A **Network** of Digital Business **Ecosystems** for **Europe:** Roots, Processes and Perspectives

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Introduction

This introductory paper summarises the needs and the processes that have led to the concept of digital business ecosystem (DBE), the impact that this area of research aims to achieve, and the scientific and conceptual perspectives that have been uncovered by this approach. This area of research and policy development is still in its infancy. With the progressive coupling of the different areas of knowledge that are related to DBEs and the construction of a multidisciplinary community, the objectives have evolved since the first paper of 2002, and we now have a better understanding of the process and the scientific and conceptual challenges ahead. Although the link between learning, or knowledge transfer, and economic development is by no means a straightforward one, by leveraging an evolutionary and open knowledge approach we have been able to engage diverse communities of small and medium-sized enterprises (SMEs) in several regions of Europe in the adoption of state-of-the-art business modelling, software development, and run-time environments.

The DBE ecosystem community realised that to bring into existence information and communication technologies (ICTs) that help in the achievement of the challenges identified by the objectives of the Council of Lisbon (higher growth, more and better jobs, and greater social inclusion (COM 2004)) we needed to widen our horizons with a more holistic and systemic approach. In addition to ICT, this new approach should consider socio-economic aspects and the human perception, communication and representation dimensions in one single research domain. This approach, applied to social and economic processes and their digital representation, is consistent with the changes in the production processes brought by networks of users/producers (Benkler, 2006), which have clarified the processes of technological and social innovation and have helped us imagine the development of (post-) industrial policy (O'Callagan, 2004).

The interaction between research strands in philosophy of science, epistemology,[1] cybernetics, information theory, linguistics, and communication theory brought to a revolution in the studies of human behaviour, interaction, and communications, led by the Palo Alto school (Watzlawick et al., 1967; Bateson, 1972). We do not know whether the DBE research effort will lead to a new science of the interaction and communications between economic and digital actors. For a new science similar to the development of the general systems theory (Bertalanffy, 1969), the path still has to be forged.[2] But the vastness of the scientific challenges and of the research we are beginning to discern does not imply that the findings will be transferable to the market only after several years and that such endeavour will produce a tangible social and economic impact only in the long-term. It has been verified in the field that the evolutionary mechanisms grounding this research area, even in their initial rudimentary implementation, could be successfully applied and transferred,[3] activating services and mechanisms capable of becoming more intelligent and effective over time.

The different areas of science, but also the actors involved in the process, have just started to communicate and express themselves using common languages and models. This is also reflected by the division of the book in four sections: Science, Economic and Social Aspects, Technology, and Adoption, expressed with different disciplinary languages whose integration is not always visible. It is also reflected by this introduction written in common by people from academia, public administration and business. Nowotny et al. (2001) argue that knowledge in contemporary societies is increasingly produced in new, more complex contexts and by an increasing number of participants. This they term mode-2 knowledge, as opposed to mode-1 knowledge which characterises the more clear divisions of the institutions of knowledge of modernity. This book presents the state of the art today, the findings so far, and the initial achievements of the process towards a common understanding; it presents the first applications to the economy of a few regions, but also the future perspectives. We would also like to give an idea of the new areas of research that have been uncovered, and a sense of the amount of research still to be done. A book is not the best medium, it is only meant to provide some teasers to stimulate the curiosity and the willingness to contribute to a shared enterprise.

In this introductory chapter we will give a high-level overview of the conceptual foundations, assumptions, and principles from which a rationale is emerging for the Digital Ecosystems methodology for sustainable socio-economic development at the regional scale. Whereas 'sustainable development' usually carries environmental connotations, in

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1) In Latin countries epistemology is associated with philosophy of science. In Anglo-Saxon countries it means the study of knowledge, or the analytical apparatus by which one can distinguish true from false knowledge relative to a set of beliefs. In this paper we mean the latter, which necessarily carries a connotation of knowledge creation—e.g. "epistemic community" (Latour and Wolgar, 1979; Knorr-Cetina, 1999).

2) "Caminante, no hay camino, se hace camino al andar" ("Travellers, there is no path, paths are made by walking") (Machado, 1912).

3) As illustrated in Section 4 of this book "Case studies Technology Transfer and Digital Ecosystems Adoption"

Digital Ecosystems research it refers to the balancing effect that a greater level of integration of the social and cultural context with the economic life of a region is assumed to have on its long-term economic viability. As shown in Fig. 1, starting from an agreed overarching goal of economic development and from basic assumptions of democratic processes and fair competition, several principles, theories, and processes are summoned to understand which ICTs and which organisations and processes can foster innovation and dense communities of users, leading to a vibrant Knowledge Economy. The original digital business ecosystem vision (Nachira, 2002) is therefore revisited here on the strength of the outputs of four years of research by traversing most of the topics shown in this figure. This article and the rest of the book will visit some of the concepts shown on this map, sometimes following a recognisable path, sometimes jumping around to satisfy other presentation rationales, such as chronology. This figure, which purposefully juxtaposes the concepts of 'Research' and 'Development' to highlight their dual role, is necessarily a radical oversimplification of the many ideas and concepts discussed in this book. Given the very significant complexity of the interdisciplinary field of Digital Ecosystems research, and its frequent forays into very theoretical research as well as very applied and action-oriented research (Lewin, 1946) through direct engagement with the software industry and socio-economic stakeholders, we hope this simplified map will help the readers keep their bearings as they make their way through the maze of this book.

Fig. 1

Research and Development in Digital Ecosystems
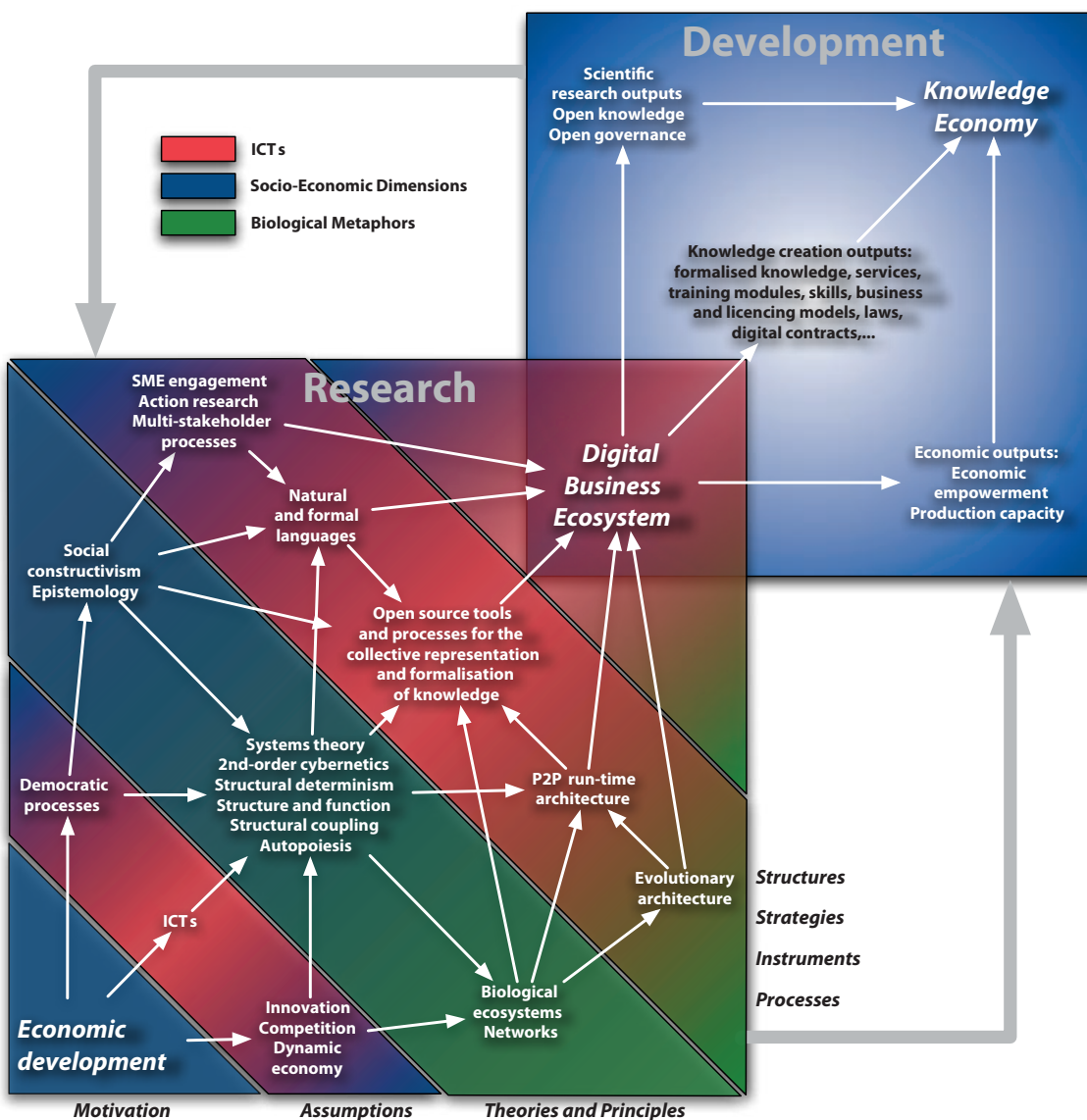
Origins

The research area related to Digital Business Ecosystems was triggered by the initiative Go Digital (EC, 2001a)[4] aimed at boosting ICT adoption by European SMEs. It is generally thought that ICT is one of the major contributors to economic growth and economic efficiency: "The decline in EU labour productivity growth rates in the mid-1990s was attributed equally to a lower investment per employee and to a slowdown in the rate of technological progress" (Kok, 2004).

In the presence of roughly 20 million small and medium-sized enterprises (SMEs) in the EU25, which make up more than 99% of all European companies by number and approximately 50% of European GDP, the Lisbon Strategy's call (COM, 2004) for "…the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social inclusion" by 2010, was interpreted as a need to boost the SME sector in Europe. Furthermore, statement like "ICTs are central to boosting productivity and improving competitiveness"; "Public and private information and communication technologies contributed nearly 50% of EU productivity growth between 2000 and 2004" (EC, 2007); and "European productivity growth could be significantly accelerated if organisations made more and better use of ICT in their organisations and production processes" (Price Waterhouse Cooper, 2004) indicated that the general policy consensus was oriented towards the achievement of the Lisbon objectives through greater ICT adoption on the part of SMEs.

ICT is also an economic sector in itself. Indeed in 2006, the ICT sector added 5.3% value to EU GDP and 3.6% of EU employment. It also accounted for 25% of total EU research in business (EC, 2006). ICT increasingly forms an integral part of all industrial and service markets through the integration of ICT in goods or service offers. Crucial for the economic development is not only the adoption of ICT, but also the diffused capacity to master ICT technologies. Local ICT industry and skill, in addition to the related employment, is an instrument of autonomy and sovereignty and provides the capacity to develop and adapt ICT to local needs.

It is difficult to characterise SMEs and their behaviour since they are involved in all industry sectors and business domains, having developed along all possible organisational forms and company structures, and continually inventing new ones. Like all companies, however, SMEs are heavily networked in a web of business and social links with their suppliers, clients, and business partners distributed at all geographical scales. These networks can be physical and logistical or virtual, they can be local or global, or a combination of all of the above. As discussed in the literature of industrial districts, technology clusters, and growth nodes (O'Callagan, 2004), it has been clear for many years that companies of all sizes benefit from network effects, which can be defined as the greater-than-linear increase in utility derived by a network node with the increase in the total number of nodes of the network.

The European Commission, in recent years, has invested in programmes in support of SMEs, providing grants and support to single SMEs. Such direct investments—in a necessarily limited number of individual SMEs—can achieve only limited results. This is especially true when favourable conditions for business are not present, e.g. appropriate legislative framework; human capital, diffused knowledge and skills; technical infrastructures; entrepreneurial culture; and critical mass of available services. Such programmes should rather become focused on creating favourable environmental conditions and ecosystems of innovation: "Like individual plants or animals, individual businesses cannot thrive alone—they must develop in clusters or economic ecosystems" (Moore, 2003).

Thus, the Digital Ecosystem initiative was based on the assumption that public sector intervention should be aimed at creating favourable conditions for business. The optimum scale of intervention was judged to be at the regional level, where a multi-stakeholder process of policy development and implementation was likely to be more effective. The policy to support SMEs shifted from an individual approach to an approach focused on the context, aimed at building environments favourable to SMEs' business and their networking, compatibly with the EC policy for "Helping SMEs to go digital" (EC, 2001a), which set three priorities:

1. promote a favourable environment and framework conditions for electronic business and entrepreneurship
2. facilitate the take-up of electronic business
3. contribute to providing Information and Communication Technology (ICT) skills.

It is worthwhile to note the integrated approach which stresses the creation of an environment, a business ecosystem, and the need for IT skills.
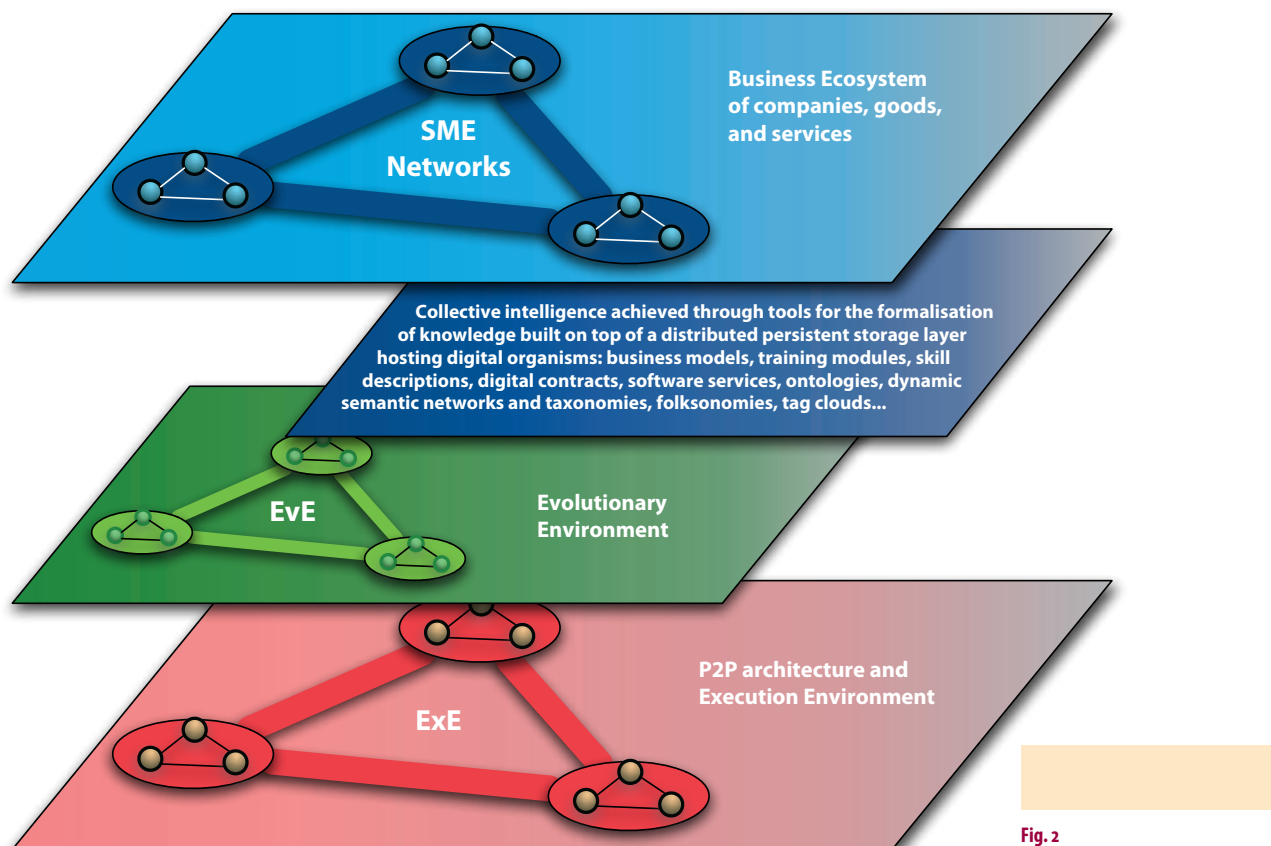
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4) http://ec.europa.eu/information_society/topics/ebusiness/godigital/index_en.htm

The Digital Business Ecosystem

The synthesis of the concept of Digital Business Ecosystem emerged in 2002 by adding "digital" in front of Moore's (1996) "business ecosystem" in the Unit ICT for Business[5] of the Directorate General Information Society of the European Commission (Nachira, 2002). In truth, Moore (2003) himself used the term Digital Business Ecosystem in 2003, but with a focus exclusively on developing countries. The generalisation of the term to refer to a new interpretation of what "socio-economic development catalysed by ICTs" means was new, emphasising the coevolution between the business ecosystem and its partial digital representation: the digital ecosystem. The term Digital Business Ecosystem can be "unpacked" as follows (Fig. 2):

Digital (ecosystem): the technical infrastructure, based on a P2P distributed software technology that transports, finds, and connects services and information over Internet links enabling networked transactions, and the distribution of all the digital 'objects' present within the infrastructure. Such 'organisms of the digital world' encompass any useful digital representations expressed by languages (formal or natural) that can be interpreted and processed (by computer software and/or humans), e.g. software applications, services, knowledge, taxonomies, folksonomies, ontologies, descriptions of skills, reputation and trust relationships, training modules, contractual frameworks, laws.

Business (ecosystem): "An economic community supported by a foundation of interacting organizations and individuals—the 'organisms of the business world'. This economic community produces goods and services of value to customers, who themselves are members of the ecosystem". (Moore, 1996) A wealthy ecosystem sees a balance between cooperation and competition in a dynamic free market.

Ecosystem: a biological metaphor that highlights the interdependence of all actors in the business environment, who "coevolve their capabilities and roles" (Moore, 1996). Also, in the case of Digital Business Ecosystem, an isomorphic model between biological behaviour and the behaviour of the software, based on theoretical computer science implications and leading to an evolutionary, self-organising, and self-optimising environment (Evolutionary Environemnt or EvE).

Business Ecosystem of companies, goods, and services

SME Networks

Collective intelligence achieved through tools for the formalisation of knowledge built on top of a distributed persistent storage layer hosting digital organisms: business models, training modules, skill descriptions, digital contracts, software services, ontologies, dynamic semantic networks and taxonomies, folksonomies, tag clouds...

Evolutionary Environment

EvE

P2P architecture and Execution Environment

ExE

Fig. 2
The stack view of the Digital Business Ecosystem [6]

5) Now Networked Enterprise and RFID Unit, Directorate General Information Society and Media.
6) Inspired by work of Thomas Kurz, Salzburg University of Applied Sciences

Bringing these three terms together has been effective in broadening the appeal of the approach to a wide range of stakeholders from academia, industry, business, and policy-making. However, it has also rendered a clear explanation of what the three terms mean *when used together* very difficult. It is especially challenging to show how these three terms necessarily imply some characteristics of the technology and not others, or how they imply some policy and governance choices and not others. The understanding of the term 'digital ecosystem' and of the stakeholders that populate it has developed during the course of the research over the last few years. For example, research conducted in the context of the DBE IP has highlighted the importance of Regional Catalysts and other intermediary actors such as professional associations or volunteer open source communities. This has led to the broadening of the conceptualisation of the term 'business'. This book could therefore be seen as a sort of "state of the art" of the Digital Business Ecosystem concept and research in 2007, partly based on the experiences of the FP6[7] projects of the Technologies for Digital Ecosystems Cluster, with specific relevance to the Digital Business Ecosystem Integrated Project (DBE) that ran from November 2003 to January 2007. The purpose of this introduction, in turn, is to provide a high-level map within which the book's contributions can be located more easily as part of an integrated vision.

Networks

Digital Ecosystems were made possible by the convergence of three networks: ICT networks, social networks, and knowledge networks. The networked connections enabled by the Internet and the World Wide Web grew along the links of the pre-existing and underlying social, professional, collaboration, and business networks between governments, researchers, businesses, companies, and friends. Computing environments likewise spilled over from the single computer to the local area network (LAN) at first, and eventually to the global Internet. Networked computers motivated the development of distributed architectures and shared resources, culminating in the peer-to-peer (P2P) model. The faster and more pervasive communications enabled by the technology reinforced the already existing trend from a material economy based on manufacturing toward a service economy based on knowledge production and distributed value chains.

If limited to these aspects, Digital Ecosystems are not very original: in information and communication technologies often a group of applications complementing a specific product or platform is considered to form a "digital ecosystem"[8]; the ICT and media companies form a "digital ecosystem community".[9] In order for "large-scale" concepts such a Information Society to make sense in the context of economic development, however, they needed to be operationalised in terms of concepts meaningful and useful to the many facets of the economic life of the individual economic players experiencing this historic transition chiefly (and often painfully) through their yearly variation in turnover This led to the extremely difficult challenge of invoking increasingly theoretical principles and ideas in order to understand how we could succeed in developing practical software technologies that reflect the social and economic relationships between people and economic actors, that could be easily adopted and mastered by European SMEs, and that would bring measurable economic gains. The answer has been, in part, to identify ICT adoption and social networking with a *process* rather than an *event*. This required the integration of the technological approach with a social science perspective, and the introduction of a holistic view of the resulting techno-social and economic system inspired by the multi-scalar biological ecosystem metaphor.

Scale and Topology

Empirical observation and the historical record in many different cultures and parts of the world indicate that economic development, industrial districts, and more recently technology clusters tend to be co-located geographically. The explanation for such a phenomenon uses a mixture of efficiency and cultural/social arguments. The interpretation favoured in the Digital Ecosystems initiative acknowledges the efficiency gains brought by shared physical infrastructures, lower transportation costs, etc, but also regards social constructivist processes as an important factor in strengthening this dynamic. In other words, it also sees the phenomenon as a natural consequence of the interpretation of technology production as an extension of the language spoken by a particular community: common language leads to a shared understanding of reality, which leads to shared means of expression and therefore similar

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7) The EU 6th Framework Programme for Research and Technological Development 2002-2006 (6th FP). It started in 2003, nearly all the supported projects will finish by 2010.

8) E.g. several authors describe the SAP platform and the surrounding applications and services as a "digital ecosystem".

9) The "Digital Ecosystem" project launched by the World Economic Forum established a Digital Ecosystem community (http://www.decommunity.net/)

and interdependent technologies. This is one of the reasons why digital ecosystems are seen as even more effective at the regional rather than at the national or international scale.

The Digital Ecosystems initiative aims at helping local economic actors become active players in globalisation, 'valorising' their local culture and vocations and enabling them to interact and create value networks at the global level. Increasingly this approach, dubbed "glocalization", is being considered a successful strategy of globalisation that preserves regional growth and identity (Khondker, 2004), and has been embraced by the mayors of thousands of municipalities and by decision-makers and intellectuals joined in the Glocal Forum (2004). Similarly, Castells (2000) has written extensively on ICTs and the tension between globalisation and localisation.

The premium placed on a local production and development context represents a constraint on the architecture of globalisation that is ultimately important for its sustainability: through its integration with the many societies and economies of the world a more constructive dynamic of interaction between the local and the global scales can be achieved. Interestingly, this architecture was indicated in the very title of Nachira's original paper, as a reference to a "*network* of digital business ecosystems" (emphasis added), distributed over different geographical regions *and* over different business domains/industry sectors.

Regarding a particular business ecosystem, two main different interpretations of its structure have been discussed in the literature. The "keystone" model was assumed by Moore (1996) and has been further developed by Iansiti (Iansiti and Levien, 2004); in this model the ecosystem is dominated by a large firm that is surrounded by a large number of small suppliers. This model works well when the central firm is healthy, but represents a significant weakness for the economy of the region when when the dominant economic actor experiences economic difficulties. This model also matches the economic structure of the USA where there is a predominant number of large enterprises at the center of large value networks of suppliers (Eurostat, 2006).The model of business ecosystem developed in Europe, on the other hand, is less structured and more dynamic; it is composed of mainly small and medium firms but can accommodate also large firms; all actors complement one another, leading to a more dynamic version of the division of labour and organised along one-dimensional value chains and two-dimensional value networks (Corallo, 2007). This model is particularly well-adapted for the service and the knowledge industries, where it is easier for small firms to reinvent themselves than, for instance, in the automotive industry.

Innovation, Openness, and Creative Destruction

Compatibly with the principles it espouses, the conceptualisation of digital ecosystems is itself emergent. It tries to find a balance between "old" theories of stagnation brought by oligopolies (Steindl, 1990) on the one hand and Open Innovation (Chesbrough, 2003) and "Crowdsourcing" [10] on the other. It asks questions about Open Source and the Linux phenomenon in the same breath as Schumpeter's (1942) oversubscribed creative destruction from IBM to Microsoft to Google. It looks at new institutional and transaction costs economics (Coase, 1937; Williamson, 1975; Benkler, 2002) as well as at the economics of sharing (Benkler, 2004) and community currencies.[11] Perhaps most importantly, it strives to remain open to new ideas coming from research and academia as well as from business and development experience. It is a body of knowledge on innovation that constantly innovates itself with new ideas and new points of view.

A greater openness[12] and a multi-stakeholder approach between academia, business, and local government implies a greater emphasis on a collaborative "sense-making" process for analysing the priorities of a particular region and for devising appropriate development strategies. For example, in the Spanish region of Aragon the Instituto Tecnológico de Aragón, partly owned by the local government, is the main actor responsible for innovative regional development. By partnering with the more advanced ICT companies based in the region a successful ICT adoption and dissemination process has been set up that is able to reach hundreds of SMEs in several sectors (tourism, manufacturing, etc.) throughout the region. In the UK, by contrast, the Midlands are characterised by more than 50 public and private entities that are in one way or another concerned with development and ICT adoption. A completely different strategy for innovation is hence being devised there,

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10) Crowdsourcing is defined as new business model in which a company or institution takes a job traditionally performed by a designated agent (usually an employee) and outsources it to an undefined, generally large group of people in the form of an open call over the Internet. Crowdsourcing has been used the first time by (Howe 2006).

11) http://www.openmoney.org. Work currently being done in the OPAALS project: www.opaals.org.

12) In the private sector this refers to fewer IPR restrictions, in adademia it refers to initiatives such as Open Access Publishing or Creative Commons.

based on the business school of the University of Central England acting as the Regional Catalyst, but partly delegating that role to a number of companies that offer a range of SME networking services, from meeting and conference space to ISP services.

Four years since the emergence of the Digital Ecosystem concept, we still believe that socio-economic growth depends on innovation, and that innovation is largely dependent on an open flow of ideas (Lessig 2002). Openness in the Knowledge Economy is not so different from encouraging spending to stimulate the dynamism of the Exchange Economy. However, we recognise that "spending" ideas are easier to implement in research environments than in business environments. Therefore, the balance that seems to work in business environments is based on a layered approach: combining an open source shared middleware infrastructure with software services, models and information that compete on the revenue models (which can vary from proprietary to shared or free). An open source ecosystem-oriented architecture provides, indeed, a distributed middleware that acts as a new ICT commons, or as a public road that lowers the cost of ICT adoption and maximises the reuse of models. It is important to build such an infrastructure in such a way as to preserve its intrinsic characteristic as a commons, that is, "a resource that anyone within a relevant community can use without seeking the permission of anyone else" (Lessig, 2006). The Digital Ecosystem could represent a new innovation commons tailored on the needs of SMEs, enabling business networking, cooperation, knowledge flows, and fostering creativity and growth.

Relativism and Reflexivity

Several statements in the above paragraphs are organised by a mixture of beliefs and interpretations of research results,[13] leading to temporary but fairly confident conclusions regarding the Digital Ecosystems approach (principles of openness, multi-stakeholder approach, and the tactic of using Regional Catalysts) as an effective methodology to achieve sustainable socio-economic development at the regional scale. Parallel research efforts starting from different assumptions and relying on different theories in Europe and elsewhere could have reached different conclusions. For example, Game Theory sees "atomised" economic agents in competition to maximise their own utilities as offering a better explanation, or even prescription, for a healthy dynamic equilibrium of economic systems. We do not consider Game Theory a good framework for explaining what has happened in the regions that have adopted the Digital Ecosystems approach primarily because it fails to take into account the complex institutional and cultural setting in which Digital Ecosystems are embedded. Evolutionary Game Theory (Maynard-Smith, 1982) offers an interesting alternative to the ecosystem metaphor preferred as a reference concept in this book. As another example, Schumpeter's creative destruction long ago offered a clean and "self-correcting" solution to the problem of the emergence of monopolies in free markets.

These (and others) alternative viewpoints should be acknowledged. However, there is not enough room here to do them justice with a thorough comparative analysis. In this article we prefer to offer some more background on the conceptual and theoretical foundations that have informed the interpretations and insights that have so far been reached in the Digital Ecosystems research area. The principal characteristic shared by the theories to be discussed in this article and in this book upon which the Digital Ecosystems approach is being built is variously referred to as relativism, subjectivity, or intersubjectivity, is connected to phenomenology and to cognition, and in general strives to expose the fallacy of assumptions of an objective reality external to ourselves. One of its consequences, in social science, has been the development of the useful tool of reflexive analysis, or reflexivity for short, through which we become better able to see ourselves through the eyes of others, reaching surprising conclusions such as, 'Software engineering is a social process'.

Systems Theory, Second-Order Cybernetics, and Radical Constructivism

Epistemology is the branch of philosophy that studies knowledge. It attempts to answer the basic question about how knowledge is built and what distinguishes true (adequate) knowledge from false (inadequate) knowledge. In practice, these questions translate into issues of scientific methodology: how can one develop theories or models that are better than competing theories?

13) www.digital-ecosystem.org

In 1936 the biologist Ludwig von Bertalanffy proposed Systems Theory (Bertalanffy, 1936) as a reaction against the reductionism inherent in the classical scientific analytical approach to isolate an external objective reality, separate it into its constituent parts or elements, and study and analyse it through correspondingly different disciplines. Such an approach is unable to uncover and highlight the interrelations between the parts that connect them into a whole and prevents the perception and understanding of systemic phenomena. In subsequent years Systems Theory's view grew in importance. Many of the concepts used by systems scientists led to the closely related approach of cybernetics. The systems scientists and cyberneticists felt the need to separate themselves from the more mechanistic analytic approaches, and they gradually came to emphasise autonomy, self-organisation, cognition, and the role of the observer in modelling a system. In the early 1970s this movement became known as second-order cybernetics, which studies how observers construct models of the systems with which they interact (Heyligen, 2001a). The movement culminated with the Principia Cybernetica Project, which developed a cybernetic philosophy based on the concept of the "meta-system transition" with implications for human evolution, political systems, and the foundations of mathematics.

The epistemology of (second-order) cybernetics and of the Principia Cybernetica Project has a radical constructivist basis. Ernst von Glasersfeld defines radical constructivism by the following two basic principles built on the ideas of Jean Piaget, who applied the biological concept of adaptation to epistemology:

► Knowledge is not passively received either through the senses or by way of communication, but is actively built up by the cognising subject.
► The function of cognition is adaptive (in the biological sense of the term), tending towards fit or viability) and serves the subject's organisation of the experiential world, not the discovery of an objective ontological reality. (von Glaserfeld, 1988, 1996)

The importance of constructivism and its relation to cognitive science is best understood by comparing it with the opposite, more traditional, approach in epistemology or cognitive science, which sees knowledge as a passive reflection of an external, objective reality. This implies a process of "instruction": in order to get such an image of reality, the subject must somehow receive the information from the environment, i.e. it must be "instructed". Cybernetics began with the recognition that all our knowledge of systems is mediated by our simplified representations—or models. Thus, first-order cybernetics studies a system as if it were a passive, objectively given "thing", that can be freely observed, manipulated, and for which we have to provide the "true" representation. A second-order cyberneticist working with an organism or social system, on the other hand, recognises that system as an agent in its own right, interacting with another agent, the observer (Heyligen, 2001b).

The following chapters will show the role that these considerations play in the practical realisation of Digital Business Ecosystems and in the implementation of policies for socio-economic development catalysed by ICTs. It is helpful to recount briefly the origins of these ideas, which have always been interdisciplinary. These philosophies were fundamentally important for analysing and designing systems that represent and mediate socio-economic interactions between enterprises and people.

Autopoiesis and Dynamic Conservatism

Maturana and Varela (1973) invented the concept of autopoiesis as a model that generalises the structure and function of a biological cell, and defines the characteristic of a living system. But, as noted by Maturana (1997), autopoiesis is an epistemological option, which goes beyond the cell and the nervous systems, becoming a fundamental instrument for the investigation of reality. The concept has long surpassed the realm of biology and has been used to explain human communication and social systems impacting on sociology, psychotherapy, management, anthropology, organisational science, and law.

An autopoietic system can be described briefly as a self-producing machine, or a self-generating system with the ability to reproduce itself recursively. An autopoietic system exhibits a network of processes and operations, which could create, destroy, or reorganise themselves in response to external inputs and perturbations. Since autopoietic systems are simultaneously producers and products, it could also be said that they are circular systems, that is, they work in terms of productive circularity. The reference to a "system" carries a specific meaning in the theory, namely the ability of an autopoietic system to delimit itself spatially through a physical boundary (the membrane for the cell, the interface with the "real word" for the digital ecosystem) in order for the autopoietic process to be able to discriminate the "inside" to which autopoiesis applies, from the "outside", to which it does not. In Digital Ecosystems research autopoiesis is used as the ultimate model of interactive computation, but it is also used as a metaphor for a generalised form of organisation. Specifically, "organisational closure" is defined as the stability of the organisational structure of

the system, even when the system is open to a flow of energy and mass, such as a cell, whereby each element or sub-process of the system conspires to maintain the organisation of the system that makes it autopoietic.[14]

Very interestingly, an almost identical concept was arrived at roughly at the same time by the American sociologist and philosopher Donald Schön (1973), who dubbed it "dynamic conservatism". Schon did not have a biological point of view, he operated entirely within the disciplinary boundaries of sociology, but in his opinion his findings applied equally well to any social system, "…whether a naval ship, an industrial firm, or a community":

The system as a whole has the property of resistance to change. I would not call this property 'inertia', a metaphor drawn from physics—the tendency of objects to move steadily along their present courses unless a contrary force is exerted on them. The resistance to change exhibited by social systems is much more nearly a form of 'dynamic conservatism'— that is to say, a tendency to fight to remain the same. (p 31)

Structural Determinism

Autopoietic systems are structure-determined systems. The potential behaviour of the system depends on its structure. Maturana calls this concept structural determinism, i.e. a process of change of an organism that, at any point in time, is determined by the organism's previous structure but is triggered by the environment. Thus, the structure of a given system is not static; it is one of many ways in which its components can interconnect whilst retaining a recognisable organisation:

Living systems have a plastic structure, and the course that their structural changes follows while they stay alive is contingent on their own internal dynamics of structural change modulated by the structural changes triggered in them by their interactions in the medium in which they exist as such (Maturana, 1997).

Thus, the organisation determines the identity of a system and the structure determines how its parts are physically articulated. Such principles apply to all the complex digital autopoietic systems, and therefore also to the Internet and its applications/services. It was remarked by Lessig when he observed that "the code is the law of cyberspace" (1999). The Internet's structure determines how the Internet is regulated. The Internet's role in innovation, based on the 'spontaneous' creation and implementation of new protocols and services, would not be possible with a different structure characterised by a centralised instead of an end-to-end and layered 'intelligence'. The change of basic structural principles "could fundamentally alter the fabulously successful end-to-end Internet":

"The remarkable social impact and economic success of the Internet is in many ways directly attributable to the architectural characteristics that were part of its design. The Internet was designed with no gatekeepers over new content or services. The Internet is based on a layered, end-to-end model that allows people at each level of the network to innovate free of any central control. By placing intelligence at the edges rather than control in the middle of the network, the Internet has created a platform for innovation. (Cerf, 2005)

In a similar way, the effort in developing the architectural principles upon which to base the digital ecosystem were to regulate indirectly its functionalities by defining a structure that determines some behaviours and prevents others. These are the same values and behaviours that were at the base of the Internet's growth and evolution. This is best understood through the concept of structural coupling.

Structural Coupling between the Business and Digital Ecosystems

An important aspect of autopoiesis is its radical relativism, which is inescapable and manifests itself as structural coupling: a form of mutual and symmetrical interdependence between two entities that, at any point in time, is determined by each entity's previous structure whilst being triggered by the other. In other words, structural coupling is a form of interdependence between two actors or entities that satisfies the criterion of structural determinism mutually and symmetrically (conceptually similar to non-linear coupling in physics). Nothing in biology exists by itself; everything interacts with everything else. By extrapolating this concept from the physical level to the neuronal

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14) See the OPAALS Network of Excellence "Open Philosophies for Associative Autopoietic Digital Ecosystems" (www.opaals.org), which also studies the dynamic processes of knowledge creation and self-organisation in support of innovation.

and cognitive levels Maturana and Varela (1998) made an explicit connection with the process of "languaging" between two or more entities. This is surprisingly well aligned with the social constructivism understanding of the intersubjective construction of reality through language.

These ideas acquire greater relevance when we consider that Digital Ecosystems include digital computable representations of both the micro-economic and the macro-economic aspects of the business ecosystem.[15] The digital ecosystem provides representations of the business ecosystem, which are used for search and discovery, for aggregating and recommending services, for reorganising value chains, and for recommending potentially cooperating business partners. The digital ecosystem influences the structure of the enterprises and of their social and business networks, whilst the business ecosystem modifies the structure of the "organisms" of the digital ecosystem. The digital ecosystem and the business ecosystem, when they are viable, are structurally coupled and co-evolve forming a dynamic innovation ecosystem, as shown in Fig. 3.

The concepts of autopoiesis and of structural coupling together with a rethinking of knowledge representation and linguistics in a social context were applied to the design of a nation-wide system, the Cybersyn project (Beer, 1980), and provided the foundations for a new way to design (Winograd and Flores, 1986).
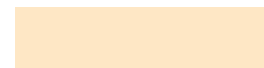
Fig. 3

Structural coupling between Business Ecosystem and Digital Ecosystem
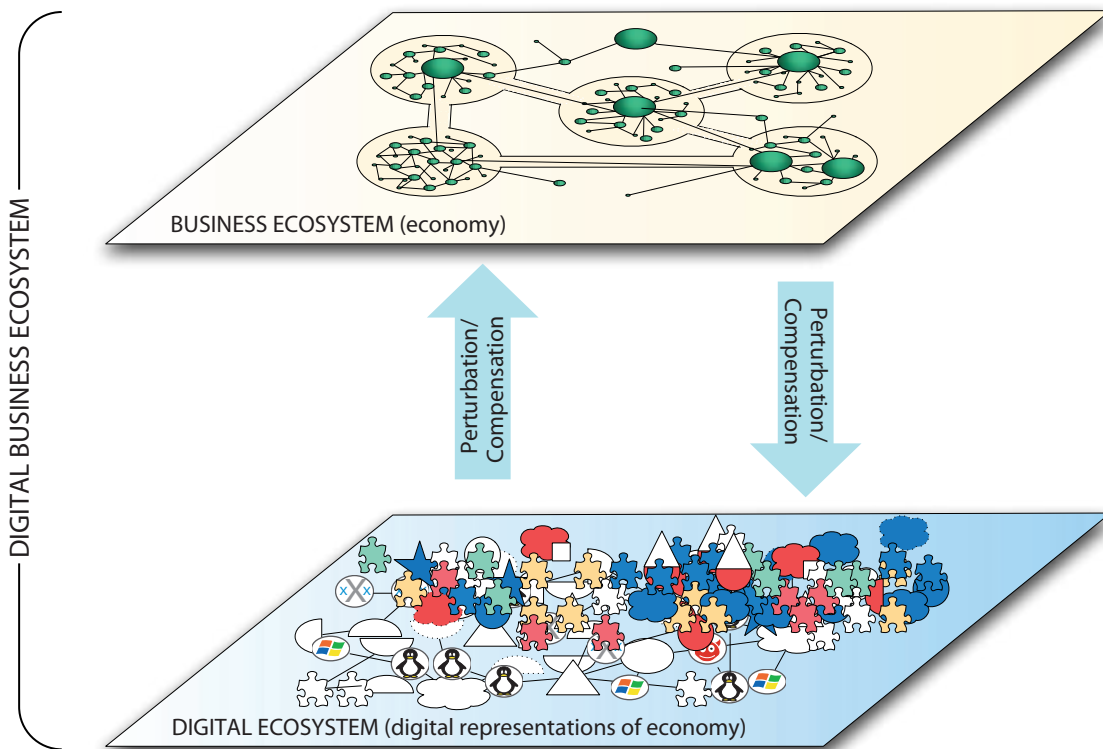
Structural Coupling between Business Ecosystem and Digital Ecosystem

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15) This includes any useful digital representation expressed in a language (formal or natural) that can be interpreted and processed (by computer software and/or humans); potentially any description of the economic and social actors, their capacities, skills and the relationships between them (EC 2005a).

Structural Principles of Digital Ecosystems

Since the digital ecosystem is structurally coupled to the socio-economic system of its users, its architectural design depends on the socio-economic properties to be facilitated or enabled. This choice is about how the world will be ordered and about which values will be given precedence (Lessig, 1999). The initial general objective of economic development was refined through online consultations and two cycles of workshops in 2002 and in 2005. It was articulated as:

Technologies and paradigms that enable the participation of SMEs and innovators in the knowledge-based economy, integrating them within local/regional/global socio-economic ecosystems and that enact unstructured dynamic business clustering to achieve greater competitiveness in the global economy.

In the course of the subsequent debates the concept was further developed into the peer production of a 'digital nervous system' that supports a participative society in which public and private organisations, professionals and individuals compete, interact, and collaborate for their own benefit and for the benefit of the organisations, teams, ecosystems and/or communities they belong to, in order to enable the participation of all players in the knowledge economy and in the knowledge society, and that empowers the creativity, the potentialities, the capacity, and the dynamic interactions (the relationships and the cooperation/competition) between all the economic players.

The public consultation process produced a research agenda (Dini et al., 2005) that is kept regularly updated[16] and a set of initial principles (EC 2005b)[17] that have to be translated and embedded within the ecosystem architecture. Some principles are general, whilst others depend on the policy aims or are specific to the structure of the local economy. In this paper we present only a few of these interrelated keystone principles, showing how they have influenced the architectural design but have also opened the need for further research. We do not explore in detail the technical and socio-economic implications or the practical implementations, which will be presented in the next sections of the book.

▶ *No single point of failure or control*
▶ *Digital ecosystems should not be dependent upon any single instance or actor*
▶ *Equal opportunity of access for all*
▶ *Scalability and robustness*

These principles imply a fully decentralised architecture; the design of a P2P structure that is robust, scalable, self-organising and self-balancing and that embeds scale-free networks and mesh topology dynamics. The open source initial implementation is freely available (http://swallow.sourceforge.net/, http://dbestudio.sourceforege.net, http://evenet.sourceforge.net) and has been adopted by SMEs in pilot regions.[18] Such networks do resemble the behaviours of social networks where node formation and dispersion is a function of activity and feedback The architecture runs over any IP network and supports the same principles also for a mesh of wireless nodes. From the information distribution perspective, it is worthwhile to note that the application of these principles means that a single node cannot access all the information in the network. By design, there is no central repository or database and there is no node/actor that has a privileged or full view of the ecosystem. However, the evolutionary architecture and distributed intelligence enable the "migration" of the (references to the) formalised knowledge and the software services where there is a greater probability of their use. From the organisational perspective these principles imply the need for balanced and decentralised governance models. The fully distributed information structures are essential for keeping the plasticity of the system[19] and for supporting the dynamic connections and re-organisation between the social, technical and knowledge networks.

▶ *Ability to evolve, differentiate, and self-organise constantly*
▶ *Activate and support self-reinforcing production and process networks*

The above are the basic mechanisms of an autopoietic system,[20] exhibited by living organisms and in natural ecosystems, but also by economic ecosystems. The objective is to produce a dynamic ecosystem of innovation; that

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16) Specific EC support projects (e.g. EFFORT) include activities devoted to ensure the evolution of the research agenda and the updating of the roadmap.

17) Also aiming at defining governance models (see the following sections) and a Bill of Rights or a Constitution of the Digital Ecosystems

18) E.g. the information about the SMEs of Aragon exploiting the digital ecosystem can be found at http://www.ita.es/dbe/?ID=223

19) The holistic distribution of the information structures and the plasticity of the network replicate how information is stored in the brain and how it is constantly reorganised and elaborated through changes in the connections of the brain's neuronal network.

20) "Network of processes of production components which through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them" (Maturana, 1980)

is, to catalyse dynamic and remote collaboration and interaction between human and digital entities and systems in various structured and unstructured organisational settings, such as collaborative working environments composed of complex heterogeneous human and digital devices and systems. The ability to implement the production and the reorganisation mechanisms is crucial. Enabling the digital organisms, their networks and the whole system to exhibit mechanisms like self-organisation, selection, mutation, adaptation, and evolution brings the concept of ecosystem beyond a simple metaphor.

► *Capability to enable global solutions that adapt to local or domain specific needs*
► *Global solutions that emerge from local and sectoral inputs*
► *Local autonomy*

Economic activities cannot help but be related to local cultures and regulations. The ability to produce solutions which operate in a global market, but are adapted to the local needs and to the local business and culture, is a competitive advantage. This structure should be able to adapt to different societal environments, which are constantly changing. Therefore, it must embed mechanisms that enable adaptation and evolution. The above mechanisms imply that we do not have a single ecosystem, but several local ecosystems produced by the adaptation to local conditions. Just considering the services or the business models, this means that in some ecosystems new services will appear, in others the same services will be modified to be adapted to local conditions, regulations, business models, in yet others the services will disappear from lack of use. Solutions that need to be developed on a European scale could have sector-specific implementations that can be adapted and tuned according to local customs. Local SMEs could provide a local support infrastructure to implement these solutions in their business operations.

The Representations that "Populate" Digital Ecosystems

The digital ecosystem is the ICT infrastructure designed to support economic activities, which contains the socially-constructed representations of the business ecosystem[21]; it is essentially composed by:
► the knowledge that expresses different socially-constructed partial interpretations and views of the economy and which is represented through a variety of continuously evolving (natural and formal) languages and protocols.
► the architectural infrastructure that enables the desired "autopoietic" mechanisms and manages the distributed and pervasive storage of such knowledge, as well as the tools enacting the formalisation and the "processing" of this persistent knowledge

We can see that digital ecosystems are similar to natural ecosystems, but instead of being populated by biological organism they are populated by fragments of knowledge: these are analogous to memes (Wilkins, 1998) that could be computed, expressed in formal or natural languages, digitised and "living" and propagating through the network. Thus, the ecosystem is an environment with a 'life support' architecture designed to enable the 'life' of its 'digital organisms'. The mechanisms[22] embedded within the digital ecosystem, like a (collective) brain, operate on such languages and protocols. The digital ecosystem in its evolution will acquire more services and will be able to include more mechanisms of interpretation of knowledge ('introspection'), becoming more intelligent and providing more support to the business ecosystem. The digital ecosystem embeds evolutionary mechanisms that support the evolution and the adaptation of the languages that populate it (in both intentional an extensional representations). This approach is fundamentally an extension and a conceptualisation of the evolution of the Internet and of the Web.

Computer Science is concerned with the construction of new languages and algorithms in order to produce novel desired computer behaviours. The Web is an engineered space created through formally specified languages and protocols (Berners-Lee, 2006).

Formal Languages that Evolve and Proliferate

The issue of how distributed knowledge should be represented - and created - is one of the main research topics related to semantics of today.

21) The business ecosystem includes the socio-economic players, the material transactions, as well as the legal and institutional framework
22) Implemented through processes that could be any type of agents with intelligence, whether computer processes, humans, or a mixture thereof.

In the Web, due to the pressure of user needs, we see a continuous evolution of the protocols and artificial languages. The evolution operates at the level of the specific languages/protocols: some languages are initially rudimental, but evolve, expanding their expressive power and increasing the processing they can support, (e.g. HTML/XHTML; URL/URI). New languages and protocols keep emerging, allowing the representation of other facets of the world. The focus of many scientists in recent years has in fact been to develop formal languages that have the expressive power to define more abstracts aspects of reality, as shown by the rapid growth of the complexity and of the layers of the semantic web stack of W3C.[23] In the ecosystem metaphor this research activity can be described as the phylogenetic tree[24] of formal languages: new and more complex languages appear in the digital ecosystem, whilst the older ones continue to be present in the ecosystem as long as someone still uses them. Thus, the languages of the ecosystem continuously evolve in response to external stimuli and are not necessarily organised, e.g. in a stack. Also, these multiple representations cannot necessarily be reconciled. The cathedral of the Semantic Web is replaced by a bazaar of descriptions and formalisms. The Digital Ecosystem can support such a bazaar of fragments of knowledge at different levels of formalisation and abstraction.

A good example of this evolution could be illustrated by the recent debate about the integration of the rules in the Semantic Web Stack and how to express business definitions for business use (to represent policies, practices and procedures) whose business rule statements are executable and could be used in rule-driven systems (Kifer, 2005; Horrocks, 2005). Different schools, depending on the main business objectives, have developed different languages that express different semantics and rules. For example, SWRL and RDF_MATCH were developed by the W3C community to express the semantic rules of language, in contrast to SBVR that was developed in OMG circles to express business rules.

In addition to the complexity arising from the need to reconcile different formalisms, also the phenomena that are represented, when described by different observers, are not necessarily the same and may need to be reconciled. When we consider that in a digital ecosystem we can also represent subjective elements of knowledge (reputations, skills…) that have economic and power-relationship implications, the question arises: 'Who has the authority to populate the ecosystem with descriptions?' or, better, 'Who has the authority to say what these descriptions mean, i.e. to provide an interpretation of reality?'. Since the digital ecosystem is fully distributed, cannot be dependent upon any single instance or actor, and cannot have any single point of failure or control, it makes it more difficult for any actor to achieve a "knowledge monopoly".

However, architectural principles can only go so far. The long-term sustainability of the digital ecosystem approach requires a deeper integration between the technology that mediates social and economic interactions and the social processes that create and shape the technology. Here is where the social constructivist approach helps to define a philosophical framework for the solution.

Social Constructivism

In the past, the definition of Truth was provided by institutions that had this authority.[25] The social constructivist (or constructionist) approach, on the other hand, affirms:

It is through the daily interactions between people in the course of social life that our versions of the knowledge become fabricated. Therefore social interaction of all kinds, and particularly language, is of great interest to social constructionists. The goings-on between people in the course of their everyday lives are seen as the practices during which our shared versions of knowledge are constructed. What is considered as truth may be thought of as our current accepted ways of understanding the world. These are product not of objective observation of the world, but of the social processes and interactions in which people are constantly engaged with each other. Descriptions or constructions of the world therefore sustain some patterns of social action and exclude others. (Burr, 2003)

Concepts and categories are developed through language, which provides a framework of meaning. Languages are the necessary precondition for thought as we know it. The ways we understand the world, and the concept and the categories we use are historically and culturally determined, and do not necessarily refer to real divisions. Not only are they specific to particular cultures and periods of history, but are dependent upon the particular social and economic arrangements prevailing in that culture at that time (Burr, 2003). With the advent of the Information Society what we

23) http://www.w3.org/2006/07/layerCake-4.png
24) In biology, phylogeny is defined as 'a succession of organic forms sequentially generated by reproductive relationships'.
25) E.g. in the Middle Ages the Church was the organisation certifying the Truth.

perceive to exist is mostly what exists in the media or on the Internet. The information, or the digital representations of the ecosystem, shapes the user perception of the business ecosystem. The more rich and more 'populated' a digital ecosystem is, the more aspects of the economy can be described and mediated. Thus, when we abandon the mirage of an objective reality and accept that reality is a collectively built and shared perception resulting from a social process mediated by languages, and we apply these insights to the digital world and to formal languages, we gain powerful instruments for development.

Digital Ecosystems research faces similar issues. The problem of regional development cannot be posed as the optimisation of an external and objective "system" within which an equally objective technology can be deployed. Not only is the problem of development fundamentally endogenous, and therefore to be negotiated between the regional stakeholders, but the technology itself needs to grow out of the languages and interactions between these stakeholders (Vaca, 2005). In other words, having embraced a holistic approach that highlights the dependence of the business models and interactions and of their formalisation into software services on their socio-economic and cultural context, no assumptions can be made by external actors about what constitutes an optimum technology for a particular business domain. Technology here is meant in a wider sense that encompasses the distributed infrastructure and middleware, the software services and applications, all the attendant web technologies, and all the software development, requirements capture, and business modelling tools up to the boundary with natural language. Clearly, the closer one approaches natural language, the easier it is to see the relevance of an intersubjective viewpoint.

One of the main methodological points and, at the same time, research objectives of the Digital Ecosystems approach, therefore, is to enable the actors that belong to a region, business domain, or industry sector to describe their businesses and their services from their locally and socially constructed point of view, automating the generation of the software to interface to the underlying mediating technology through appropriate transformations.

Multiple and Subjective Descriptions

The software engineering approach and the Semantic Web approach are based on the description of some aspect of reality through formal ontologies and imposed by experts mediating on behalf of the users. The formal languages used have a high expressive power, but due to their complexity the codification requires mediation by experts. As a consequence, due to the scarcity of human resources, very limited aspects of the 'real world' have been described. Furthermore, the key unconfessed assumption of the first computational ontologists was that the knowledge described is based upon an objective description of the world, although simplified and focussed on the elements that are relevant to the context, as all domain models are. This could be a reasonable assumption in the description of a mechanical system or a business transaction. But it becomes difficult to defend this thesis when defining, for example, the reputation of a company. It is clearly unreasonable to regard the description of the competences, capacity, abilities and talent of organisations or individuals as objective.

This limitation has led to the emergence of a broad range of simpler codifications, less structured and with less expressive power, without predefined categories, but where one does not have to agree on a detailed taxonomy, like the codification made through simple tagging (Halpin, 2006a; 2007). The emergence of collaborative tagging is a natural evolution of the tagging concept itself. Collaborative tagging, social bookmarking etc. do represent the user experience in organising online information, in contrast to the approach of establishing formal ontologies by domain experts. Loose associations of concepts and a greater flexibility and adaptability in organising information links are based on a minimum level of shared meaning that allows the emergence of cooperation among users. Through collaborative tagging users do not need to rely on intermediaries to describe their business, activities, needs, they can participate directly in the modelling of reality. The descriptions made by the users through collaborative tagging are less expressive and detailed than the descriptions made with formal languages; however, being much easier to write, they are effectively made by the users, and the ecosystems are populated (Halpin, 2007).

The point of view of social constructivism, which until a few years ago would have seemed radical or simply strange in most technological fields, is actually rather obviously the basis of the Web 2.0 phenomenon. In fact, we can now say more confidently that most of the evolutions in the Information Society do not depend on the advances in technology, but on exploiting the power of social interactions (Halpin, 2006b).

The translation of this power into a mode of economic production is the central question of open source research.

Open Source in Digital Ecosystems

Two of the three[26] deep trends due to which, according to Dalle et al. (2005), FLOSS[27] has commanded the attention of social scientists are:

► The movement of information goods to centre stage as drivers of economic growth
► The ever more widespread use of the peer-to-peer modes of conducting the distribution and utilisation of information, including its re-use in creating new information goods

These two trends are bound together and reinforced by the growing recognition that the "open" (and co-operative) process of knowledge production offers economic efficiencies that in general surpass those of other institutional arrangements, namely those that address the resource allocation problems posed by 'public goods' by protecting secretive practices, or creating and enforcing intellectual property monopolies (Dalle et al., 2005).

The Digital Ecosystem realises a public good that expands the space of the digital public domain by creating an intangible 'digital commons', a digital resource that anyone within the relevant community can use under content-neutral terms (Lessig, 2002:19-22). The access to the infosphere created by the digital ecosystem commons represents one of the most promising strategies to reduce the digital divide between SMEs and large enterprises. Although there is no consensus yet, many believe that lowering the barriers to entry, reducing cost and investment, and working at the centre of a peer knowledge production process allows small enterprises to overcome the activation threshold needed to use ICT in a novel and productive way.

The Open Source approach has thus been the only possible choice for the Digital Ecosystem infrastructure, not only for the intrinsic behaviours and knowledge sharing needed for the ecosystems to flourish, which would not be possible in a proprietary schema, but also because code, and its access, is not only the law of cyberspace, but also its DNA, its genotype, and its architecture.

Access to code allows the growth of social networks able to build and transform their business/economic environment according to their shared description of the world. However, access to the code does not solve everything. There are many factors that influence the uptake of open source by companies, such as their connections in the open source community, or the know-how of the way the open source process works and the implications of different types of licences. Digital Ecosystems can then be seen as the structure that connects and mobilises such knowledge and that facilitates such processes. Furthermore, if we understand code either as Lessig reads it—the performative law of cyberspace—or as Baudrillard reads it—the hegemonic law of the symbolic and hence of real space—then open source systems become capable of alleviating some of the fears that arise when we deal and rely on closed systems: fears of monopoly, tyranny, and unjust use of power (David, work in progress). Finally, the Digital Ecosystem FLOSS approach is a public good envisaged to be co-produced and maintained by volunteers, and counters the common economic belief that private agents, without property rights, will not invest sufficient effort in the development of public goods because of free-rider externalities (Bessen, 2002).

Open source communities are epistemic communities[28] (Edwards, 2001) organised as a distributed network of agents that are not just based on altruism, reputation or hacker ethics. The key actors in the development of an open source product are the individual contributors companies (for profit and non-profit) and researchers. All sets of actors respond to the legal incentives embodied in open source production.

Up to now economic theory suggests that long-term incentives are stronger under three conditions:
1) more visible performance to the relevant audience (peers, labour market, and venture capital community);
2) higher impact of effort on performance;
3) more informative performance about talent. The first condition gives rise to what economists call 'strategic complementarities'. To have an 'audience', programmers will want to work on software projects that will attract a large number of other programmers". (Lerner, 2006)

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26) The third reason is simply the very large amount of empirical data on open source communities and software production, which is certainly important for social scientists but less relevant to this discussion.

27) The acronym FLOSS stands for "Free/Libre/Open-Source Software"

28) An 'epistemic community' is a network of knowledge-based experts or groups with an authoritative claim to policy-relevant knowledge within the domain of their expertise. Members hold a common set of causal beliefs and share notions of validity based on internally defined criteria for evaluation, common policy projects, and shared normative commitments (Edwards, 2001).

The Digital Ecosystems initiative faces such a challenge to build strategic complementarities. Digital Ecosystems surely require a variety of business models to be viable and sustainable in the long run. Some of these models will be based mainly on a new Exchange Economy characterised by peer production behaviour to become integrated with the Gift Economy.[29] In the gift economy a immediate remuneration is not sought, and in many cases it is not expected. Reciprocity is believed to work eventually to provide a 'return on investment' that may in any case be difficult to monetise, such as one's reputation among peers. In other words, an "exchange rate" is required by the companies and the people who straddle both economies.

Social constructivism takes a further step to what we have discussed so far in its recognition of language as a medium of power relationships. We therefore begin to notice that by following a rather tortuous interdisciplinary route we are gradually building a comprehensive structural and process view of a Digital Ecosystem that is compatible with the latest software and web technologies, with social systems and social processes, and with the construction of a shared reality through language—but that we have not quite tackled yet the most difficult problem of all: the governance framework required to arrive at a healthy relationship between knowledge and community.

Open Knowledge, Open Governance and Community

In Digital Ecosystems research we make an explicit claim that knowledge creation and community building processes are inextricably linked. A 'knowledge model' will always also implicitly be a 'knowledge process'. A knowledge creation process, in turn, will also always imply an organisational structure.

The emergence of an organisational structure can be understood as a universal process of institutionalisation that characterises the dynamics of all social groups. From a social constructivist point of view this phenomenon is associated with the formalisation *through* language of power relationships mediated *by* language. If allowed to develop spontaneously and unhindered, therefore, such a process can become an obstacle for democratic processes or knowledge production. It is useful to invoke a natural science metaphor, namely the balance between crystallisation (order, equilibrium) and randomised reconfiguration (chaos, constant variation) that biological organisms are able to strike as a fundamental requirement to remain alive. The 'biological condition' can thus be characterised by its ability to harness its perpetual 'falling' toward equilibrium as an 'engine' that drives order construction processes in the presence, however, of a constant flow of energy, mass, and information that maintains the organism perpetually far from equilibrium and able to adapt to changing environmental conditions.

From our social constructivist viewpoint the constraints on the knowledge production processes brought about by spontaneous institutionalisation processes could then imply a constraint on the social dynamics, and therefore a possible erosion of the democratic processes themselves upon which the community is based. It is therefore important (1) to acknowledge the emergence of power relationships and hierarchies as a direct consequence of the mediation of social interactions by language and communications; and (2) to devise a governance process that can maintain the dynamics of the community "far from equilibrium". In other words, an open community will allow a constant flow of members and ideas to influence its internal knowledge production and decision-making processes. Such a constant flow of 'new blood' will counteract the encroachment of incumbents and the formation of monopolies on any aspect of the knowledge or the community. The mechanisms by which the 'counteraction' is achieved depend on transparency and accountability. The former depends upon and reinforces trust, the latter implies a process of formalisation of behaviour and its comparison with a shared memory of agreed principles of behaviour. Such a shared memory implies a rudimentary form of collective intelligence. We therefore see how the processes of formalisation of knowledge necessarily must begin with a fundamentally reflexive activity of formalisation of community through a transparent and open governance process. In a sustainable community, the dependence of knowledge production on the formalisation of governance hints at the possibility to apply the same reasoning recursively as a general requirement of epistemic communities. The next step in this line of argument would then be to attempt to extend the metaphor to autopoietic systems.

Fig. 4 is a simple schematic that attempts to show the interdependencies between several concepts that have been discussed in this introductory paper. The figure indicates the dependencies between concepts with arrows that

29) "Those who have been waiting for a new and economically viable free-standing business model for free and open source software, one uncoupled to any complementary commercial activity, may justifiably wonder whether they, too, are 'waiting for Godot'. But, instead of any such miraculous business plan, something else has emerged: the apparent willingness of profit-seeking producers of complementary goods and services to source software" (Dalle 2005).

also express a process. In other words, Language leads to Power, which leads to Organisational Structure. Adding Transparency, Accountability, Identity, and Trust leads to an Open Governance and Institutional Innovation process, which breathes new air in the OKS Community. The consequence of community renewal is to keep it open to the production of new knowledge. In the absence of Open Governance, the spontaneous (Self-Organisation) processes of institutionalisation would cause the Digital Ecosystem Community to "fossilise", making self-renewal more difficult and leading to rigid and hierarchical command & control structures. On the right of the figure a similar flow can be seen between more technical concepts and components, also depicted with thicker arrows. This second process is also important for the enablement of the self-renewal of the Digital Ecosystem Community.

It is with this framework in mind that Digital Ecosystems research looks to the future, to arrive at a participatory socio-economic development process that can bootstrap the Knowledge Economy in any regional context to construct a sustainable, global, pluralistic, and democratic Knowledge Society.
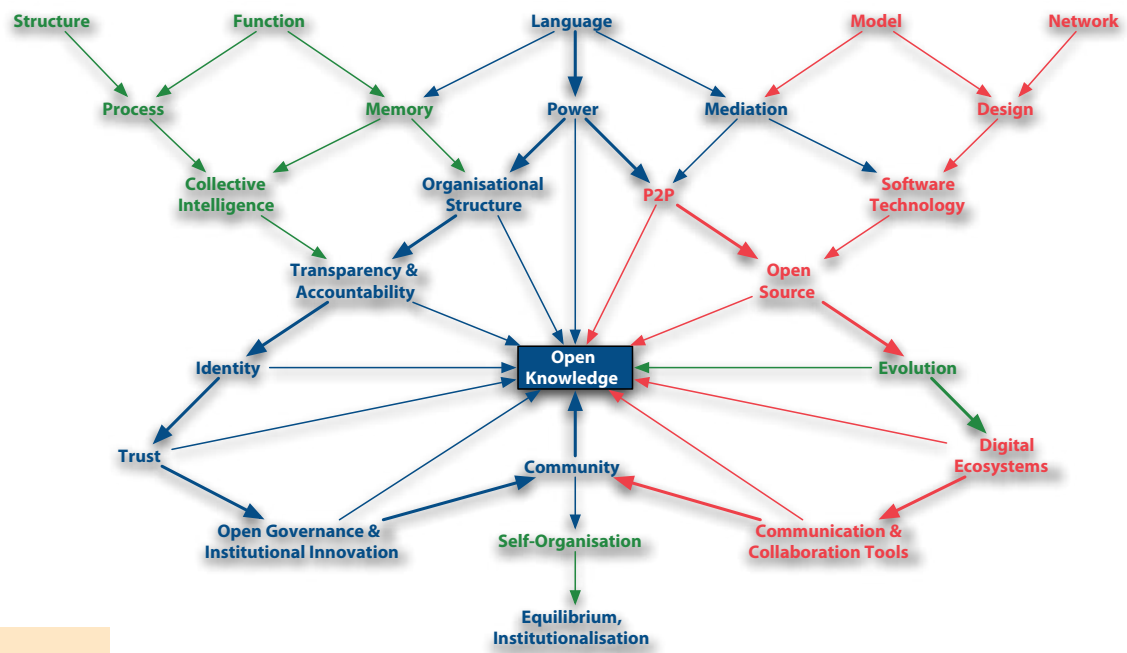
Fig. 4
Flow of innovation through community to sustain open knowledge productio

Over the last four years a path for a new science of the Digital Business Ecosystem has been opened, a community has emerged, the first technological solutions and implementations have been built, the first pilot business ecosystems have been launched, and a network of regional digital ecosystems has been established[30]. The articles in this book will go deeper in the discussion of the achievements of these first years in research (in Section 1 and Section 2), in technology and implementation (Section 3), and in deployment and adoption (Section 4).

References

Bateson, G (1972). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*, University of Chicago Press.

Baudrillard, J (1975). *The Mirror of Production*, Mark Poster (trans.), St. Louis: Telos Press.

Beer, S, Espejo, R, Grandi, M, and H Schwember (1980). "Progetto cybersyn: cibernetica per la democrazia", Edited by De Cindio F, and De Michelis G, CLUP/CLUED.

Bertalanffy, L von, (1968). *General System theory: Foundations, Development, Applications*, New York: George Braziller. Revised edition 1976, tr. It "Teoria Generale dei Sistemi", Milano: Mondadori.

Benkler, Y (2002). "Coase's Penguin, or, Linux and *The Nature of the Firm*", *Yale Law Journal*, Vol 112, pp 369-446.

30) REDEN: Regional Digital Ecosystem Network, http://reden.opaals.org

Benkler, Y (2004). "Sharing Nicely: On Shareable Goods and the Emergence of Sharing as a modality of Economic Production", *Yale Law Journal*, Vol 114, pp 273-358.

Benkler, Y (2006). *The Wealth of Networks: How social production transforms Market and Freedom*, New Haven and London: Yale University Press.

Berners-Lee, T, Hall, W, Hendler, J, Shadbolt, N and D J Weitzner (2006). "Creating a Science of the Web", *Science*, 11 August 2006: Vol. 313. no. 5788, pp. 769-771

Berners-Lee, T; Hall, W; Hendler, J; O'Hara, K; Shadbolt, N and Weitzner D J (2006). "A Framework for Web Science", Foundations and trends in Web Science, Vol. 1. No 1 (2006). 1-130

Bessen, J (2002). "Open Source Software: Free Provision of Complex Public Goods", SSRN-id588763. http://citeseer.ist.psu.edu/bessen02open.html, last accessed 1/7/07.

Burr, V (2003). *Social Constructionism*, 2nd Ed., Routledge.

Castells, M (2000). *The Information Age: Economy, Society and Culture volume 1: The rise of the network society*. Oxford: Blackwell.

Chesbrough, H (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Boston: Harvard Business School Press.

Cerf, V (2005). Letter about Net Neutrality of Vint Cerf to the Chairman of US Committee on Energy and Commerce, 8.11.2005 http://googleblog.blogspot.com/2005/11/vint-cerf-speaks-out-on-net-neutrality.html last visit 1/6/2007.

Coase, R (1937). "The Nature of the Firm", *Economica*.

Corallo, A, G Passiante and A Prencipe (2007). *Digital Business Ecosystems*, Cheltenham: Edward Elgar Publishing.

Dalle, J-M, David, P A, Ghosh, R A, and W E Steinmueller (2005). "Advancing Economic Research on the Free and Open-Source Software Mode of Production", in *How Open is the Future?*, M Wynants and J Cornelis Eds., Brussels: VUB University Press.

David S. "On Sourcescapes and Filescapes: Towards a Critique of the Political Economy of Free/Open Source Software and Peer-To-Peer File Sharing Networks", Cornell University.
http://www.shaydavid.info/indexpapers.html, last accessed 1/7/07.

Dini, P, Darking, M L, Rathbone, N, Vidal, M, Hernandez, P, Ferronato, P, Briscoe, G, and S Hendryx (2005). The Digital Ecosystem research Vision: 2010 and Beyond". Position paper following the cycle of workshops 2005 and the online debate, July 2005, Bruxelles.
http://www.digital-ecosystems.org/events/2005.05/de_position_paper_vf.pdf last accessed 30/5/2006.

Edwards, K (2001). "Epistemic Communities, Situated Learning and Open Source Software Development", Working Paper, Department of Manufacturing Engineering and Management, Technical University of Denmark.

European Commission (2001a). Communication from the Commission: "Helping SMEs to "go digital". COM(2001)136 final. 2001, 13 March.

European Commission (2003). Communication from the Commission, COM(2003) 729. "The EU Economy: 2003 Review".

European Commission (2004). Communication from the Commission, COM(2004). 480 - 13.07.2004

European Commission, DG-INFSO (2005a), "*What is an European Digital Ecosystem ? Policy Priorities and Goals*", internal report, Bruxelles, February 2006. http://www.digital-ecosystems.org/doc/fp7-de-shortintro.pdf last visit 1/6/2007

European Commission, DG-INFSO (2005b) "Towards Business Cases and User-Oriented Services in Digital Business Ecosystems", Conclusions of the FP7 Workshop on Needs and Requirements of Regions, Bruxelles, 18 April 2005.
http://europa.eu.int/information_society/topics/ebusiness/godigital/sme_research/doc/dbe_discussionpaper.pdf last visit 30/5/2006

European Commission (2006). "*More interoperability needed to boost the European ICT industry, competitiveness*", IP/06/1635, Brussels, 2 pp.

Glocal Forum (2004). "The Glocalization Manifesto", CERFE, September.

Halpin H (2006a). "*Representations: The Hard Problem for Artificial Life*", School of Informatics, University of Edinburgh, Edinburgh.

Halpin, H (2006b). "Digital Sovereignty: The immaterial aristocracy of the World Wide Web", Forthcoming in *Immaterial Labor, Multitudes, and New Social Subjects: Class Composition in Cognitive Capitalism*", edited by Ed Emery, Cambridge, (draft last accessed 10/5/2007 available at http://www.geocities.com/immateriallabour/halpinpaper2006.html).

Halpin H (2007). "The Complex Dynamics of Collaborative Tagging", IW3C2 session e-communities, WWW 2007, May 8-12, 2007, Alberta, Canada: Banff.

Heylighen, F and C Joslyn (2001a). "*Cybernetics and Second Order Cybernetics*", in: R.A. Meyers (ed.), Encyclopedia of Physical Science & Technology, Vol. 4 (3rd ed.), New York: Academic Press, pp. 155-170.

Heylighen, F (2001b). "Second-Order Cybernetics", in: F. Heylighen, C. Joslyn and V. Turchin (editors): *Principia Cybernetica Web* (Principia Cybernetica, Brussels), http://cleamc11.vub.ac.be/SECORCYB.html last visited 1/5/2007.

Howe, J (2006). "The Rise of Crowdsourcing", *Wired*, June.

Iansiti, M and R Levien (2004). *The Keystone Advantage: What The New Dynamics of Business Ecosystems Mean for Strategy, Innovation and Sustainability*, Boston: Harvard Business School Press.

Khondker, H (2004), "*Glocalization as Globalization: Evolution of a Sociological Concept*", "Bangladesh e-Journal of Sociology, Vol. 1. No. 2. July, 2004

Knorr-Cetina, K (1999). *Epistemic cultures: How the sciences make knowledge*, Cambridge, MA: Harvard University Press.

Kok, W (2004). "Facing the Challenge: the Lisbon strategy for growth and employment". Report from the High Level Group, OPOCE, Luxembourg.

Latour, B, and S Woolgar (1979). *Laboratory life: The social construction of scientific facts*, Los Angeles, London: Sage.

Lerner, J; P A Pathak; J Tirole (2006), "The Dynamics of Open-Source Contributors", in *The American Economic Review*, Vol. 96, Nr. 2, May 2006 , pp. 114-118(5), American Economic Association.

Lessig, L (1999). *Code and Other Laws of the Cyberspace*, New York: Basic Books.

Lessig, L (2002). *The Future of Ideas*, New York: Random House.

Lessig, L (2006). *Code 2.0*, New York: Basic Books.

Lewin, K (1946). "Action research and minority problems", *J Soc. Issues,* 2(4): 34-46.

Machado, A (1912). "Proverbios y cantares XXIX", in *Campos de Castilla,* Madrid.

Marrow, P (2000). "*Nature-inspired computing technology and applications*", *BT Technol J,* Vol 18 No 4, October.

Maturana, H and F Varela (1998). *The Tree of Knowledge*: *The Biological Roots of Human Understanding*, revised edition, Boston: Shambhala.

Maturana, H (1997). "Metadesign", in: *Articulos y Conferences "Diez Años de Post-Racionalismo en Chile"* (Instituto de Terapia Cognitiva Web, Santiago) http://www.inteco.cl/articulos/006/doc_ing1.htm last visited 1/6/2007.

Maynard-Smith, J (1982). *Evolution and the Theory of Games*, Cambridge University Press.

Moore, J F (1996). *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*, New York: Harper Business.

Moore, J F (2003). "*Digital Business Ecosystems in Developing Countries: An Introduction*", Berkman Center for Internet and Society, Harvard Law School. http://cyber.law.harvard.edu/bold/devel03/modules/episodeII.html

Nachira, F (2002). "Toward a network of digital business ecosystems fostering the local development", http://www.europa.eu.int/information_society/topics/ebusiness/godigital/sme_research/index_en.htm

Nowotny, H, Scott, P and M Gibbons (2001). *Re-thinking science: knowledge and the public in an age of uncertainty*. Cambridge, UK: Polity.

O'Callagan, R (2004). "Technological Innovation in Organisations and Their Ecosystems", in *Transforming Enterprise: The Economic and Social Implications of Information Technology*, Edited by William H. Dutton*,* Boston: MIT Press.

Price Waterhouse Coopers (2004). *Rethinking the European ICT Agenda - Ten ICT Breakthroughs for Reaching Lisbon*, The Netherlands (EU presidency 2004), Ministry of Economic Affairs, Directorate-General for Telecommunications and Post, The Hague, August.

Schön, D A (1973). *Beyond the Stable State: Public and private learning in a changing society*, Harmondsworth: Penguin.

Steindl, J (1990). "From Stagnation in the 1930s to Slow Growth in the 1970s", in *Political Economy in the 20th Century*, Maxine Berg Ed., London: Philip Allan.

Schumpeter, J (1942). *Capitalism, Socialism, and Democracy*. New York: Harper.

Vaca, A (2005). "Extremadura and the Revolution of Free Software", in *How Open is the Future?*, M Wynants and J Cornelis Eds., Brussels:VUB University Press.

Varela, Francisco J, and H R Maturana (1973). *De Máquinas y Seres Vivos: Una teoría sobre la organización biológica*. Santiago de Chile: Editorial Universitaria.

Von Glasersfeld, E (1988). The reluctance to change a way of thinking. *The Irish Journal of Psychology*, 9(1), 83-90.

Von Glasersfeld, E (1996). *Radical Constructivism: A Way of Knowing and Learning*, London: Routledge.

Watzlawick, P, Beavin, J H, and D Jackson (1967). *Pragmatics of Human Communication,: A Study of Interactional Patterns, Pathologies, and Paradoxes*, New York: Norton.

Wilkins, J S (1998). "What's in a Meme? Reflections from the perspective of the history and philosophy of evolutionary biology". *Journal of Memetics - Evolutionary Models of Information Transmission*, Vol, 2, Nr 1. http://jom-emit.cfpm.org/1998/vol2/wilkins_js.html last visit 1/6/2007.

Williamson, O (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*, New York: The Free Press.

Winograd, T and F Flores (1986). "*Understanding Computers and Cognition*, A new foundation for Design", Noorwood, NewYersey: Ablex Publishing Corporation.