1. The innovation ecosystem

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1. INTRODUCTION

1.1 Specialized Knowledge as Key to Competitive Advantage

Developed and developing economies alike face increased resource scarcity and competitive rivalry. Science and technology increasingly appear as a main source of competitive and sustainable advantage for nations and regions alike. However, the key determinant of their efficacy is the quality and quantity of entrepreneurship-enabled innovation that unlocks and captures the pecuniary benefits of the science enterprise in the form of private, public or hybrid goods. In this context, linking university basic and applied research with the market, via technology transfer and commercialization mechanisms including government–university–industry partnerships and risk capital investments, constitutes the essential trigger mechanism and driving device for sustainable competitive advantage and prosperity. In short, university researchers, properly informed, empowered and supported, are bound to emerge as the architects of a prosperity that rests on a solid foundation of scientific and technological knowledge, experience and expertise, and not in fleeting and conjectural 'financial engineering' schemes. Building on these constituent elements of technology transfer and commercialization, 'open innovation diplomacy' encompasses the concept and practice of bridging distance and other divides (cultural, socio-economic, technological etc.) with focused and properly targeted initiatives to connect ideas and solutions with markets and investors ready to appreciate them and nurture them to their full potential. Chapter 6 develops this in more detail.

The emerging gloCalizing (global/local; Carayannis and von Zedtwitz, 2005; Carayannis and Alexander, 2006) frontier of converging systems, networks and sectors of innovation that is driven by increasingly complex, non-linear and dynamic processes of knowledge creation, diffusion and use confronts us with the need to reconceptualize – if not reinvent – the ways and means that knowledge production, utilization and renewal take place in the context of the knowledge economy and society.

Perspectives from and about different parts of the world and diverse human, socio-economic, technological and cultural contexts are interwoven to produce an emerging new worldview on how specialized knowledge, embedded in a particular socio-technical context, can serve as the unit of reference for stocks and flows of a hybrid, public/private, tacit/codified, tangible/virtual good that represents the building block of the knowledge economy, society and polity.

Thus the major purposes of this chapter could be paraphrased as:

(a) adding to the theories and concepts of knowledge further discursive inputs, such as suggesting a linkage of systems theory and the understanding of knowledge, emphasizing multi-level systems of knowledge and innovation, summarized as the Mode 3 knowledge production systems approach to knowledge creation, diffusion and use that we discuss below;
(b) using this diversified and conceptually pluralized understanding to support practical and application-oriented decision making with regard to knowledge, knowledge optimization and the leveraging of knowledge for other purposes, such as economic performance: knowledge-based decision making has ramifications for knowledge management of firms (global multinational corporations) and universities as well as for public policy (knowledge policy, innovation policy);
(c) exploring, identifying and understanding the key triggers, drivers, catalysts and accelerators of high-quality and -quantity (continuous as well as discontinuous, reinforcing as well as disruptive) innovation and sustainable entrepreneurship (financially and environmentally – see Carayannis and Campbell, 2010) that serve as the foundations of robust competitiveness within the operational framework of open innovation diplomacy (Carayannis and Campbell, 2011) and diaspora entrepreneurship and innovation networks (ibid.) (see also Chapter 6).

1.2 Mode 3 Knowledge Production System

We postulate that one approach to the required reconceptualization is what I call the 'Mode 3' knowledge production system (expanding and extending the 'Mode 1' and 'Mode 2' knowledge production systems), which is at the heart of the fractal research, education and innovation ecosystem (FREIE[1]) ('innovation ecosystem' for short[2]) consisting of 'innovation networks' and 'knowledge clusters' (see definitions below) for knowledge creation, diffusion and use (Carayannis and Campbell, 2006a).

'Mode 3' is a multi-lateral, multi-nodal, multi-modal, and multi-level systems approach to the conceptualization, design, and management of real and virtual, 'knowledge-stock' and 'knowledge-flow', modalities that catalyze, accelerate, and support the creation, diffusion, sharing, absorption, and use of co-specialized knowledge assets. 'Mode 3' is based on a system-theoretic perspective of socio-economic, political, technological, and cultural trends and conditions that shape the co-evolution of knowledge with the 'knowledge-based and knowledge-driven, gloCal economy and society'. (Carayannis and von Zedtwitz, 2005, p. 22).

The Mode 3 knowledge production system is in short the nexus or hub of the emerging twenty-first-century innovation ecosystem, where people,[3] culture[4] and technology[5] (Carayannis and Gonzalez, 2003) meet and interact to catalyze creativity, trigger invention and accelerate innovation across scientific and technological disciplines, public and private sectors (government, university, industry and non-governmental knowledge production, utilization and renewal entities, as well as other civil society entities, institutions and stakeholders) in a top–down, policy-driven as well as bottom–up, entrepreneurship-empowered fashion. One of the basic ideas of this chapter is the coexistence, co-evolution and co-specialization of different knowledge paradigms and different knowledge modes of knowledge production and knowledge use. We can postulate a dominance of knowledge heterogeneity at the systems (national, transnational) level. Only at the subsystem (sub-national) level should we expect homogeneity. We can paraphrase this understanding by the term 'Mode 3' knowledge production system.

1.3 Mode 3 and Systems Theory

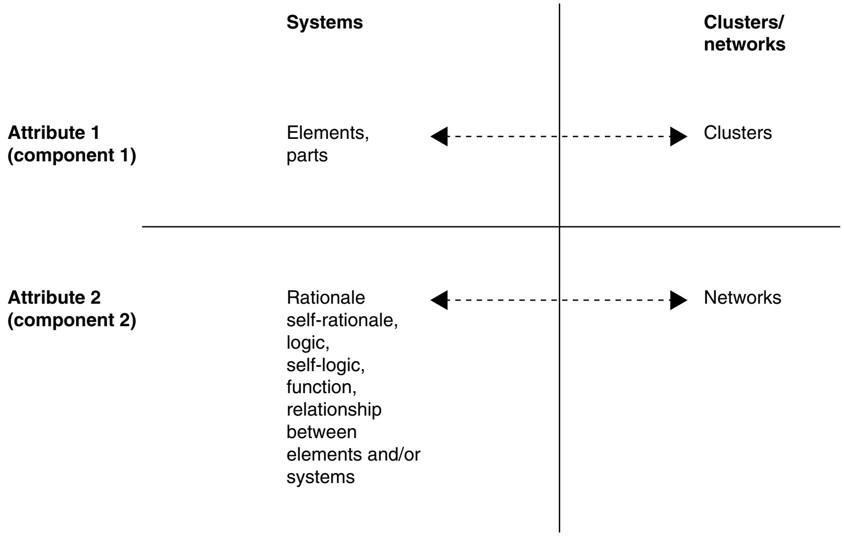
Embedding concepts of knowledge creation, diffusion and use in the context of general systems theory could prove mutually beneficial and enriching for systems theory as well as knowledge-related fields of study, as this could:

(a) reveal for systems theory a new and important field of application; and
(b) at the same time, provide a better conceptual framework for understanding knowledge-based and knowledge-driven events and processes in the economy, and hence reveal opportunities for optimizing public sector policies and private sector practices.

To fully leverage the potential of systems (and systems theory) one should demonstrate how a system design can be brought in line with other available concepts, such as innovation networks and knowledge clusters. With regard to clusters, at least three types can be listed:

1. *Geographic (spatial) clusters* Here a cluster represents a certain geographic, spatial configuration, either tied to a location or to a larger region. Geographic, spatial proximity, for example for the exchange of tacit knowledge, is considered crucial. While 'local' clearly represents a sub-national entity, a 'region' could be either sub-national or transnational.
2. *Sectoral clusters* Here different industrial or business sectors develop specific profiles with regard to knowledge production, diffusion and use. One could add that sectoral clusters even support the advancement of particular 'knowledge cultures'. In innovation research, the term 'innovation culture' is now acknowledged (Kuhlmann, 2001, p. 958).
3. *Knowledge clusters* Knowledge clusters are agglomerations of co-specialized, mutually complementary and reinforcing knowledge assets in the form of 'knowledge stocks' and 'knowledge flows' that exhibit self-organizing, learning-driven, dynamically adaptive competences and trends in the context of an open systems perspective. Here, a cluster represents a specific configuration of knowledge, and possibly also of knowledge types. However, in geographic (spatial) and sectoral terms, a knowledge cluster is not predetermined. In fact, a knowledge cluster can cross-cut different geographic locations and sectors, thus operating globally and locally (across a whole multi-level spectrum). It may express an innovative capability, and produce knowledge that excels (knowledge-based) economic performance. A knowledge cluster, furthermore, may include more than one geographic and/or sectoral clusters.

Networks emphasize interaction, connectivity and mutual complementarity, and reinforcement. They can be regarded as the internal configuration that ties together and determines a cluster, and can also express the relationship between different clusters. The concept of networking is important for understanding the dynamics of advanced and knowledge-based societies. Networking links together different modes of knowledge production and knowledge use, and also connects (sub-nationally, nationally, transnationally) different sectors or systems of society. Systems theory, as presented here, is flexible enough for integrating and reconciling systems and networks, thus creating conceptual synergies. Innovation



Source: Carayannis and Campbell (2009).

Figure 1.1 Theoretical equivalents between conceptual attributes of systems and clusters/networks

networks are real and virtual infrastructures and infra-technologies that serve to nurture creativity, trigger invention and catalyze innovation in a public and/or private domain context (e.g. government–university–industry public–private research and technology development co-opetitive partnerships) (see Carayannis and Alexander, 1999a, 2004). Innovation networks and knowledge clusters thus resemble a matrix, indicating the interactive complexity of knowledge and innovation. Should the (proposed) conceptual flexibility of systems (and systems theory) be fully leveraged, it appears important to demonstrate how systems relate conceptually to knowledge clusters and innovation networks, as they are key in understanding the nature and dynamics of knowledge stocks and flows. We suggest linking the two basic components (attributes) of systems ('elements/parts' and 'rationale/self-rationale'; Campbell, 2001, p. 426) with clusters and networks (Carayannis and Campbell, 2006a, pp. 9–10). What results is a formation of two pairs of theoretical equivalents (see Figure 1.1).

1. *Elements and clusters* The elements (parts) of a system can be regarded as an equivalent to clusters (knowledge clusters).

2. *Rationale and networks* The rationale (self-rationale) of a system can be understood as equivalent to networks (innovation networks).

The rationale of a system holds together the system elements and expresses the relationship between different systems. It could be argued that, at least partially, this rationale manifests itself ('moves through') networks. At the same time, elements of a system might also manifest themselves as clusters. Perhaps networks could be affiliated with the functions of a system, and clusters with the structures of systems. This would help to show us what to look for. This, obviously, does not imply that structures and functions of knowledge (innovation) systems fall only into the conceptual boxes of 'clusters' and 'networks'. However, clusters and networks should be regarded as crucial subsets for the elements and rationales of systems.

This equation (between elements/clusters and rationales/networks) might need further conceptual and theoretical development. But it opens a convincing route for better understanding knowledge and innovation, through tying together two strong conceptual traditions (systems theory with clusters and knowledge). A further ramification of networks, as we will demonstrate later on, could also imply understanding knowledge strategies as complex network configurations.

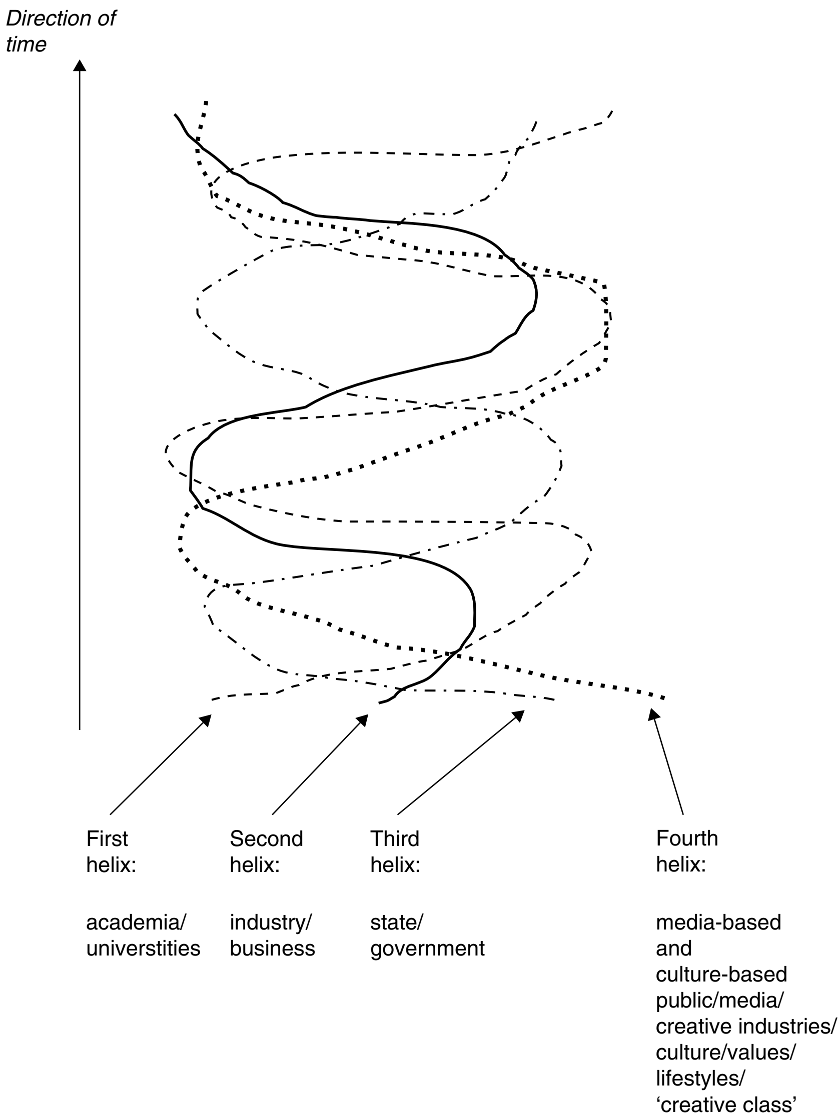
1.4 Integrating Different Knowledge Modes

The following presents in greater detail different aspects of advanced knowledge. Crucial for the suggested 'Mode 3' approach is the idea that an advanced knowledge system may integrate different knowledge modes. Some knowledge (innovation) modes will certainly die out. However, what is important for the broader picture is that a co-evolution, co-development and co-specialization of different knowledge modes emerges. This pluralism of knowledge modes should be regarded as essential for advanced knowledge-based societies and economies. This may point to similar features of advanced knowledge and advanced democracy. We could state that the competitiveness and sustainability of the gloCal knowledge economy and society increasingly depend on the elasticity and flexibility of promoting a co-evolution and thereby a cross-integration of different knowledge (innovation) modes. This heterogeneity of knowledge modes should create hybrid synergies.

The 'triple helix' model of knowledge, developed by Henry Etzkowitz and Loet Leydesdorff (2000, pp. 111–12), stresses three 'helices' that intertwine and thereby generate a national innovation system: academia/universities, industry, and state/government. Etzkowitz and Leydesdorff are inclined to speak of 'university–industry–government relations' and networks, also placing a particular emphasis on 'tri-lateral networks and hybrid organizations', where those helices overlap. In extension of the triple helix model we suggest a 'quadruple helix' model (see Figure 1.2), which adds to the above-stated helices a 'fourth helix' that we identify as the 'media-based and culture-based public'. This fourth helix is associated with 'media', 'creative industries', 'culture', 'values', 'lifestyles', and perhaps also the notion of the 'creative class' (a term coined by Richard Florida, 2004). The explanatory potential of such a fourth helix is that culture and values, on the one hand, and the way that 'public reality' is being constructed and communicated by the media, on the other hand, influence every national innovation system. The proper 'innovation culture' is key to promoting an advanced knowledge-based economy. Public discourses, transported through and interpreted by the media, are crucial for a society to assign top priority to innovation and knowledge (research, technology, education).

Figure 1.3 displays from which conceptual perspectives the co-evolution and cross-integration of different knowledge modes could be approached. Mode 3 emphasizes the additionality and surplus effect of a co-evolution of a pluralism of knowledge and innovation modes. The quadruple helix refers to structures and processes of the gloCal knowledge economy and society. Furthermore, innovation ecosystem stresses the importance of a pluralism of a diversity of agents, actors and organizations: universities, small and medium-sized enterprises and major corporations, arranged along the matrix of fluid and heterogeneous innovation networks and knowledge clusters. All this may result in a 'democracy of knowledge', driven by a pluralism of knowledge and innovation and by a pluralism of paradigms for knowledge modes.

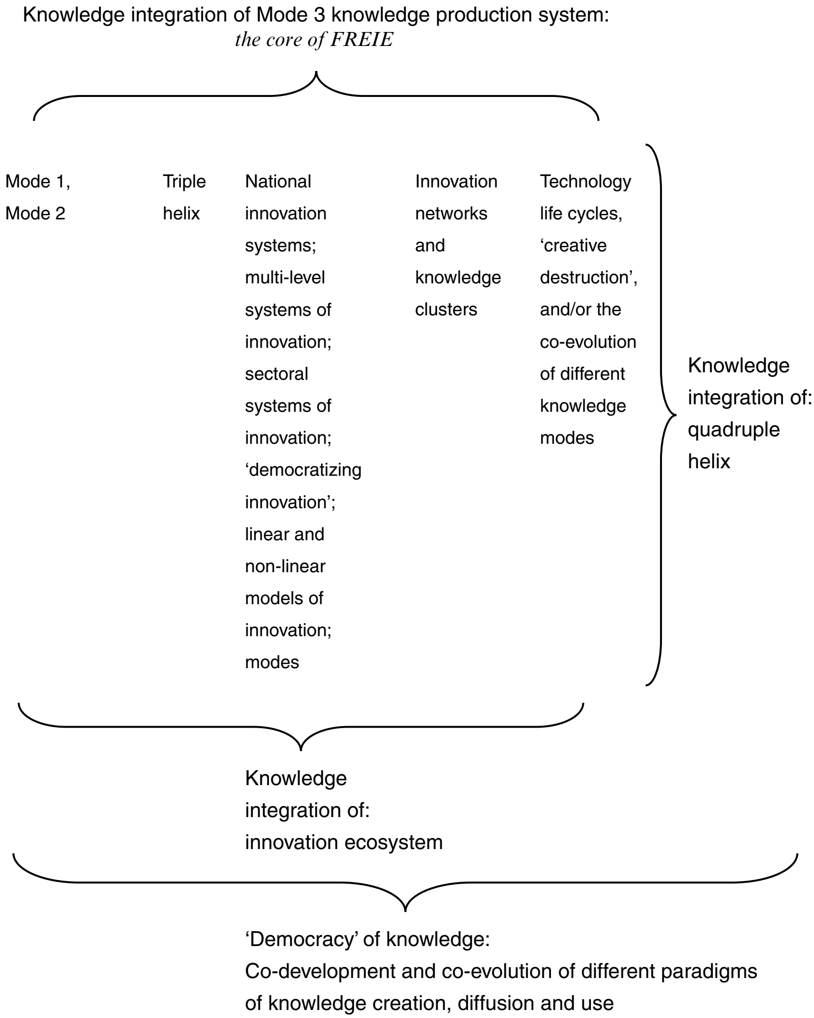
In the *Frascati Manual*, the OECD (1994, p. 29) distinguishes between the following categories of research (R&D, research and experimental development): basic research; applied research; and experimental development. Basic research represents a primary competence of university research, whereas business R&D focuses heavily on experimental development. In an empirical assessment of the USA, one of the leading national innovation systems with regard to the financial volume of R&D resources, experimental development ranks first, applied research second and basic research third (see Figure 1.4). What is interesting, however, is the dynamic momentum when observed for a longer period of time. Basic research in the USA grew faster than applied research. In 1981, 13.4 percent of US R&D was devoted to basic research. By 2004, basic research increased its percentage share to 18.7 percent. During the same time period the percentage shares of applied research and experimental development declined



Note: Triple helix: university–industry–government relations (helices); quadruple helix: university–industry–government–media- and culture-based public relations (helices).

Source: Carayannis and Campbell (2009).

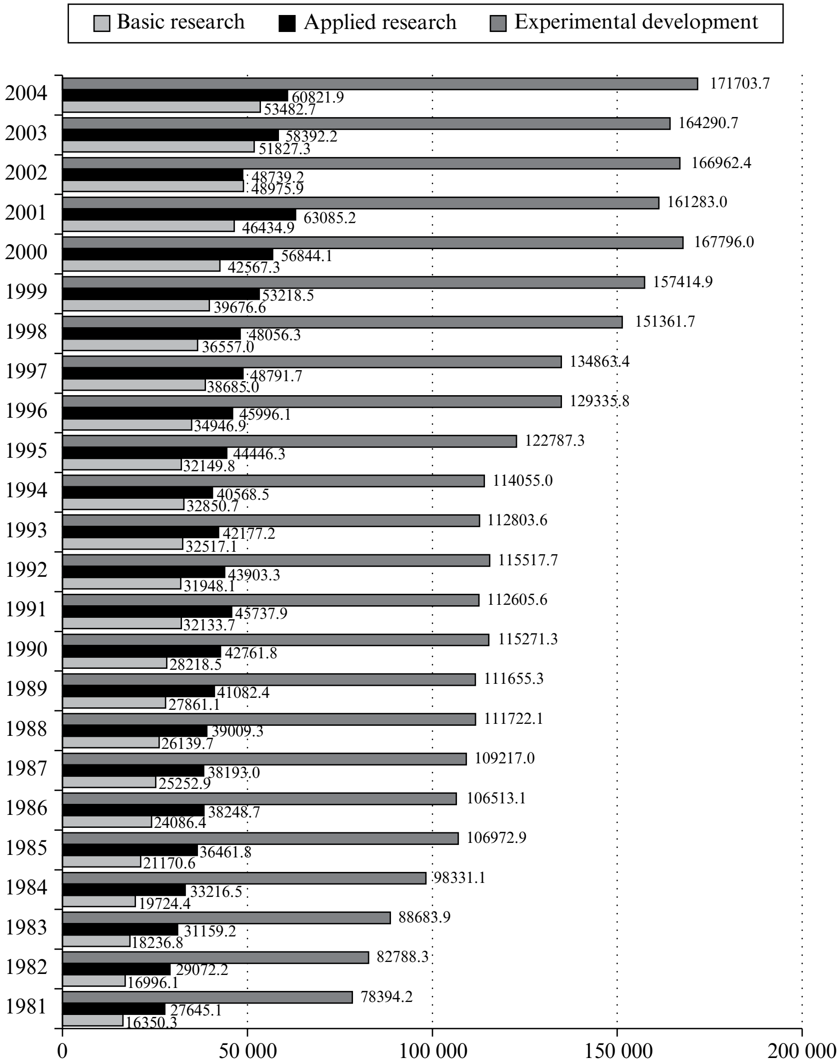
Figure 1.2 Conceptualization of the quadruple helix



Source: Carayannis and Campbell (2009).

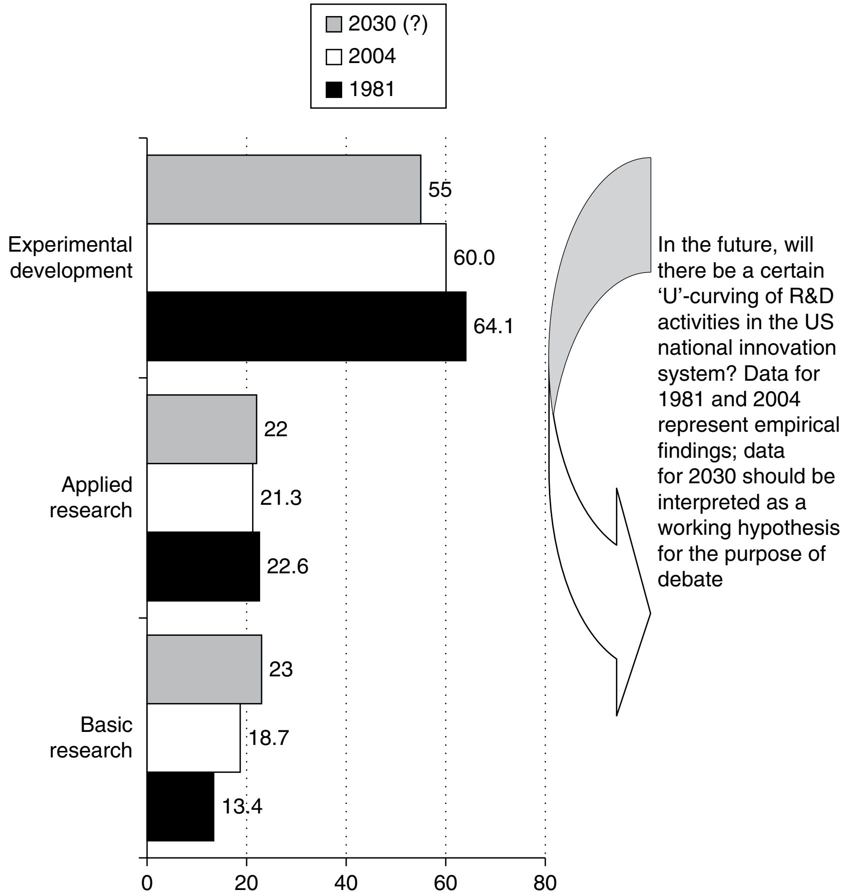
Figure 1.3 Knowledge creation, diffusion and use in a gloCal knowledge economy and society

(Figure 1.5). This links to the question whether we should expect R&D to follow a U-shaped curve for the US innovation system, implying that basic research will further increase its percentage share of overall R&D expenditure. This would go hand in hand with an important gain in basic research.



Source: OECD (2006).

Figure 1.4 National R&D performance of the USA according to the 'R&D activities' of basic research, applied research and experimental development (million constant $ 2000 prices and PPPs, 1981–2004)



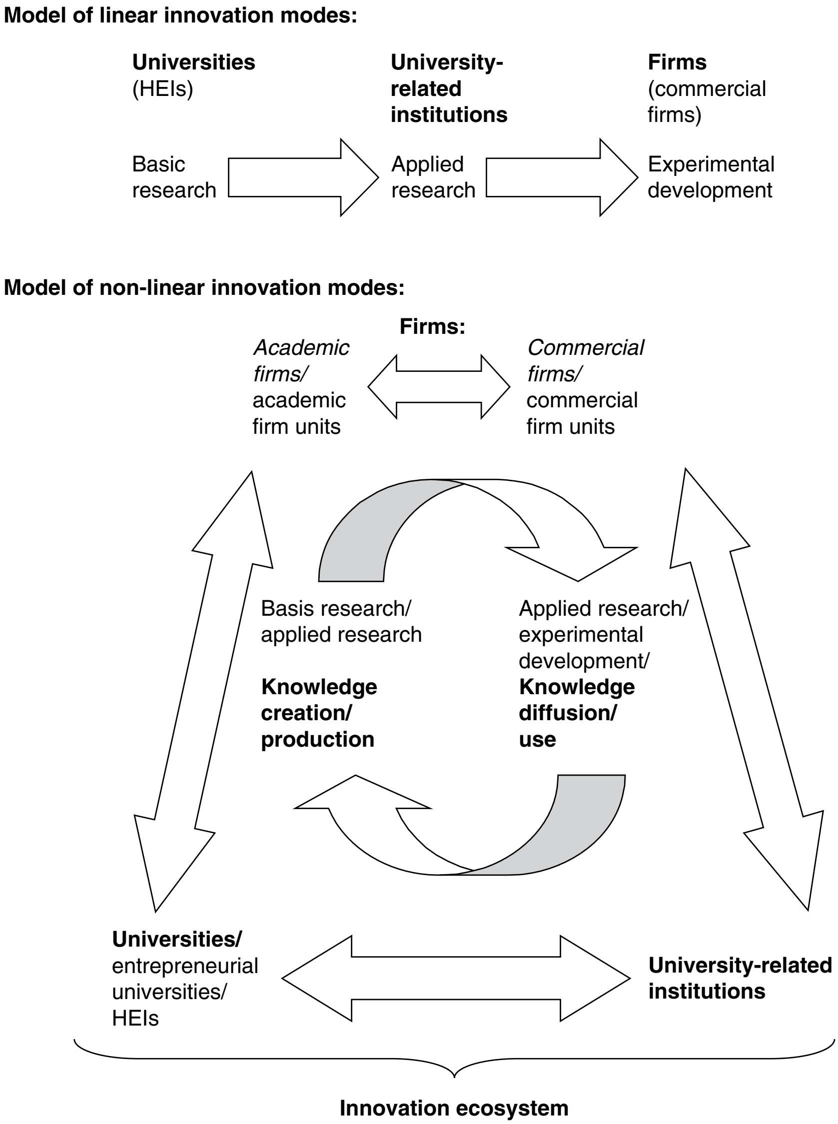
Source: Carayannis and Campbell (2009), based on OECD (2006).

Figure 1.5 National R&D performance of the USA according to the 'R&D activities' of basic research, applied research and experimental development (% of annual R&D activities: 1981, 2004, and a possible projection for 2030)

Furthermore, would such a potential future scenario for the USA also spill over to other national innovation systems?

In a simple interpretation, the linear model of innovation claims that, first, there is basic university research. Later this basic research converts into applied research of intermediary organizations (university-related institutions). Finally, firms pick up, and transform applied research into experimental development, which is then introduced as commercial market applications. This linear view is often attributed to Vannevar Bush (1945), even though Bush himself, in his famous report, neither mentions 'linear model of innovation' nor even the word 'innovation'. Non-linear models of innovation, on the contrary, underscore a more parallel coupling of basic research, applied research and experimental development. Thus universities or HEIs (higher education institutions), university-related institutions and firms join together in variable networks and platforms for creating innovation networks and knowledge clusters. Even though there continues to be a division of labor and a functional specialization of organizations with regard to the type of R&D activity, universities, university-related institutions and firms can perform, at the same time, basic and applied research and experimental development. Surveys on sectoral innovation in the pharmaceutical sector (McKelvey et al., 2004) and in the chemical sector (Cesaroni et al., 2004) reveal how each of these industries may be characterized by complex network configurations and arrangement of a diversity of academic and firm actors. The innovation ecosystem thus represents a model for a simultaneous coupling of 'non-linear innovation modes' (see Figure 1.6).

The concept of the 'entrepreneurial university' captures the need to link more closely university research with the R&D market activities of firms (see, e.g., Etzkowitz, 2003). Just as important as the entrepreneurial university is the concept of the 'academic firm' (Campbell and Güttel, 2005), which represents the complementary business organization and strategy *vis-à-vis* the entrepreneurial university. The interplay of academic firms and entrepreneurial universities should be regarded as crucial for advanced knowledge-based economies and societies. The following characteristics represent the academic firm (ibid., p. 171): 'support of the interfaces between the economy and the universities'; 'support of the paralleling of basic research, applied research and experimental development'; 'incentives for employees to codify knowledge'; 'support of collaborative research and of research networks'; and 'a limited "scientification" of business R&D'. Despite continuing important functional differences between universities and firms, some limited hybrid overlapping may also occur between entrepreneurial universities and academic firms, expressed in the fact that entrepreneurial universities and academic firms can engage more easily in university/business research networks. In an innovation-driven economy, business R&D gains support and excels when it refers to inputs from networking of universities and firms. The academic firm also engages in 'basic business research'. Of course, we must always bear in mind that academic firms and universities are not identical, because academic firms represent commercial units, interested in creating commercial



Source: Carayannis and Campbell (2009).

Figure 1.6 Linear and non-linear innovation modes linking universities with commercial and academic firms revenues and profits. Alternatively, the academic firm could be seen in two ways: (1) as a concept for the whole firm; (2) or as a concept only for a subdivision, sub-unit or branch of the firm. In many contexts, this second option appears to be more realistic, particularly when we analyze multinational companies or corporations (MNCs) that operate in a global context. For the future, this may have the following implication: how can or should firms balance, within their 'organizational boundary', the principle of the academic and of the traditional 'commercial' firm?

The 'technology life cycles' explain why there is always a dynamic in the gloCal knowledge economy and society (Tassey, 2001). The 'saturation tendency' within every technology life cycle demands the creation and launch of new technology life cycles, leading to the market introduction of next-generation technology-based products and services. In reality, different technology life cycles with a varying degree of market maturity will operate in parallel. To a certain extent, technology life cycles are also responsible for the cyclicality (growth phases) of a modern market economy. Perhaps the most succinct way of describing the economic thinking of Joseph A. Schumpeter is to present the following equation:

Entrepreneurship + leveraging opportunities of new technology life cycles = Economic growth

Addressing the cyclicality of capitalist economic life, Schumpeter (1942) used the notion of 'creative destruction'. Mode 3 may open up a route for overcoming or transforming the destructiveness of 'creative destruction' (Carayannis et al., 2007).

2. INNOVATION

Innovation is often linked with creating a sustainable market around the introduction of new and superior product or process. Specifically, in the literature on the management of technology, technological innovation is characterized as the introduction of a new technology-based product into the market:

> *Technological innovation* is defined . . . as a situationally new development through which people extend their control over the environment. Essentially, technology is a tool of some kind that allows an individual to do something new. A technological innovation is basically information organized in a new way. So technology transfer amounts to the communication of information, usually from one organization to another. (Tornazky and Fleischer, 1990)

The broader interpretation of the term refers to an 'idea, practice or material artifact' (Rogers and Shoemaker, 1971, p 19) adopted by a person or organization, where that artifact is 'perceived to be new by the relevant unit of adoption' (Zaltman et al., 1973). Therefore innovation tends to change perceptions and relationships at the organizational level, but its impact is not limited there. Innovation, in its broader socio-technical, economic and political context, can also substantially impact, shape and evolve ways and means people live their lives, businesses form, compete, succeed and fail, and nations prosper or decline.

From a business perspective, an innovation is perceived as the happy ending of the commercialization journey of an invention, when that journey is indeed successful and leads to the creation of a sustainable and flourishing market niche or new market. Therefore a technical discovery or invention (the creation of something new) is not significant to a company unless that new technology can be utilized to add value to the company, through increased revenues, reduced cost and similar improvements in financial results. This has two important consequences for the analysis of any innovation in the context of a business organization.

First, an innovation must be integrated into the operations and strategy of the organization, so that it has a distinct impact on how the organization creates value or on the type of value the organization provides in the market.

Second, an innovation is a social process, since it is only through the intervention and management of people that an organization can realize the benefits of an innovation.

The discussion of innovation clearly leads to the development of a model to understand its evolving nature. Innovation management is concerned with the activities of the firm undertaken to yield solutions to problems of product, process and administration. Innovation involves uncertainty and disequilibrium. Nelson and Winter (1982) propose that almost any change, even trivial, represents innovation. They also suggest, given the uncertainty, that innovation results in the generation of new technologies and changes in the relative weighting of existing technologies (ibid.). This results in the disruptive process of disequilibrium. As an innovation is adopted and diffused, existing technologies may become less useful (reduction in weight factors) or even useless (weighing equivalent to zero) and abandoned altogether. The adoption phase is where uncertainty is introduced. New technologies are not adopted automatically but rather, markets influence the adoption rate (Carayannis and Allbritton, 1997; Rogers et al., 1998). Innovative technologies must propose to solve a market need such as reduced costs or increased utility or increased productivity. The markets, however, are social constructs and subject to non-innovation-related criteria. For example, an invention may be promising, offering a substantial reduction on the cost of a product which normally would influence the market to accept the given innovation; but due to issues like information asymmetry (the lack of knowledge in the market concerning the invention's properties), the invention may not be readily accepted by the markets. Thus the innovation may remain an invention. If, however, the innovation is accepted by the market, the results will bring about change to the existing technologies being replaced, leading to a change in the relative weighting of the existing technology. This is in effect disequilibrium.

Given the uncertainty and change inherent in the innovation process, management must develop skills and understanding of the process, and a method for managing the disruption. The problems of managing the resulting disruption are strategic in nature. The problems may be classified into three groups: engineering, entrepreneurial, and administrative (Drejer, 2002). This grouping correlates to the related types of innovation, namely, product, process and administrative innovation:

- The engineering problem is one of selecting the appropriate technologies for proper operational performance.
- The entrepreneurial problem refers to defining the product/service domain and target markets.
- Administrative problems are concerned with reducing the uncertainty and risk during the previous phases.

In much of the foregoing discussion of innovation, a recurring theme is that of uncertainty, leading to the conclusion that an effective model of innovation must include a multidimensional approach (uncertainty is defined as unknown unknowns whereas risk is defined as known knowns). One model posited as an aid to understanding is the multidimensional model of innovation (MMI) (Cooper, 1998). This model attempts to define innovation by establishing three-dimensional boundaries. The planes are defined as product–process, incremental–radical, and administrative–technical. The product–process boundary concerns itself with the end product and its relationship to the methods employed by firms to produce and distribute the product. Incremental–radical defines the degree of relative strategic change that accompanies the diffusion of an innovation. This is a measure of the disturbance or disequilibrium in the market. Technological–administrative boundaries refer to the relationship of innovation change to the firm's operational core. The use of 'technological' refers to the influences on basic firm output, while the 'administrative' boundary would include innovations affecting associated factors of policy, resources and social aspects of the firm.

Innovation \ Knowledge	*yes*	*no*
yes	Knowledge-based innovation or knowledge which, through innovation, is linked with society, economy and politics. Examples: Mode 1 and technology cycles in the long run, Mode 2, triple helix	Innovation, taking place with no (almost no) references to knowledge. Examples: management innovations in businesses, which are not R&D or technology-based
no	Knowledge, without major references to innovation (and use). Examples: 'pure research', perhaps some components of Mode 1 and of early phases of technology life cycles	*? (Not of primary concern for our conceptual mapping)*

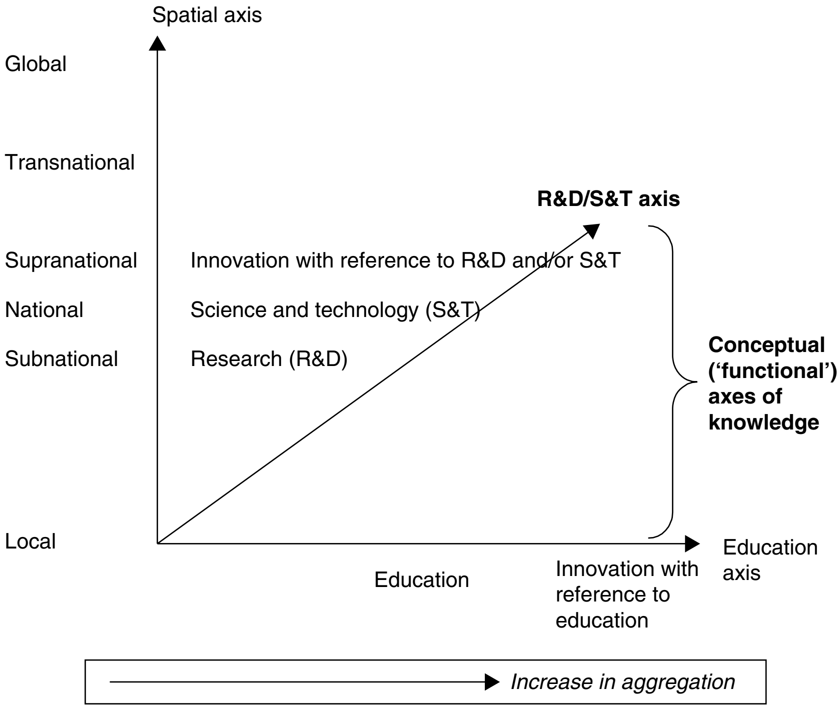
Source: Carayannis and Campbell (2009).

Figure 1.7 A four-fold typology of possible cross-references and interactions between knowledge and innovation

2.1 The Relationship between Knowledge and Innovation

What is the relationship between knowledge and innovation? From our viewpoint it makes sense not to treat knowledge and innovation as interchangeable concepts. The ramifications of this are (see Figure 1.7):

1. There are aspects, areas of knowledge, that can be analyzed without considering innovation (e.g. 'pure basic research' in a linear understanding of innovation).
2. Consequently, there are areas or aspects of innovation that are not (necessarily) tied to knowledge (see various contributions to Shavinina, 2003).
3. However, there are also areas where knowledge and innovation coexist. These we would like to call 'knowledge-based innovation', indicating areas where knowledge and innovation have a mutual interaction.



Source: Carayannis and Campbell (2009).

Figure 1.8 A multi-level modeling knowledge

In the case of knowledge-based innovation, we can then speak of innovation that deals with knowledge. Our impression is that in many contexts, when the focus falls on innovation, almost automatically this type of innovation is implied. Even though we will focus on this knowledge-based innovation, it is important to acknowledge the possibilities of a knowledge without innovation, and of innovation independent of knowledge. To further illustrate our point, the notion of the 'national innovation system' or 'national system of innovation' (NSI) conventionally expresses linkages to knowledge (see Lundvall, 1992; Nelson, 1993).

In research on the European Union (EU), references to a 'multi-level architecture' are quite common (see, e.g., Hooghe and Marks, 2001). This 'multi-level' approach is being applied in a diversity of fields, since it supports the understanding of complex processes in a globalizing world. Inspired by this, we suggest using the concept of 'multi-level systems of knowledge' (see Figure 1.8; see also Carayannis and Campbell, 2006a).

One obvious axis, therefore, is the spatial (geographic, spatial–political) axis that expresses different levels of spatial aggregations. The national level, coinciding with the nation state (the currently dominant manifestation of arranging and organizing political and societal affairs), represents one type of spatial aggregation. Sub-national aggregations fall below the nation-state level, and point toward local political entities. Transnational aggregations, for example, can refer to the supranational integration process of the EU. This raises the interesting question whether we should be prepared to expect that in the twenty-first century we will also witness a proliferation of supranational (transnational) integration processes in other world regions, possibly implying a new stage in the evolution of politics, where (small and medium-sized) nation-state structures become absorbed by supranational (transnational) clusters (Campbell, 1994). The highest level of transnational aggregation that we currently know is globalization. Interestingly, the aggregation level of the term 'region(s)' has never been convincingly standardized. In the context and political language of the EU, regions are understood sub-nationally. American scholars, on the other hand, often refer to regions in a state-transcending interpretation (i.e., a region consists of more than one nation state). The term 'gloCal' (explained earlier) underscores the potentials and benefits of a mutual and parallel interconnectedness of different levels.

Despite the importance of this spatial axis, we do not wish to exhaust the concept of multi-level systems of knowledge with spatial–geographic metaphors. We suggest adding on non-spatial axes of aggregation. These we may call conceptual (functional) axes of knowledge. In that context, two axes certainly are pivotal: education and research (R&D, research and experimental development). For research, the level of aggregation can develop accordingly: R&D; S&T (science and technology);[6] and R&D-based innovation, involving a broad spectrum of considerations and aspects. Obviously, every 'axis direction' of further aggregation – as demonstrated here for R&D – depends on a specific conceptual understanding. Should, for example, a different conceptual approach for defining S&T be favored, then the sequence of aggregation might change. (Concerning the education axis, we leave it to the judgment of other scholars what meaningful terms at different levels of aggregation may be.)

How many non-spatial (conceptual) axes of knowledge can there be? We focused on the R&D and education axes, but do not thereby imply that there may not be more than two conceptual axes. Here, at least in principle, a multitude or diversity of conceptual model-building approaches is possible and also appropriate. Perhaps, we could even integrate 'innovation' as an additional conceptual axis, following the aggregation line from local, to national and transnational innovation systems.

We would then have to consider what the relationship is between such an 'extra innovation axis' with the 'innovation' of the research and education axes. 'Regional' innovation could cross-refer to local and transnational innovation systems, implying even gloCal innovation systems and processes that simultaneously link through different aggregation levels.

We have already discussed the conceptual boundary problems between knowledge and innovation. One approach to balancing ambiguities in this context is to acknowledge that a partial conceptual overlap exists between a knowledge-centered and an innovation-centered understanding. Depending on the focus of the preferred analytical view, the same 'element(s)' can be conceptualized as part of a knowledge or of an innovation system. Concerning knowledge, we pointed to some of the characteristics of multi-level systems of knowledge, underscoring the understanding of aggregation of spatial and non-spatial (conceptual) axes. Introducing multi-level systems of knowledge also justifies speaking of multi-level systems of innovation, developing the original concept of the national innovation system (Lundvall, 1992; Nelson, 1993) further. For example, the spatial axis of aggregation of knowledge (Figure 1.8) also applies to innovation. Of course, Lundvall (1992, pp. 1, 3) also explicitly stresses that national innovation systems are permanently challenged (and extended) by regional as well as global innovation systems. But, paraphrasing Kuhlmann (2001, pp. 960–61), as long as nation-state-based political systems exist, it makes sense to acknowledge national innovation systems. In a spatial (or geographic) understanding, the term 'multi-level systems of innovation' is already being used (Kaiser and Prange, 2004, pp. 395, 405–6; Kuhlmann, 2001, pp. 970–71, 973). However, only more recently has it been suggested to extend this multi-level aggregation approach of innovation to the non-spatial axes of innovation (Campbell, 2006a; Carayannis and Campbell, 2006a). Therefore multi-level systems of knowledge as well as multi-level systems of innovation are based on spatial and non-spatial axes. A further advantage of this multi-level systems architecture is that it results in a more accurate and realistic description of processes of globalization and gloCalization. For example, internationalization of R&D cross-cuts these different multi-level layers, links together organizational units of business, academic and political actors at national, transnational and sub-national levels (Von Zedtwitz and Heimann, 2006). One interpretation of R&D internationalization emphasizes how different sub-national regions and clusters cooperate on a global scale, creating even larger transnational knowledge clusters.

The concept of 'sectoral systems of innovation' (SSI) cross-cuts the logic of the multi-level systems of innovation or knowledge. A sector is often understood in terms of industrial sectors. Sectors can perform locally/

regionally, nationally and transnationally. Reviews of SSIs often place particular emphasis on: knowledge and technologies; actors and networks; and institutions. Malerba (2004, p. i) recommends that analyses of sectoral systems of innovation should include 'the factors affecting innovation, the relationship between innovation and industry dynamics, the changing boundaries and the transformation of sectors, and the determinants of the innovation performance of firms and countries in different sectors'.

2.2 Linear versus Non-linear Innovation Models (Modes)

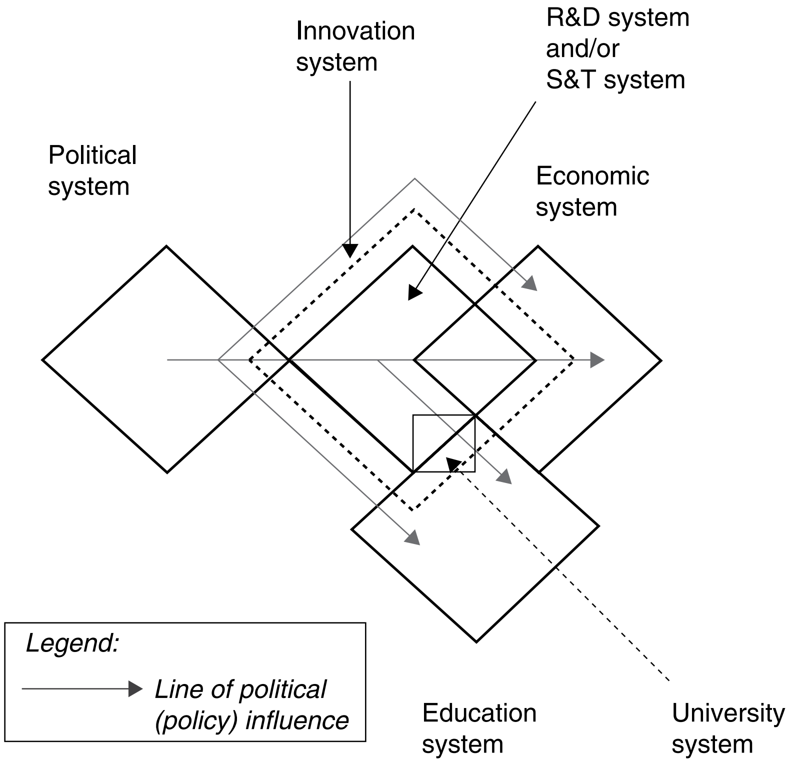
Is the linear model of innovation still valid? In an ideal-typical understanding the linear model states: first there is basic research, carried out in a university context. Later on, this basic research is converted into applied research, and moves from the university to the university-related sectors. Finally, applied research is translated into experimental development, carried out by business (the economy). What results is a first-then relationship, with the universities and/or basic research being responsible for generating the new waves of knowledge creation that are later taken over by business, and where business carries the final responsibility for the commercialization and marketing of R&D. National (multi-level) innovation systems, operating primarily on the premises of this linear innovation model, obviously would be disadvantaged: the time horizon for a whole R&D cycle to reach the markets could be quite extensive (with negative consequences for an economy operating in the context of rapidly intensifying global competition). Furthermore, the linear innovation model exhibits serious weaknesses in communicating user preferences from the market end back to the production of basic research. In addition, how should the tacit knowledge of the users and markets be reconnected to basic research? After 1945, the USA was regarded as a prototype for the linear innovation model system, with a strong university base from where basic research gradually would diffuse to the sectors of a strong private economy, without the intervention of major public innovation policy programs (see Bush, 1945, p. 5). As long as the USA represented the world-leading national economy, this understanding was sufficient. But with the intensification of global competition, the demand for shortening the time horizon from basic research to market implementation of R&D increased (OECD, 1998, pp. 179–81, 185–6). In the 1980s, Japan in particular heavily pressured the USA. In the 2000s, global competition within the triad of the USA, Japan and the EU escalated further, with China and India emerging as new competitors in the global context. In a nutshell, increasing economic competition and intrinsic knowledge demands challenged the linear innovation model.

As a consequence, we can observe a significant proliferation of non-linear innovation models. There are several approaches to non-linear innovation models. The 'chain-linked model' developed by Kline and Rosenberg (1986; cited in Miyata, 2003, p. 716; see also Carayannis and Alexander, 2006), emphasizes the importance of feedback between the different R&D stages. In particular, the coupling of marketing, sales and distribution with research claims to be important. 'Mode 2' (Gibbons et al., 1994, pp. 3–8, 167) underscores the linkage of production and use of knowledge by referring to the following five principles: knowledge produced in the context of application; transdisciplinarity; heterogeneity and organizational diversity; social accountability and reflexivity; and quality control (see also Nowotny et al., 2001, 2003). Metaphorically speaking, the first–then sequence of relationships of different stages within the linear model is replaced by a paralleling of different R&D activities (Campbell, 2000, p. 139–41). Paralleling means: (1) linking together in real time different stages of R&D, for example basic research and experimental development, and/or (2) linking different sectors, such as universities and firms. As mentioned earlier, the 'triple helix' model of Etzkowitz and Leydesdorff (2000, pp. 109, 111) stresses the interaction between academia, state and industry, focusing consequently on 'university–industry–government relations' and 'tri-lateral networks and hybrid organizations'. Carayannis and Laget (2004, pp. 17, 19) emphasize the importance of cross-national and cross-sectoral research collaboration by testing these propositions for transatlantic public–private R&D partnerships. Anbari and Umpleby (2006, pp. 27–9) claim that one rationale for establishing research networks lies in the interest of bringing together knowledge producers, but also practitioners, with 'complementary skills'. Etzkowitz (2003) speaks of the 'entrepreneurial university'. An effective coupling of university research and business R&D demands, furthermore, the complementary establishment of the entrepreneurial university and the 'academic firm' (Campbell and Güttel, 2005, pp. 170–72). Extended ramifications of these discourses also refer to the challenge of designing proper governance regimes for the funding and evaluation of university research (Geuna and Martin, 2003; see also Shapira and Kuhlmann, 2003; Campbell, 1999, 2003). Furthermore, this imposes consequences on structures and performance of universities (Pfeffer, 2006). Interesting also is the concept of 'democratizing innovation', used by Eric von Hippel in his 'user-centric innovation' model, in which 'lead users' represent 'innovating users', who again contribute crucially to the performance of innovation systems. 'Lead users' can be individuals or firms. Users often innovate, because they cannot find in the market what they want or need (Von Hippel, 1995, 2005). Non-proprietor knowledge, such as the 'open source' movement in the software industry (Steinmueller, 2004, p. 240), may be seen as successful examples for gloCally self-organizing 'user communities'.

In summary, one could set up the following hypothesis for discussion: while Mode 1 and perhaps also the concept of 'technology life cycles' (see Cardullo, 1999; Tassey, 2001) appear to be more closely associated with the linear innovation model, the Mode 2 and triple helix knowledge modes have more in common with a non-linear understanding of knowledge and innovation. At the same time we should add that national (multi-level) innovation systems are challenged by the fact that several technology life cycles, at different stages of market maturity (closeness to commercial market introduction), perform in parallel. This parallel, as well as sequentially time-lagged unfolding of technology life cycles, also expresses characteristics of Mode 2 and of non-linear innovation, because organizations (firms and universities) must often must develop strategies of simultaneously cross-linking different technology life cycles. Universities and firms (commercial and academic firms) must balance the non-triviality of a fluid pluralism of technology life cycles.

2.3 From Triple to Quadruple Helix

Knowledge and innovation policies and strategies must acknowledge the important role of the 'public' in achieving goals and objectives. On the one hand, public reality is being constructed and communicated by the media and the media system. On the other hand, the public is also influenced by culture and values. Knowledge and innovation policy should aim to reflect the dynamics of 'media-based democracy', to draft policy strategies. Particularly when we assume that traditional economic policy gradually (partially) converts into innovation policy, leveraging knowledge for economic performance and thus linking the political system with the economy, then innovation policy should communicate its objectives and rationales, via the media, to the public to seek legitimation and justification (see Figure 1.9; see also Carayannis and Campbell, 2006a, p. 18; 2006b, p. 335). Also the PR (public relations) strategies of companies engaged in R&D must reflect on the fact of a 'reality construction' by the media. Culture and values also express a key role. Cultural artifacts, such as movies, can influence public opinion of the public and their willingness to support public R&D investment. Some of the technical and engineering curricula at universities are not gender-symmetric, because a majority of the students are male. Trying to make women more interested in enrolling in technical and engineering studies would also imply changing the 'social images' of technology in society. The sustainable backing and reinforcing of knowledge and innovation in the gloCal knowledge economy and



Source: Carayannis and Campbell (2006a).

Figure 1.9 Different societal system: lines of political (policy) influence

society requires substantive support of the development and evolution of 'innovation cultures' (Kuhlmann, 2001, p. 954). Therefore the successful engineering of knowledge and innovation policies and/or strategies leverages the self-logic of the media system and leverages or alters culture and values.

2.4 Coexistence and Co-evolution of Different Knowledge and Innovation Paradigms

Discussing the evolution of scientific theories, Thomas S. Kuhn (1962) introduced the concept of 'paradigms'. Paradigms can be understood as basic fundamentals upon which a theory rests. In that sense paradigms are axiomatic premises that guide a theory but cannot be explained by the theory itself. However, paradigms add to the explanatory power of theories that are interested in explaining the (outside) world. They represent something like beliefs. According to Kuhn, scientific theories evolve following a specific pattern: there are periods of 'normal science', interrupted by intervals of 'revolutionary science' again converting into 'normal science', again challenged by 'revolutionary science', and so on (Carayannis, 1993, 1994, 2000, 2001; see also Umpleby, 2005, pp. 287–8). According to Kuhn, every scientific theory, with its associated paradigm(s), has only a limited capacity for explaining the world. Confronted with phenomena that cannot be explained, a gradual modification of the same theory might be sufficient. However, at one point a revolutionary transformation is necessary, demanding that a whole set of theories/paradigms be replaced by new theories/paradigms. For a while, the new theories/paradigms are adequately advanced. However, in the long run, these cycles of periods of normal science and intervals of revolutionary science represent the dominant pattern.

Kuhn emphasizes this shift of one set of theories and paradigms to a new set, meaning that new theories and paradigms represent not so much an evolutionary offspring, but actually replace the earlier theories and paradigms. While this is certainly often true, particularly in the natural sciences, we want to stress that there also can be a coexistence and co-evolution of paradigms (and theories), implying that paradigms and theories can learn from each other. Particularly in the social sciences this notion of coexistence and co-evolution of paradigms might sometimes be more appropriate than the replacement of paradigms. For the social sciences, and politics in general, we can point to the pattern of a permanent mutual contest between ideas. Umpleby (1997, p. 635), for instance, emphasizes the following aspect of the social sciences: 'Theories of social systems, when acted upon, change social systems.' Not only (social) scientific theories refer to paradigms, also other social contexts or factors can be understood as being based on paradigms: we can speak of ideological paradigms or of policy paradigms (Hall, 1993). Another example would be the long-term competition and fluctuation between the welfare-state and the free-market paradigms (with regard to the metrics of left–right placement of political parties in Europe, see Volkens and Klingemann, 2002, p. 158).

These different modes of innovation and knowledge creation, diffusion and use, which we discussed earlier, can also be understood as linking to knowledge paradigms. Because knowledge and innovation systems clearly relate to the context of a (multi-level) society, the (epistemic) knowledge paradigms can be regarded as belonging to the 'family of social sciences'. Interestingly, Mode 2 addresses 'social accountability and reflexivity' as one of its key characteristics (Gibbons et al., 1994, pp. 7, 167–8). In addition to the possibility that a specific knowledge paradigm is replaced by a new knowledge paradigm, the relationship between different knowledge and innovation modes may often be described as an ongoing and continuous interaction of a dynamic coexistence and (over time) a co-evolution of different knowledge paradigms. This reinforces the understanding that, in the advanced knowledge-based societies and economies, linear and non-linear innovation models can operate in parallel.

2.5 The 'Co-opetitive' Networking of Knowledge Creation, Diffusion and Use

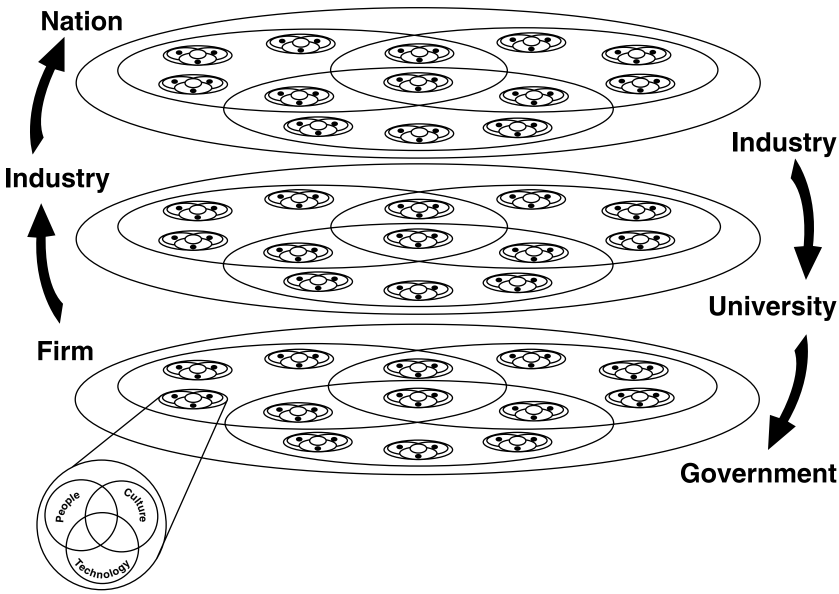
Knowledge systems are highly complex, dynamic and adaptive. To begin with, there exists a conceptual (hybrid) overlapping between multi-level knowledge and multi-level innovation systems. Multi-level systems proceed simultaneously at the global, transnational, national, and sub-national levels, creating gloCal (global and local) challenges. Advanced knowledge systems should demonstrate the flexibility to integrate different knowledge modes – on the one hand, combining linear and non-linear innovation modes; on the other hand, conceptually integrating the modes of Mode 1, Mode 2 and triple helix (for an overview of Mode 1, Mode 2, triple helix, and technology life cycles, see Campbell, 2006a, pp. 71–5). This shows the practical usefulness of an understanding of a coexistence and co-evolution of different knowledge paradigms, and what the qualities of an 'innovation ecosystem' could or even should be. The elastic integration of different modes of knowledge creation, diffusion and use should generate synergistic surplus effects of additionality. Hence for advanced knowledge systems, networks and networking are important (Carayannis and Alexander, 1999b; Carayannis and Campbell, 2006b, pp. 334–9; for a general discussion of networks and complexity, see also Rycroft and Kash, 1999).

How do networks relate to cooperation and competition? 'Co-opetition', as a concept (Brandenburger and Nalebuff, 1997) underscores that there can always exist a complex balance of cooperation and/or competition. Market concepts emphasize a competitive dynamics process between (1) forces of supply and demand, and (2) the need to integrate market-based as well as resource-based views of business activity. To be exact, networks do not replace market dynamics, thus they do not represent an alternative to the market-economy principle of competition. Instead, networks apply a 'co-opetitive' rationale, meaning: internally, networks are based primarily on cooperation, but may also allow a 'within' competition. The relationship between different networks can be guided by a motivation for cooperation. However, in practical terms, competition in knowledge and innovation will often be carried out between different and flexibly configured networks. While a network cooperates internally, it may compete externally. In short, 'co-opetition' should be regarded as a driver for networks, implying that the specific content of cooperation and competition is always decided in a case-specific context.

3. CONCLUSION

The Mode 3 systems approach (the innovation ecosystem) to knowledge creation, diffusion and use emphasizes the following key elements (Carayannis and Campbell, 2006c):

1. *GloCal multi-level knowledge and innovation systems* Because of its comprehensive flexibility and explanatory power, systems theory is regarded as suitable for framing knowledge and innovation in the context of multi-level knowledge and innovation systems (Carayannis and Von Zedtwitz, 2005; Carayannis and Campbell, 2006c; Carayannis and Sipp, 2006). GloCal expresses the simultaneous processing of knowledge and innovation at different levels (e.g. global, national and sub-national; see Gerybadze and Reger, 1999; Von Zedtwitz and Gassmann, 2002), and also refers to stocks and flows of knowledge with local meaning and global reach. Knowledge and innovation systems (and concepts) express a substantial degree of hybrid overlapping, meaning that often the same empirical information or case could be discussed under the headings of knowledge or innovation.
2. *Elements/clusters and rationales/networks* In a theoretical understanding, we pointed to the possibility of linking the elements of a system with clusters and the rationale of a system with networks. Clusters and networks are common and useful terms for the analysis of knowledge.
3. *Knowledge clusters, innovation networks and co-opetition* More specifically, we emphasized the terms knowledge clusters and innovation networks (Carayannis and Sipp, 2006). Clusters, by taking demands of a knowledge-based society and economy seriously for a competitive and effective business performance, should be represented as knowledge configurations. Knowledge clusters, therefore, represent a further evolutionary development of geographical (spatial) and sectoral clusters. Innovation networks, internally driving and operating knowledge clusters or cross-cutting and cross-connecting different knowledge clusters, enhance the dynamics of knowledge



Source: Carayannis (2000–2011).

Figure 1.10 The innovation ecosystem

and innovation systems. Networks always express a pattern of co-opetition, reflecting a specific balance of cooperation and competition. Intra-network and inter-network relations are based on a mix of cooperation and competition, that is co-opetition (Brandenburger and Nalebuff, 1997). When we speak of competition, it will often be a contest between different network configurations.

4. *Knowledge fractals* These emphasize the continuum-like bottom–up and top–down progress of complexity. Each sub-component (sub-element) of a knowledge cluster and innovation network can be seen as a micro-level sub-configuration of knowledge clusters and innovation networks (see Figure 1.10). At the same time, one can also move upward. Every knowledge cluster and innovation network can also be understood as a sub-component (sub-element) of a larger macro-level knowledge cluster or innovation network – in other words, innovation meta-networks and knowledge meta-clusters.
5. *The adaptive integration and co-evolution of different knowledge and innovation modes, the 'quadruple helix'* Mode 3 allows and emphasizes the coexistence and co-evolution of different knowledge and innovation paradigms. A key hypothesis is: The competitiveness and

> superiority of a knowledge system is highly determined by its adaptive capacity to combine and integrate different knowledge and innovation modes via co-evolution, co-specialization and co-opetition knowledge stock and flow dynamics (e.g. Mode 1, Mode 2, triple helix, linear and non-linear innovation). The specific context (circumstances, demands, configurations, cases) determines which knowledge and innovation mode (multi-modal), at which level (multi-level), involving what parties or agents (multi-lateral) and with what knowledge nodes or knowledge clusters (multi-nodal) will be appropriate. What results is an emerging fractal knowledge and innovation ecosystem well configured for the knowledge economy and society challenges and opportunities of the twenty-first century by being endowed with mutually complementary and reinforcing as well as dynamically co-evolving, co-specializing and co-opeting, diverse and heterogeneous configurations of knowledge creation, diffusion and use. The intrinsic litmus test of the capacity of such an ecosystem to survive and prosper in the context of continually gloCalizing and intensifying competition represents the ultimate competitiveness benchmark with regard to the robustness and quality of the ecosystem's knowledge and innovation architecture and topology as it manifests itself in the form of a knowledge value-adding chain. The concept of the quadruple helix broadens our understanding because it adds the 'media-based and culture-based public' to the picture.

The societal embeddedness of knowledge represents a theme that Mode 2 and the triple helix explicitly acknowledge. As a last thought for this chapter we want to underscore the potentially beneficial cross-references between democracy and knowledge for a better understanding of knowledge. Democracy could be seen as an interplay of two principles (Campbell, 2005): (1) as a method or procedure based on the application of the rule of the majority (see Schumpeter, 1942). This acknowledges the 'relativity of truth' and 'pluralism' in a society, implying that decisions are carried out, not because they are 'right' (or more right), but because they are backed and legitimized by a majority. Since, over time, these majority preferences normally change, this creates political swings, driving the government/opposition cycles, which crucially add to the viability of a democratic system. (2) Democracy can also be understood as a substance, where understood as an evolutionary manifestation of fundamental rights (O'Donnell, 2004, pp. 26–7, 47, 54–5). Obviously, the method/procedure and the substance approach overlap. Without fundamental rights, the majority rule could neutralize or even destroy itself. On the other hand, the 'real political' implementation of rights also demands a political method, an institutionally set-up procedure. For the purpose of bridging democracy with knowledge and innovation, we highlight the following aspects (see Figure 1.11 for a suggested visualization; see also Godoe, 2007, p. 358; Carayannis and Ziemnowicz, 2007):

1. *Knowledge-based and innovation-based democracy* The future of democracy depends on evolving, enhancing and ideally perfecting the concepts of a knowledge-based and innovation-based democratic polity as the manifestation and operationalization of what one might consider the 'twenty-first-century platonic ideal state':

   > It has been basic United States policy that Government should foster the opening of new frontiers. It opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains. It is in keeping with the American tradition – one which has made the United States great – that new frontiers shall be made accessible for development by all American citizens. (Bush, 1945, p. 10)

   Knowledge, innovation and democracy interrelate. Advances in democracy and advances in knowledge and innovation express mutual dependencies.[7] The 'quality of democracy' depends on a knowledge base. We see how the gloCal knowledge economy and society and the quality of democracy intertwine. Concepts such as 'democratizing innovation' (Von Hippel, 2005) underscore such aspects. Also the media-based and culture-based public of the quadruple helix emphasizes the overlapping tendencies of democracy and knowledge.[8]
2. *Pluralism of knowledge modes* Democracy's strength lies exactly in its capacity for allowing and balancing different parties, politicians, ideologies, values and policies, an ability discussed by Lindblom (1959) as disjointed incrementalism,[9] as the partisan mutual adjustment process. Just as entrepreneurs and consumers can conduct their buying and selling without anyone attempting to calculate the overall level of prices or outputs for the economy as a whole, Lindblom argued, so in politics. In many conditions adjustments among competing partisans will yield more sensible policies than are likely to be achieved by centralized decision makers relying on analysis (Lindblom, 1959, 1965). This is partly because interaction economizes on precisely the factors on which humans are short, such as time and understanding, while analysis requires their profligate consumption. To put this differently, the lynchpin of Lindblom's thinking was that analysis could be – and should be – 'no more than an adjunct to interaction in political life' (http://www.rpi.edu/~woodhe/docs/redner.724.htm). Similarly, democracy enables the integrating, coexistence and co-evolution of

Source: Carayannis and Campbell (2009).

Figure 1.11 Knowledge, innovation and democracy. GloCal governance styles of the gloCal knowledge economy and society?

different knowledge and innovation modes. We can speak of a pluralism of knowledge modes, and can regard this as a competitiveness feature of the whole system. Different knowledge modes can be linked to different knowledge decisions and knowledge policies, reflecting the communication skills of specific knowledge producers and knowledge users to convince other audiences of decision makers.

3. *Knowledge swings* Through political cycles or *swings* (Campbell, 1992) a democracy ties together different features: (a) decides who currently governs; (b) gives the opposition a chance to come to power in the future; and (c) acknowledges pluralism. Democracy represents a system that always creates and is being driven by an important momentum. For example, the statistical probability of governing parties to lose an upcoming election is higher than to win an election (Müller and Strøm, 2000, p. 589). Similarly, one could paraphrase the momentum of political swings by referring to 'knowledge swings': in certain periods and concrete contexts, a specific set of knowledge modes expresses a 'dominant design' position; however, the pool of non-hegemonic knowledge modes is also necessary for allowing alternative approaches in the long run, adding crucially to the variability of the whole system. Knowledge swings raise at least two issues: (a) What are dominant and non-dominant knowledge modes in a specific context? (b) There is a pluralism of knowledge modes, which exist in parallel, and thus also co-develop and co-evolve. Diversity is necessary to draw a cyclically patterned dominance of knowledge modes.
4. *Forward-looking, feedback-driven learning* Democracy should be regarded as a future-oriented governance system, fostering and relying upon social, economic and technological learning. The 'Mode 3 FREIE' is at its core an open, adaptive, learning-driven knowledge and innovation ecosystem reflecting the philosophy of strategic or active incrementalism (Carayannis, 1993, 1994, 1999, 2000, 2001) and the strategic management of technological learning (Carayannis, 1999; see also De Geus, 1988). In addition, one can postulate that the government/opposition cycle in politics represents a feedback-driven learning and mutual adaptation process. In this context, a democratic system can be perceived as a pendulum with a shifting pivot point reflecting the evolving, adapting dominant worldviews of the polity as they are shaped by the mutually interacting and influencing citizens and the dominant designs of the underlying cultures and technological paradigms (Carayannis, 2001, pp. 26–7).

In conclusion, we have attempted to provide an emerging conceptual framework to serve as the 'creative whiteboard space' of 'knowledge weavers' across disciplines and sectors as they strive to tackle the twenty-first-century challenges and opportunities for socio-economic prosperity and cultural renaissance based on knowledge and innovation.

NOTES

1. The notion of fractals comes from geometry to define objects that are irregular and appear 'broken up': some have a self-similar structure and can describe situations that cannot be explained by classical geometry. In relation to knowledge they help to explain non-linearities (see Carayannis, 2001; Carayannis and Campbell, 2011; Gleick, 1987).
2. See also Milbergs (2005).
3. See discussion on democracy in the conclusion of this chapter.
4. 'Culture is the invisible force behind the tangibles and observables in any organization, a social energy that moves people to act. Culture is to the organization what personality is to the individual – a hidden, yet unifying theme that provides meaning, direction, and mobilization' (Killman, 1985, p. 65–8).
5. Technology is defined as that 'which allows one to engage in a certain activity . . . with consistent quality of output', the 'art of science and the science of art' (Carayannis, 2001, p. 82–3) or '*the science of crafts*' (Braun, 1997, 97–9).
6. In that context also the mutual overlapping between R&D, S&T and ICT (information and communication technology) should be stressed.
7. For attempts to analyze the quality of a democracy, see for example Campbell and Schaller (2002).
8. On 'democratic innovation', see also Saward (2006).
9. Developed by Lindblom (1959, 1965) and Lindblom and Cohen (1979), this approach found several fields of application: 'The Incrementalist approach was one response to the challenge of the 1960s. This is the theory of Charles Lindblom, which he described as "partisan mutual adjustment" or disjointed incrementalism. Developed as an alternative to RCP, this theory claims that public policy is actually accomplished through decentralized bargaining in a free market and a democratic political economy' (http://www3.sympatico.ca/david.macleod/PTHRY.HTM).

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