in effort to put a rationalizing order into a perceived disordered reality. Rather it turns out to be an intrinsic attitude (i.e. a culturally embedded property) of a collective agent to cope with issues which are both socially relevant and collectively pertinent (see Occelli 2005).
Building on these arguments the main point of this note is that today Information and Communication Technologies (ICT), make it available a further dimension which does not simply combine with the existing social, economic and functional ones (see, Mackenzie 2003). Rather, ICT configure a novel superimposing environment, a so-called *information-wired environment*, which concocts innovative system functionalities, i.e. new artifacts, additional capabilities of affordances, new ways to enable reflexive abilities.
A claim is made that within this environment, the existing lines of enquire (methodological approaches) are modified and may play a novel role in supporting agents' decision-making and behaviors. The discussion is laid out as follows. First, in section 2, the major contribution of ICT to the evolution of today urban systems is emphasized. This stems from the intrinsic components of innovativeness underlying ICT, which enable the building of an information-wired environment. Next, in section 3, the main methods of enquire of urban systems, i.e. models, indicators and spatial representations are briefly recalled in relation to the context of the current trends of changes. Finally, in section 4, it is argued that in an information-wired environment created by ICT the role of existing methodologies is strengthened. This, however, would not simply result from technological convergence, which makes methodological approaches easier to integrate. Rather it stems from a deeper integrative process based on knowledge integration, which human agents; - within a reflexive urban system coupled with an enabling *information-wired environment- would* be capable to instantiate.

2. Challenging features of ICT

In the recent debate about ICT emphasis has been put to the fact it is that they entail innovation, and, more specifically, a peculiar type of innovation. Underlying it, in fact, are two inter-linked components (see Ocilla, 2001, 2003, Occelli and Staricco, 2001):

- the *hard component*, which is the tangible part of the innovation, i.e. a type of commodity, a technological artefact, an idea, a behaviour;
- And the s*oft component*, a bundle of intangible aspects related to its operation, which enable the creation of knowledge potentials for both the users, i.e. novel possibilities for agents to learn about their surrounding world and the organizations users belong to, i.e. new roles and functionalities for firms, institution, cities and regions.

This is schematically represented in Fig.1 which maintains that innovation is made by up of three interlinked elements:

- Information and Communication Technologies (ICT), which consist of the set of artefacts set forth 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 ICT, i.e. all the information related activities deemed to affect the value-chain (performance) of a transaction;
- 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 ICT and Information.

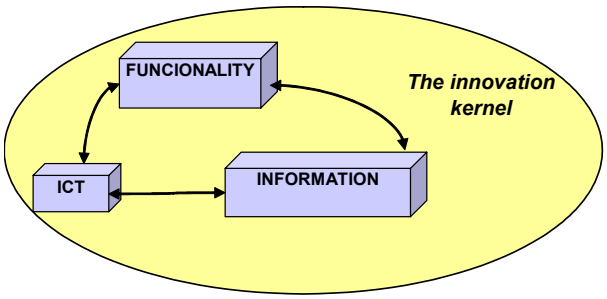

Figure 1 The innovation kernel

A foremost fundamental aspect of innovation is that it is inherent to the evolution of human organizations. This would explain why: a) it is searched for in spite of its usually costly investment and b) positive expectations about new functionalities of innovation are recognized as major drivers of this search (Witt, 2004)[1].

[1] According to Witt (2004), these expectations can be explained in terms of hypotheses related to "the individuals' past present disposition as the motivation for action" (p.10). Major complementary hypotheses about the driving disposition would concern:

- dissatisfaction with the status quo relative to a variable aspiration level, which in turn might reflect earlier successes or failures. According to this hypothesis, therefore, the search for novelty, would be most likely triggered in situation of crisis;
- deprivation of novel mental experiences, relative to the appreciation of cognitive stimuli provided by an environment. Whenever there is a lack of such stimuli, then, individuals may be motivated to create them anew. In this case, the driver for innovation would depend on the preferences for experiencing novelty. Depending on the fluctuating rate of preferences, therefore, innovation is likely to be looked for at a lower but constant basic rate.

Associated with the manifestation of novel situations in human organizations is the production of a whole set of modifications, whose outcomes ultimately depend on how the innovation kernel of Fig.1, will be operated upon along the path of evolution of systems[2].

As far as urban systems are concerned, three main stages of this path have been identified in the literature (see Graham, 2000):

a) substitution, according to which ICT applications would mainly aim at replacements organizational and system functions in order to improve efficiency;
b) 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;
c) recombination, according to which ICT and their operation introduce a further relational dimension which superimposes over the already existing social, economic, spatial and institutional ones. Actually, the technological dimension does not simply plug in an additional layer, but turns out to be generative of new ways of dealing with those relational dimensions.

A schematic representation of the deployment of the innovation kernel is shown in Fig. 2. Initially, as a result of the mere presence of the hard component of ICT, only substitution would occur.

Then as ICT progressively consolidate into the system environment, their effects spread out and become increasingly perceived. New information can be extracted from the enhanced environment, and a range of alternatives of existing function be developed (co-evolution). At this stage, the information component would become fully active, and foster a range of additional transformations which ultimately produce new system functionalities.

At all stages, processes of generation and evaluation of innovations are entailed and differentially put in place. Knowledge, i.e. transferable information and aptitudes to mental novelty, is required to both activate and support the working of the innovation kernel, while, in the process, other types of knowledge may be produced and stocked away into an information-wired environment. These can be exploited to feed other innovation kernels, still at a potential stage, or activate new ones in subsequent stages of system evolution.

3. Methods of enquire in urban system

[2] Novel situations require interlinked processes of expression and evaluation, i.e. the former being the manifestation of novelty, the latter referring to both the acknowledgment and assessment of its realization. As shown in the table, evaluation, is essential for: a) recognizing the appearance of a certain innovation, (i.e. attributing meaning to it), b) favouring its diffusion and c) creating the conditions for its encoding (consolidation) within the existing socio-economic structure. In many cases, undertaking such an evaluation process would also mean adopting a cultural attitude prone to search for mental novelty in order to deal with the solution of current problems, or removing constraints to changes.

Features of innovation in relation to its generation and evaluation processes

	Evaluation process		
Generation process	Usefulness	Viability	Critical aspects
Dissatisfaction of status quo	A) Socio-economic upgrading according to reference criteria in the activity system. Improving activity performances	B) Easing constraints and assessing compatibilities of targeted upgraded socio-economic situations. Supporting competitiveness of cities and regions	E) Intrinsic area non - homogeneity of ICT potentials. Worsening existing disparities. Exposures to external exploitations
Deprivation of mental novelty	C) Identifying behavioural principles underlying socio-economic upgrading. Aligning activity changes with context changes	D) Stimulating agents' responsible engagement in socio-economic development. Cooperative behavioural trends within functional hierarchies	F) Difficulties to reconcile perceived local needs with external requirements and constraints (i.e. UE policies, international trade)

3.1 Premises

Applying the notion of complex system to cities and territories has the unwarranted advantage to make it possible to establish several conceptual links between the many facets of urban phenomena and processes. Apart from the metaphorical advantages of using the notion (see Mackenzie, 2004) we can regard an urban system as complex because (Occelli, 2005), see Fig. 3:

a. it is intrinsically *open* as it belongs to a wide network of socio-economic spatial and cultural relationships that extend beyond its geographical boarders, while possessing a willingness to both self-reflection and update its own systemic descriptions;
a. it is *self-organized,* as its overall organization derives from the interacting behaviours of its manifold components;
b. it is *aware* of its identity and therefore its uniqueness, its various roles in relation to the different networks it belongs to, while being able to evaluate itself, i.e. to assess its own state and needs;
c. it has a *pro-active behaviour* and is therefore open to external relationships and unexpected events, aware of the driving forces underlying its self-organization processes, keen to improve its knowledge in order to face new challenges.

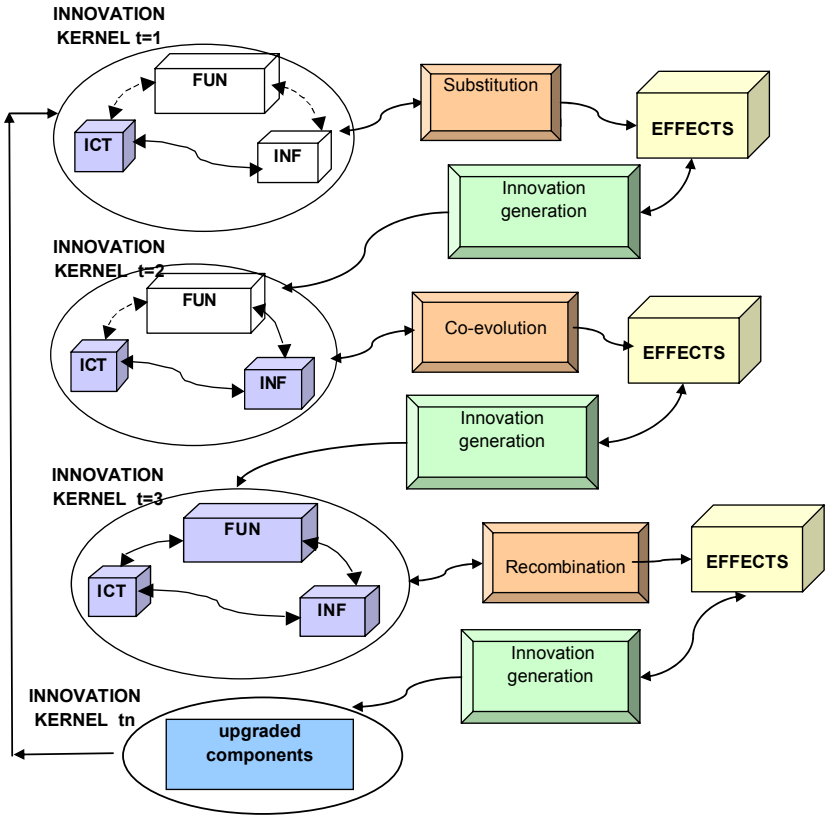

Figure 2 The innovation kernel in action: learning to innovate

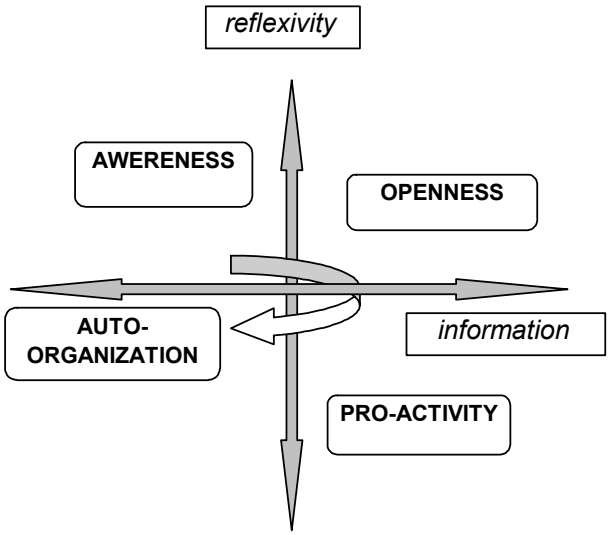

Figure 3. Dimensions of an urban complex system

While the features concerning openness and self-organization have been extensively scrutinized as fundamental attributes of the complexity of urban systems (see Bertuglia and Staricco, 2002, Portugali, 2000, Pumain, Sanders, Saint-Julien, 1989), those concerning pro-activity and awareness have been generally viewed as external. At most, they have been considered as desirable features of a group of agents, i.e. experts, planners and educated people, entitled to steer the evolution of the urban system towards more desirable and sustainable paths of change. This is also detectable in several domains of the urban literature, were two major views can be distinguished (see Occelli, 2004):

- a substantial view, which mainly focuses on the issues related to the functioning and evolution of cities. Topics of interests are the features of the urban phenomena, i.e. the characteristics of the activity systems, transport network, and built environment as well as the processes steering the overall urban behaviours, i.e. the driving forces, inertia, structure of system relationships, temporal deployment. In this view, the city is a complex system sharing the properties of any other living but fundamentally physical systems. Understanding these features and processes is therefore crucial for the theoretical and methodological advancement typically belonging to the scientific domains of the cultural world;
- a procedural view, which deals with the decision-making process underlying the behaviours of both ordinary agents (i.e. individuals, firms and organizations) and stakeholders. The profiles of choices alternatives, evaluation indicators and judgment values are a few ingredients in the procedural approaches the definition of which is rooted in the human mental products. For this view, the physical world is an object of observation/ evaluation on which agents' decisions should act upon. Improving the understanding of the decision-making underlying individuals' behaviours is thus important to explain the structuring and evolution of urban phenomena.

Since the eighties, a number of efforts have been undertaken to better integrate the two views (for a general overview see Bertuglia, Bianchi, Mela eds. 1998). The growth in desktop computing and the diffusion of communication and information technologies, i.e. information systems and GIS, played a significant role in this respect. A confident view was held that a clever linking of the components pertaining to the physical and cultural worlds would enable analysts (and planners) to yield a sounder understanding of the novel or unexpected kind of phenomena likely to occur in modern city. To date, however, the expectations do not seem to have been fulfilled yet.

Acknowledging pro-activity and awareness as additional attributes of city complexity essentially means that there exists a reflexive property, which is intrinsically constitutive of an urban system.

i.e. a collective agent constituted by an interacting group of social cognizant agents supported by a physical, social and technological environment, see Fig 4[3].

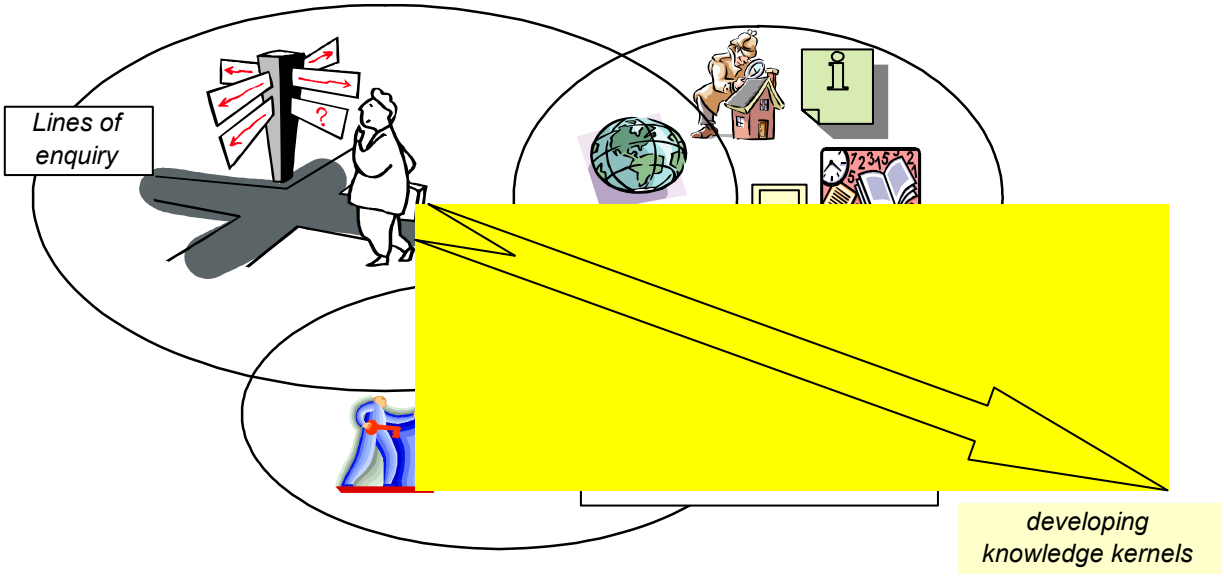

Figure 4. Blocks of a reflexive urban system

3.2 Analytical methods as cognitive mediators

In urban analysis three kinds of analytical tools are most frequently used (Occelli, 1998): a) indicators, b) models (and by models we include all those methods which are relevant for urban analysis) and c) graphical representations, such as maps.
Underlying their logical and operational assumptions, there is a common goal, and namely the creation of knowledge gains. This is one major point which has been most widely emphasized in the information oriented perspective of urban system analysis and which has guided the integration between the above mentioned substantial and procedural views, see Fig.3.
When considering the reflexive oriented perspective, however, one has also to deal with the various relationships by which in a reflexive urban system analytical tools are operated upon. That means that one has to:

- understand human affairs, that is to define a notion of *human activity system, i.e.* a system model of the activities people need to undertake in order to pursue a particular purpose;
- acknowledge that the knowledge models which are produced are primarily epistemological devices used to find out about the real world;
- recognize that in reflexive urban systems knowledge models are contributions to a debate about a possible change.

[3] In this regard, Maturana's arguments about the drive of the explanatory search for understanding which characterizes a living being can be understood as an internal drive of an urban system (Maturana, 2000). The search for truth, the search for operational coherence and the search for mythical causes are major attitudes, which are involved in that search. Another attitude, even more relevant, is to explain how urban agents operate as observers by asking reflexive questions about how they do what they do. Associated with the acknowledgment of reflexivity is the fact that in the process, knowledge gains are created which set out themselves according to both their epistemic and ontological dimensions.

Within this framework, the above mentioned analytical tools share a substantial similarity as far as the path leading to the provision of the information gain is concerned. As a result they can be viewed as part of a large family of knowledge tools which have been labelled cognitive mediators (see Occelli, 2001, 2002). Although the term has been originally coined in relation to the modeling activity it can be extended to include also the indicators and maps, see Fig.5. The common thread resulting from several facts and namely from:

- the fact that a general structural-cognitive shift has occurred in the urban domain, i.e. from a view according to which modeling is an activity through which an understanding of the organizational structure of an urban system is obtained (the *structural perspective). A* model therefore would be a simplified representation of both urban phenomena and the ways they are produced. To a view in which modeling is an activity for testing, exploring, creating and communicating knowledge about certain urban phenomena (the *cognitive perspective)*. Models therefore would be means for representing the working of our knowledge hypotheses, and of their outcome.
- the fact that, in this shifts a new role for analytical tools is being created. They, in fact, acts *as cognitive mediators*, between a so called internal loop, i.e. that related to the conventional steps underlying a process of abstraction, and a so-called external loop, i.e. that representing the general context of a modelling activity. As the observable is no longer the only link between the two loops, cognitive mediators, allow us to establish and investigate the various relationships likely to be established between them. In this respect ;
- the fact that some major aspects of novelty of the currently used *cognitive mediators,* such as simulation models, GIS systems and indicators' data-bases, are related to both their overall tasks (i.e. aims and functions of the tools) and technological support (i.e. the computer environment, HC interfaces, portability);
- the fact that the form of cognitive mediation enabled by a certain tool is not unique but could be instantiated in several ways, depending on the type and role of the tool as well as on the engagement of the users.

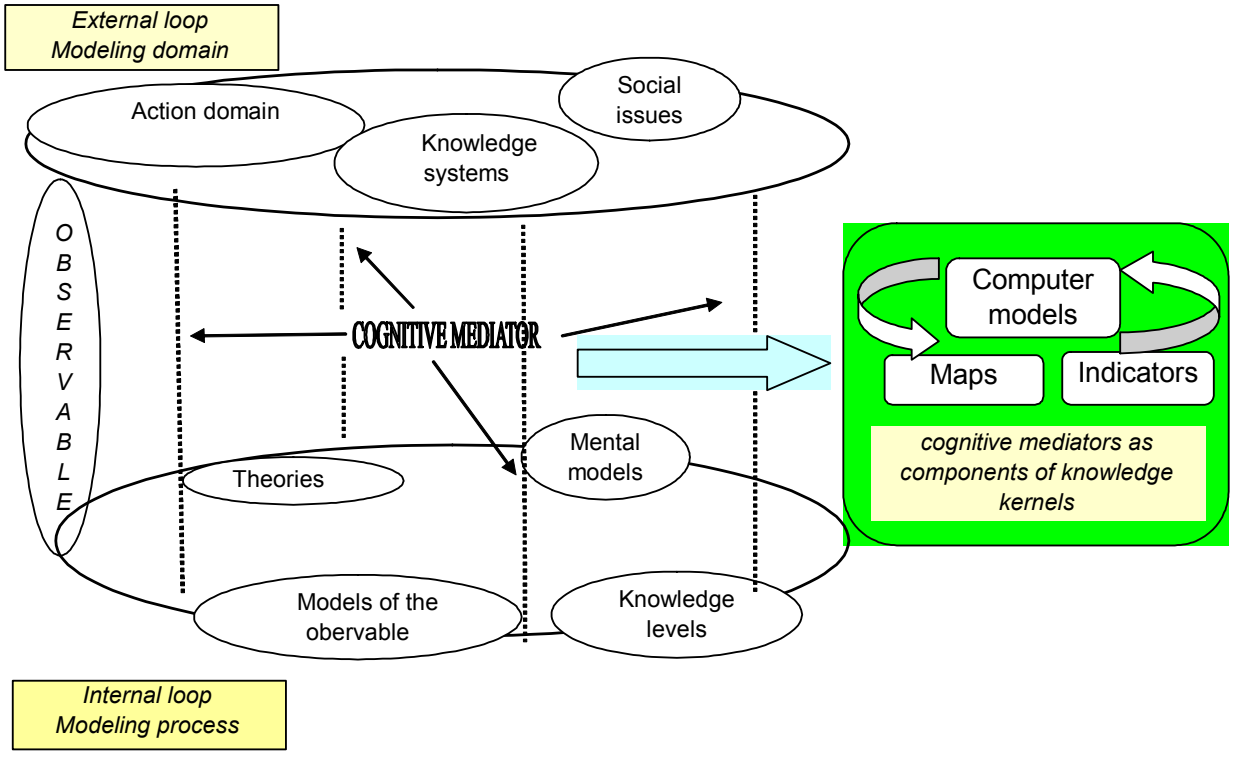

Figure 5. Analytical tools as cognitive mediators

A cognitive mediator has three main components (Occelli, 2002):

a. a syntactic component, which entails a method of analysis (i.e. a coherent set of steps of enquire) which through an abstraction process (the encoding and decoding process) yields an explanation of the mechanisms underlying the observed urban phenomena;
b. a representational (semantic) component, related to the sense associated with the representations of the phenomena provided by the cognitive mediator artifact. The kind of system structure we refer to in our view of city and the meaningfulness of the relative urban descriptions conveyed by the model are crucial aspects of this component, i.e. the range of prototypical images which are produced by humans' perceptions and categorization of cities (i.e. the kind of Inter-Representation Network linking internal and external maps, see Portugali, 2000);
c. a knowledge project component, associated with the purports of the investigation project underlying a certain application (i.e. aims of the model application, resources required for the model implementation, expected results, etc.).

4. Cognitive mediator artifacts within an information-wired environment

Being rooted in the pro-activity of the reflexive urban system (see Fig.2), the knowledge project component endows cognitive mediator artifacts with an additional functional role: providing the linking between the conceptual understanding of how knowledge contribute to system goals and the practical issues of how to achieve knowledge based solutions that meet those goals[4].It is this second-order linking, compared with the first-order type of relationships shown in Fig.5, which is mostly sensitive to the *information-wired environment* created by ICT.
Three aspects of this linking can be emphasized which may have relevant implications in policies concerning the human activity system.

A) The first concerns the fact that underlying the notion of cognitive mediator artifact is the idea of *embodied information*. It reflects the fact that in human decision-making, hardly ever, the relevant information is available in the agent's mind but need to be extracted from the environment or from a certain contexts (which may be created by interacting agents). Information is encoded in the material world, it is situated and embodied in it and may become apparent (accessed to by agents) in certain context situations. This is at the basis of the concept of *affordances*, i.e. the potentialities held by objects for certain actions, originally introduced by Gibson in the field of ecological psychology (see Knappett, 2003).
In an ICT *information-wired environment*, not only cognitive mediator artifacts possess the attributes of technology (Morrison and Morgan, 1999), thus revealing their strength as they are used, but:

- as they increasingly rely on computing technology they can have their own hardware and software identity. In this regard, they can facilitate the deployment of the innovation kernel, we mentioned earlier, and make its evolutionary path more robust (i.e. think for example to the

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4 In this respect it can be related to what has been called the Knowledge Flows Approach (Newman, 2002). This can be broadly understood as collections of actions performed by agents on artefacts towards some meaningful end. Central to the approach are three main elements:

- agency, as a property of an entity to perform transformations on artifacts (see Conte, 2000, Vink, 2000):
- an artefact is a product of a human activity, which didn't exist before that activity and can't be understood outside that activity;
- the use of an artefact transforms the activity for which it was originally conceived. The transformations relate to the re-organization of the means by which both the interactions with the environment and the planning of actions and social relations take place.

possibilities for human agents to sharpen their exploratory ability, while neglecting a number of cognitive burdens which are dealt with by the embedded technologies of the information wired environment);

- they can also set up scaffolding structures for the linking functions between the external and internal loops of a modeling process, thus providing human agents with new ways of interacting, (i.e. think for example to the new possibilities offered by web-sites as higher order artifacts, capable to act as knowledge multipliers).

B)The second aspect is related to the fact that, thank to an *information-wired environment,t* cognitive mediator artifacts are essential supports to what has been called the knowledge leverages of a reflexive urban system, and namely, see Tab.1:

- recognition, the identification of knowledge needs in order to sustain a pro-active endeavour;
- guidance, how to make effective the recognized knowledge needs, in order to get involved in a purposeful line of enquiry ;
- capability, the achievements of social valued outcome for somebody who cares.

Leverages		Problems they address	Expectations	Leverages in action: the filtering process
Recognition	Identification of the knowledge needs	Creating shared understanding	Agent engagement and self-aware community	Leveraging knowledge
Guidance	Insights required for delivering the recognised knowledge	Bridging and sharing knowledge chunks	Living collective memory, self-organizing cultural repository	Mapping knowledge, and road maps
Capability	Accomplishing some results of value to someone who cares	Information overload, but limited attention	Making the relevant information available	Nurturing communities

Table 1. Knowledge leverages in a reflexive urban system (adapted from Vetschera and Koszegi, 2001)

B) A final aspect, which also reads as a provisional conclusion, emphasizes the fact that– by favouring the integration of knowledge in a non-reductionist way (see, Fig.5) - cognitive mediator artifacts are, in the current information age, knowledge generators. They imply in fact a constant rethinking of both the ways and means by which urban system are looked at..
This is clearly reflected in the parallelism one may find between the technological layers involved in ICT applications and those underlying the implementation of a cognitive artefact, see Tab 2.

Technological layers (see Rosembloom, 2004)	Cognitive mediator layer (see Occelli and Rabino, 2004)
Organization layer. It aims to support groups of people in working towards common goals	It aims to set the problem: how to think about WHAT do to, i.e. what to do IF
Interface layer. It provides easy ways for people to interact with the environments	It organizes the entity to be investigated and their relationships
Environment layer. It deals with the organization of resources (knowledge and contents) over domains of interests (i.e. human body, the city)	It searches for the range of possible actions which are responsible of the system's behavior
Grid layer. It converts networks of platforms into shared resource pools. It provides services yielding uniform access across the set of networked resources	It aims to identify the representation levels of phenomena, windows of observation
Network layer. It provides connectivity among multiple platforms	It identifies the most appropriate available tools of investigation
Platform layer (PDAs, equipments, computers). It provides the range of resources to be embedded in the environments	It looks for the significant information and perceptions

Table 2. Hierarchy of technological layers and connections with the layers involved in the implementation of a cognitive mediator artifact

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