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CONFIDENTIALA "MODE 3" SYSTEMS APPROACH FOR KNOWLEDGE CREATION, DIFFUSION AND USE:
TOWARDS A 21[ST] CENTURY FRACTAL INNOVATION ECOSYSTEM

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ABSTRACT AND KEY WORDS OF THE ARTICLE:

A "MODE 3" SYSTEMS APPROACH FOR KNOWLEDGE CREATION, DIFFUSION AND USE:
TOWARDS A 21ST CENTURY FRACTAL INNOVATION ECOSYSTEM

"Mode 3" allows and emphasizes the co-existence and co-evolution of different knowledge and innovation paradigms: *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 of knowledge stock and flow dynamics.* What results is an emerging fractal knowledge and innovation ecosystem, well-configured for the knowledge economy and society. 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 regards to the robustness and quality of the ecosystem's knowledge and innovation architecture and topology.

KEY WORDS: "Mode 3" Knowledge and Innovation Ecosystem; Innovation Networks; Knowledge Clusters; Knowledge Fractals; Knowledge Nuggets; GloCal; Multi-dimensional and Multi-attribute Knowledge and Innovation Systems; Technological Learning Dynamics; "Knowledge Swings"; Disjointed Incrementalism; Partisan Mutual Adjustment, Strategic Incrementalism; Strategic Management of Technological Learning; Conceptual Branding; "Knowledge Weavers".

I. INTRODUCTION AND DEFINITION OF TERMS

"New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life."--
FRANKLIN D. ROOSEVELT
November 17, 1944.

The emerging *gloCalizing,* globalizing and localizing[1], frontier of converging systems, networks and sectors of innovation driven by increasingly complex, non-linear and dynamic processes of knowledge creation, diffusion and use, confronts us with the need to re-conceptualize – if not re-invent – the ways and means that knowledge production, utilization and renewal takes 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 inter-woven to produce an emerging new worldview on how specialized knowledge, that is 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 (see Figures I.1, I.2 and I.3).

We postulate that one approach to such a re-conceptualization is what we call the "Mode 3" System consisting of Innovation Networks and Knowledge Clusters (see definitions below) for knowledge creation, diffusion and use. This is *a multi-layered, multi-modal, multi-nodal and multi-lateral system,* encompassing mutually

[1] Elias G. Carayannis and Maximilian von Zedtwitz, 'Architecting GloCal (Global – Local), Real-Virtual Incubator Networks (G-RVINs) as Catalysts and Accelerators of Entrepreneurship in Transitioning and Developing Economies', *Technovation*, 25 (2005), 95-110.

complementary and reinforcing innovation networks and knowledge clusters consisting of human and intellectual capital, shaped by social capital and underpinned by financial capital (see Table I.1).

The ***"Mode 3 INNOVECO"*** is in short the nexus or hub of the emerging 21st century Innovation Ecosystem[2], where *people*[3], *culture*[4] *and technology*[5] [6] (forming the essential ***"Mode 3 INNOVECO"*** building block or "knowledge nugget"[7]) 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) and in a top-down, policy-driven as well as bottom-up, entrepreneurship-empowered fashion (see Table I.2). One of the basic ideas of the article is: *co-existence*, *co-evolution* and *co-specialization* of different knowledge paradigms and different knowledge modes of

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[2] See, furthermore: Egils Milbergs, *Innovation Ecosystems and Prosperity* (Center for Accelerating Innovation, 2005) [http://www.innovationecosystems.com].
[3] See discussion on democracy in the conclusion of this article.
[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." [R. Killman, *Gaining Control of the Corporate Culture* (New York: McGraw-Hill, 1985)].
[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"* [Elias G. Carayannis, *The Strategic Management of Technological Learning* (Boca Raton, Florida: CRC Press, 2001)] or *"the science of crafts"* [C.F. von Braun, *The Innovation War* (Upper Saddle River, NJ: Prentice Hall, 1997)].
[6] We consider the following quote useful for elucidating the meaning and role of a "***knowledge nugget***" as a building block of the "Mode 3 INNOVECO": "People, culture, and technology serve as the institutional, market, and socio-economic "glue" that binds, catalyzes, and accelerates interactions and manifestations between creativity and innovation as shown in Figure 3, along with public-private partnerships, international Research & Development (R&D) consortia, technical / business / legal standards such as intellectual property rights as well as human nature and the "creative demon". The relationship is highly non-linear, complex and dynamic, evolving over time and driven by both external and internal stimuli and factors such as firm strategy, structure, and performance as well as top-down policies and bottom-up initiatives that act as enablers, catalysts, and accelerators for creativity and innovation that leads to competitiveness" [Elias G. Carayannis and Edgar Gonzalez, 'Creativity and Innovation = Competitiveness? When, How, and Why', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003), 587-606, especially on 593].
[7] Elias G. Carayannis, 'Measuring Intangibles: Managing Intangibles for Tangible Outcomes in Reserch and Innovation', *International Journal of Nuclar Knowledge Management*, 1 (2004).

knowledge production and knowledge use as well as their co-specialization as a result. We can postulate a dominance of knowledge heterogeneity at the systems (national, trans-national) level. Only at the sub-system (sub-national) level we should expect homogeneity. This understanding we can paraphrase with the term Mode 3.

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.

Thus, the two major purposes of this article 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 also under the term of *"Mode 3" Systems Approach to knowledge creation, diffusion and use* that we discuss below.
b. This diversified and conceptually pluralized understanding should 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).

I.1. Definition Of Terms

To fully leverage the potential of systems (and systems theory) one should also 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 of clusters can be listed:

1. *Geographic (spatial) clusters:* In that understanding, a cluster represents a certain geographic, spatial configuration, either tied to a location or a larger region. Geographic, spatial proximity, for example for the exchange of tacit knowledge, is considered as crucial. While "local" clearly represents a sub-national entity, a "region" could be either sub-national or trans-national.

2. *Sectoral clusters:* This cluster approach is carried by the understanding that different industrial or business sectors develop specific profiles with regard to knowledge production, diffusion and use. One could even add that sectoral clusters even support the advancement of particular "knowledge cultures". In innovation research, the term "innovation culture" already is being acknowledged.[8]

3. *Knowledge clusters:* 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). Crucial for a knowledge is, if it expresses an innovative capability, for example produces knowledge that excels (knowledge-based) economic performance. A knowledge cluster, furthermore, may even include more than one geographic and/or sectoral clusters.

Networks emphasize *interaction, connectivity and mutual complementarity and reinforcement*. Networks, for example, can be regarded as the internal configuration that

[8] Stefan Kuhlmann, 'Future Governance of Innovation Policy in Europe – Three Scenarios', *Research Policy*, 30 (2001), 953-976, especially on 958.

ties together and determines a cluster. Networks also can express the relationship between different clusters. *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. What we suggest is to link the two basic components (attributes) of systems ("elements/parts" and "rationale/self-rationale")[9] with clusters and networks. What results is a formation of two pairs of theoretical equivalents (see Figure I.4):

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 an 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 indicating to us, should we be interested in searching for structures and functions of

[9] David F. J. Campbell, 'Politische Steuerung über öffentliche Förderung universitärer Forschung? Systemtheoretische Überlegungen zu Forschungs- und Technologiepolitik', *Österreichische Zeitschrift für Politikwissenschaft*, 30 (2001), 425-438, especially on 426.

knowledge and innovation systems, what exactly to look for. This, obviously, does not imply to claim that structures and functions of knowledge (innovation) systems only fall 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 formula (between elements/clusters and rationales/networks) might need further conceptual and theoretical development. But it lays open 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 to understand (at least the large-scale) knowledge strategies as complex network configurations.

As a new input for discussion, we wish to introduce the concept of *the "Mode 3" knowledge creation, diffusion and use system,* and we define below the essential elements or building blocks of "Mode 3". The notion "Mode 3" was coined by Carayannis (in late fall of 2003), and was as a concept jointly developed by Carayannis and Campbell.[10] In the following, we list some of the key definitions, which refer to "Mode 3" and associated concepts.

- ***The "MODE 3" Systems Approach for knowledge creation, diffusion and use:***

> *"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,*

[10] Elias G. Carayannis and David F. J. Campbell, '"Mode 3": Meaning and Implications from a Knowledge Systems Perspective', in Elias G. Carayannis and David F. J. Campbell (eds.), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia* (Westport, Connecticut: Praeger, 2006), 1-25.

"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"[11].

- ***INNOVATION NETWORKS:***

Innovation Networks[12] *are real and virtual infra-structures and infra-technologies that serve to nurture creativity, trigger invention and catalyze innovation in a public and/or private domain context (for instance, Government-University-Industry Public-Private Research and Technology Development Co-opetitive Partnerships*[13] [14]*).*

- ***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.

- ***21ST CENTURY INNOVATION ECOSYSTEM:***

A 21st Century Innovation Ecosystem is a multi-level, multi-modal, multi-nodal and multi-agent system of systems. The constituent systems consist of innovation meta-networks (networks of innovation networks and knowledge clusters) and knowledge meta-clusters (clusters of innovation networks and knowledge clusters)

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[11] Carayannis and Zedwitz, *op. cit.* note 1.

[12] 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, trans-nationally) 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.

[13] Elias G. Carayannis and Jeffrey Alexander, 'Strategy, Structure and Performance Issues of Pre-competitive R&D Consortia: Insights and Lessons Learned', *IEEE Transactions of Engineering Management*, 52 (2004).

[14] Elias G. Carayannis and Jeffrey Alexander, 'Winning by Co-opeting in Strategic Government-University-Industry (GUI) Partnerships: The Power of Complex, Dynamic Knowledge Networks', *Journal of Technology Transfer*, 24 (1999), 197-210.

as building blocks and organized in a self-referential or chaotic[15] *fractal*[16] [17] *knowledge and innovation architecture, which in turn constitute agglomerations of human, social, intellectual and financial capital stocks and flows as well as cultural and technological artifacts and modalities, continually co-evolving, co-specializing, and co-opeting. These innovation networks and knowledge clusters also form, re-form and dissolve within diverse institutional, political, technological and socio-economic domains including Government, University, Industry, Non-governmental Organizations and involving Information and Communication Technologies, Biotechnologies, Advanced Materials, Nanotechnologies and Next Generation Energy Technologies.*

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[15] Carayannis (*op. cit.* note 5, especially 169-170) discusses chaos theory and fractals in connection to technological learning and knowledge and innovation system architectures: "Chaos theory is a close relative of catastrophe theory, but has shown more potential in both explaining and predicting unstable non-linearities, thanks to the concept of self-similarity or fractals [*patterns within patterns*] and the chaotic behavior of attractors (Mandelbrot) as well as the significance assigned to the role that initial conditions play as determinants of the future evolution of a non-linear system (Gleick, 1987) [see *op. cit.* note 16]. There is a strong affinity with strategic incrementalism, viewed as a third-order (triple-layered), feedback-driven system that can exhibit instability in any given state as a result of the operational, tactical, and strategic technological learning … that takes place within the organization in question."

[16] See the discussion in: James Gleick, *Chaos: Making a New Science* (New York: Viking Press, 1987).

[17] "A **fractal** is a geometric object which is rough or irregular on all scales of length, and so which appears to be 'broken up' in a radical way. Some of the best examples can be divided into parts, each of which is similar to the original object. Fractals are said to possess infinite detail, and some of them have a self-similar structure that occurs at different levels of magnification. In many cases, a fractal can be generated by a repeating pattern, in a typically recursive or iterative process. The term *fractal* was coined in 1975 by Benoît Mandelbrot, from the Latin *fractus* or 'broken'. Before Mandelbrot coined his term, the common name for such structures (the Koch snowflake, for example) was *monster curve*. Fractals of many kinds were originally studied as mathematical objects. *Fractal geometry* is the branch of mathematics which studies the properties and behaviour of fractals. It describes many situations which cannot be explained easily by classical geometry, and has often been applied in science, technology, and computer-generated art. The conceptual roots of fractals can be traced to attempts to measure the size of objects for which traditional definitions based on Euclidean geometry or calculus fail." [http://en.wikipedia.org/wiki/Fractal].

II. THE CONCEPTUAL UNDERSTANDING OF KNOWLEDGE AND INNOVATION

Knowledge does matter: but the question is when, how, and why? Moreover, with the advancement of economies and societies, *knowledge matters even more* and in ways that are not always predictable or even controllable (for example see the concepts of *strategic knowledge serendipity* and *strategic knowledge arbitrage*)[18]. The successful performance of the developed *and* the developing economies, societies and democracies increasingly depends on knowledge. One branch of knowledge develops along R&D (research and experimental development), S&T (science and technology) and innovation.[19]

II.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. Ramifications of this are (see Figure II.1):

(1) There are aspects, areas of knowledge, which can be analyzed, without considering innovation (for example: "pure basic research" in a linear understanding of innovation).

[18] Elias G. Carayannis, Edgar Gonzalez, and John Wetter, 'The Nature and Dynamics of Discontinuous and Disruptive Innovations From a Learning and Knowledge Management Perspective', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003), 115-138.
[19] Another branch of knowledge can be based on education and its diversified manifestations.

(2) Consequently, also there are areas or aspects of innovation, which are not (necessarily) tied to knowledge.[20]

(3) However, there are also areas, where knowledge and innovation co-exist. These we would like to call *knowledge-based innovation,* indicating areas, where knowledge and innovation express a mutual interaction.

In the case of knowledge-referring innovation, we then can 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 "knowledge-referring" or "knowledge-based" innovation is implied. Even though we will focus on this knowledge-based innovation, it still is important to acknowledge these possibilities of a knowledge without innovation, *and* of innovation, independently of knowledge. To further illustrate our point, the notion of the "national innovation system" conventionally expresses linkages to knowledge.[21] [22]

II.2. The "Mode 3" systemic multi-level approach to knowledge and innovation:

[20] In that context, see the different contributions to: Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003).
[21] Bengt-Åke Lundvall (ed.), *National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning* (London: Pinter Publishers, 1992).
[22] Richard R. Nelson (ed.), *National Innovation Systems. A Comparative Analysis* (Oxford: Oxford University Press, 1993).

In research about the European Union (EU), references to a "multi-level architecture" are quite common.[23] Originating from this research about the EU, 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 II.2).[24] 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. Trans-national 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 witness a proliferation of supranational integration processes also in other world regions, possible implying a new stage in the evolution of politics, where (small and medium-sized) nation state structures become absorbed by supranational clusters.[25] The highest level of trans-national aggregation, 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 understanding (i.e., a region consists more than one

[23] See, for example: Liesbet Hooghe and Gary Marks, *Multi-Level Governance and European Integration* (Lanham: Rowman & Littlefield Publishers, 2001).
[24] Elias G. Carayannis and David F. J. Campbell, *op. cit.* note 10.
[25] David F. J. Campbell, 'European Nation-State under Pressure: National Fragmentation or the Evolution of Suprastate Structures?', *Cybernetics and Systems: An International Journal*, 25 (1994), 879-909.

nation states). The new term "gloCal" (global/local)[26] underscores the potentials and benefits of a mutual and parallel interconnectedness between different levels.

Despite the importance of this spatial axis, we wish not 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)[27]; and R&D-referring innovation, involving a whole 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 favoured, then the sequence of aggregation might change. (Concerning the education axis, for the moment, we want to leave it to the judgment of other scholars, what here meaningful terms at different levels of aggregation may be.) In Figure II.2 we present a three-dimensional visualization of a multi-level system of knowledge, combining one spatial with two non-spatial (conceptual) axes of knowledge (R&D and education).

How many non-spatial (conceptual) axes of knowledge can there be? We focused on the R&D and education axes. By this, however, we do not want to imply that there may not be more than two conceptual axes. Here, at least in principle, a multitude or diversity of

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[26] Carayannis and Zedwitz, *op. cit.* note 1.
[27] In that context also the mutual overlapping between R&D, S&T and ICT (information and communication technology) should be stressed.

conceptual model-building approaches is possible and also appropriate. Perhaps, we even could integrate "innovation" as an additional conceptual axis, following the aggregation line from local, to national and trans-national innovation systems. We then would have to contemplate what the relationship is between such an "extra innovation axis" with the "innovation" of the research and education axes. "Regional" innovation could cross-reference local and trans-national innovation systems, implying even "gloCal" innovation systems and processes that simultaneously link through different aggregation levels.

We already discussed the conceptual boundary problems between knowledge and innovation. One approach, how to balance ambiguities in this context, is to acknowledge that a partial conceptual overlap exists between a *knowledge-centered* and *innovation-centered* understanding. Depending on the focus of the preferred analytical view, the same "element(s)" can be conceptualized as being 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 further. For example, the spatial axis of aggregation of knowledge (Figure II.2) also applies to innovation. Of course, also Lundvall[28] explicitly stresses that national innovation systems are permanently challenged (and extended) by regional as well as global innovation systems. But, paraphrasing Kuhlmann[29], as long as nation state-based political systems exist, it makes

[28] Lundvall, *op. cit.* note 21, especially 1, 3.
[29] Kuhlmann, *op. cit.* note 8, especially 960-961.

sense to acknowledge national innovation systems. In a spatial (or geographic) understanding, the term multi-level systems of innovation already is being used.[30] However, only more recently has it been suggested to extend this multi-level aggregation approach of innovation also to the non-spatial axes of innovation.[31] 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 closer-to-reality description of processes of globalization and gloCalization. For example, internationalisation of R&D cross-cuts these different multi-level layers, links together organizational units of business, academic and political actors at national, trans-national and sub-national levels.[32] One interpretation of R&D internationalization emphasizes how different sub-national regions and clusters cooperate on a global scale, creating even larger trans-national knowledge clusters.

II.3. Linear versus (and/or) 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

[30] Robert Kaiser and Heiko Prange, 'The Reconfiguration of National Innovation Systems – The Example of German Biotechnology', *Research Policy*, 33 (2004), 395-408; Kuhlmann, *op. cit.* note 8, especially 970-971, 973.

[31] David F. J. Campbell, 'The University/Business Research Networks in Science and Technology: Knowledge Production Trends in the United States, European Union and Japan', in Elias G. Carayannis and David F. J. Campbell (eds.), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia* (Westport, Connecticut: Praeger, 2006), 67-100.

[32] Max von Zedtwitz and Philip Heimann, 'Innovation in Clusters and the Liability of Foreignness of International R&D', in Elias G. Carayannis and David F. J. Campbell (eds.), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia* (Westport, Connecticut: Praeger, 2006), 101-122.

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, which are, later on, 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 horizons 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 re-connected back to basic research? In the past, after 1945, the U.S. 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.[33] As long as the U.S. represented the world-leading national economy, this understanding was sufficient. But with the intensification of global competition, also the demand for shortening the time horizons from basic research to the market implementation of R&D increased.[34] In the 1980s, Japan in particularly heavily pressured the U.S. In the 2000s, global

[33] Vannevar Bush, *Science: The Endless Frontier* (Washington, D.C.: United States Government Printing Office, 1945) [http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm#transmittal], especially the chapter "The Importance of Basic Research".
[34] OECD, *Science, Technology and Industry Outlook* (Paris: OECD, 1998), especially 179-181, 185-186.

competition within the triad of the U.S., Japan and the EU escalated further, with China and India emerging as new competitors in the global context. In a nutshell, further-going 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[35] (cited according to Miyata[36]), emphasizes the importance of feedback between the different R&D stages. Particularly, the coupling of marketing, sales and distribution with research claims to be important. "Mode 2"[37] 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".[38] [39] Contrary to "Mode 2", "Mode 1" can be characterized as: "... Mode 1 problems are set and solved in a context governed by the, largely academic, interests of a specific community. Mode 1 is disciplinary ... Mode 1 is characterized by

[35] S.J. Kline and N. Rosenberg, 'An Overview of Innovation', in R. Landau and N. Rosenberg (eds.), *The Positive Sum Strategy* (Washington, D.C.: National Academy Press, 1986).
[36] Yukio Miyata, 'An Analysis of Research and Innovative Activities of Universities in the United States', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003), 715-738, especially on 716.
[37] Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott, and Martin Trow, *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies* (London: Sage, 1994), especially 3-8, 167.
[38] See, furthermore: Helga Nowotny, Peter Scott, and Michael Gibbons, *Re-thinking Science. Knowledge and the Public in an Age of Uncertainty* (Cambridge: Polity Press, 2001); Helga Nowotny, Peter Scott, and Michael Gibbons, 'Mode 2 Revisited: The New Production of Knowledge', *Minerva*, 41 (2003), 179-194.
[39] Should we add a further comment to the concepts of Mode 1 and Mode 2, it would be interesting to consider, how Mode 1 and Mode 2 relate to the notions of "Science One" and "Science Two", which were invented and developed by Umpleby; Stuart A. Umpleby, 'Should Knowledge of Management be Organized as Theories or as Methods?', in Robert Trappl (ed.), *Cybernetics and Systems 2002. Proceedings of the 16th European Meeting on Cybernetics and Systems Research, Volume 1* (Vienna: Austrian Society for Cybernetic Studies, 2002), 492-497.

homogeneity … Mode 1 is hierarchical and tends to preserve its form …".[40] Consequently following the ramifications of "Mode 2", and 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.[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. The "Triple Helix" model of Etzkowitz and Leydesdorff[42] 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[43] 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[44] claim that one rationale, for establishing research networks, lies in the interest of bringing together knowledge producers, but also practitioners, with "complementary skills". Etzkowitz[45] speaks also of the "entrepreneurial university". An effective coupling of university research and business R&D demands, furthermore, the complementary

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[40] Gibbons et al., *op. cit.* note 37, especially on 3.

[41] David F. J. Campbell, 'Forschungspolitische Trends in wissenschaftsbasierten Gesellschaften. Strategiemuster für entwickelte Wirtschaftssysteme', *Wirtschaftspolitische Blätter*, 47 (2000), 130-143, especially 139-141.

[42] Henry Etzkowitz and Loet Leydesdorff, 'The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government Relations', *Research Policy*, 29 (2000), 109-123, especially 109, 111.

[43] Elias G. Carayannis and Patrice Laget, 'Transatlantic Innovation Infrastructure Networks: Public-Private, EU-US R&D Partnerships', *R&D Management*, 34 (2004), 17-31, especially 17, 19.

[44] Frank T. Anbari and Stuart A. Umpleby, 'Productive Research Teams and Knowledge Generation', in Elias G. Carayannis and David F. J. Campbell (eds.), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia* (Westport, Connecticut: Praeger, 2006), 26-38, especially 27-29.

[45] Henry Etzkowitz, 'Research Groups as "Quasi-Firms": The Invention of the Entrepreneurial University', *Research Policy*, 32 (2003), 109-121.

establishment of the entrepreneurial university and the "academic firm".[46] Extended ramifications of these discourses also refer to the challenge of designing proper governance regimes for the funding and evaluation of university research.[47]

Put in summary, one could set up the following hypothesis for discussion: while Mode 1 and perhaps also the concept of "Technology Life Cycles"[48] appear to be closer 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.

II.4. Co-existence and co-evolution of different knowledge and innovation paradigms:

Discussing the evolution of scientific theories, Kuhn introduced the concept of *paradigms*.[49] Paradigms can be understood as basic fundamentals, upon which a theory rests. In that sense paradigms are axiomatic premises, which guide a theory, however, cannot be explained by the theory itself: but, paradigms add to the explanatory power of theories that are interested in explaining the (outside) world. Paradigms represent

[46] David F. J. Campbell and Wolfgang H. Güttel, 'Knowledge Production of Firms: Research Networks and the "Scientification" of Business R&D', *International Journal of Technology Management*, 31 (2005), 152-175, especially 170-172.
[47] Aldo Genna and Ben R. Martin, 'University Research Evaluation and Funding: An International Comparison', *Minerva*, 41 (2003), 277-304.
[48] For a more detailed discussion of the concept of the Technology Life Cycles, see: Mario W. Cardullo, 'Technology Life Cycles', in Richard C. Dorf (ed.), *The Technology Management Handbook* (Boca Raton, Florida: CRC Press, 1999), 3-44 until 3-49; Gregory Tassey, 'R&D Policy Models and Data Needs', in Maryann P. Feldman and Albert N. Link (eds.), *Innovation Policy in the Knowledge-Based Economy* (Boston: Kluwer Academic Publishers, 2001), 37-71.
[49] Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: The University of Chicago Press, 1962).

something like beliefs. According to Kuhn, there operates an evolution of scientific theories, following a specific pattern: there are periods of "normal science", interrupted by intervals of "revolutionary science", again converting over into "normal science", again challenged by "revolutionary science", and so on.[50] According to Kuhn, every scientific theory, with its associated pardigm(s), has only a limited capacity for explaining the world. Confronted with phenomena, which 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 will 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 off-spring, but actually replace the earlier theories and paradigms. While this certainly often is true, particularly in the natural sciences, we want to stress that there also can be a *co-existence and co-evolution of paradigms* (and theories), implying that paradigms and theories can mutually learn from each other. Particularly in the social sciences this notion of co-existence and co-evolution of paradigms might be sometimes more appropriate than the replacement of paradigms. For the social sciences, and politics in more general, we can

[50] Stuart A. Umpleby, 'What I Learned from Heinz von Foerster about the Construction of Science', *Kybernetes*, 34 (2005), 278-294, especially 287-288; in addition, see: Elias G. Carayannis, 'Incrementalisme Strategique', *Le Progrès Technique*, (1993), Paris: France; Elias G. Carayannis, 'Gestion Strategique de l'Apprentissage Technologique', *Le Progrès Technique*, (1994), Paris: France; Elias G. Carayannis, 'Investigation and Validation of Technological Learning versus Market Performance', *International Journal of Technovation*, 20 (2000), 389-400.

point toward the pattern of a permanent mutual contest between ideas. Stuart A. Umpleby, for instance, emphasizes the following aspect of the social sciences very accurately: "Theories of social systems, when acted upon, change social systems".[51] 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.[52] Another example would be the long-term competition and fluctuation between the welfare-state and the free-market paradigms.[53]

These different modes of innovation and knowledge creation, diffusion and use, which we discussed earlier, certainly qualify to be understood also 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.[54] 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 co-existence and (over time) a co-evolution of different knowledge paradigms. This reinforces the understanding that, in the

[51] Stuart A. Umpleby, 'Cybernetics of Conceptual Systems', *Cybernetics and Systems: An International Journal*, 28 (1997), 635-652, especially on 635.
[52] Peter A. Hall, 'Policy Paradigms, Social Learning, and the State. The Case of Economic Policymaking in Britain', *Comparative Politics*, (1993), 257-296.
[53] With regard to the metrics of left-right placement of political parties in Europe, see: Andrea Volkens and Hans-Dieter Klingemann, 'Parties, Ideologies, and Issues. Stability and Change in Fifteen European Party Systems 1945-1998', in Kurt Richard Luther and Ferdinand Müller-Rommel (eds.), *Political Parties in the New Europe. Political and Analytical Challenges* (Oxford: Oxford University Press, 2002), 143-167, especially on 158.
[54] Gibbons et al., *op. cit.* note 37, especially on 7, 167-168.

advanced knowledge-based societies and economies, linear and non-linear innovation models can operate in parallel.

II.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 process simultaneously at the global, trans-national, national, and sub-national levels, creating "gloCal" (global and local) challenges. Advanced knowledge systems should demonstrate the flexibility of integrating 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.[55] This displays the practical usefulness of an understanding of a co-existence 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.[56]

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[55] For an overview of Mode 1, Mode 2, Triple Helix, and Technology Life Cycles, see: David F. J. Campbell, 'The University/Business Research Networks in Science and Technology: Knowledge Production Trends in the United States, European Union and Japan', in Elias G. Carayannis and David F. J. Campbell (eds.), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia* (Westport, Connecticut: Praeger, 2006), 67-100, especially 71-75.

[56] Elias G. Carayannis and Jeffrey Alexander, 'Technology-Driven Strategic Alliances: Tools for Learning and Knowledge Exchange in a Positive-Sum World', in Richard C. Dorf (ed.), *The Technology Management Handbook* (Boca Raton, Florida: CRC Press, 1999), 1-32 until 1-41; Elias G. Carayannis and David F. J. Campbell, "Conclusion: Key Insights and Lessons Learned for Policy and Practice", in Elias G.

How do networks relate to *cooperation and competition?* "Co-opetition"[57], as a concept, 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 the need of integrating (2) 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 often will 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.

Carayannis and David F. J. Campbell (eds.), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia* (Westport, Connecticut: Praeger, 2006), 331-341; for a general discussion of networks and complexity, see also: Robert W. Rycroft and Don E. Kash, *The Complexity Challenge. Technological Innovation for the 21st Century* (London: Pinter, 1999).

[57] Adam M. Brandenburger and Barry J. Nalebuff, *Co-Opetition* (New York: Doubleday, 1997).

III. CONCLUSION

"Until philosophers are kings, or the kings and princes of this world have the spirit and power of philosophy,... cities will never have rest from their evils –
no, nor the human race as I believe..." [emphasis added]
[Plato, The Republic, Vol. 5, p. 492]

"The empires of the future are the empires of the mind"
Winston Churchill, 1945

The "Mode 3" systems approach for knowledge creation, diffusion and use emphasizes the following key elements (see Figure III.1):[58]

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.[59] "GloCal" expresses the simultaneous processing of knowledge and innovation at different levels (for example, global, national and sub-national)[60], 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 premises of knowledge or innovation.

[58] See, also: Elias G. Carayannis and David F. J. Campbell, 'Introduction and Chapter Summaries', in Elias G. Carayannis and David F. J. Campbell (eds.), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia* (Westport, Connecticut: Praeger, 2006), ix-xxvi.

[59] Carayannis and Zedwitz, *op. cit.* note 1; Elias G. Carayannis and Caroline Sipp, *E-Development towards the Knowledge Economy: Leveraging Technology, Innovation and Entrepreneurship for "Smart Development"* (London: MacMillan, 2006) (forthcoming).

[60] See, furthermore: Alexander Gerybadze and Guido Reger, 'Globalization of R&D: Recent Changes in the Management of Innovation in Transnational Corporations', *Research Policy*, 28 (1999), 251-274; Max von Zedtwitz and Oliver Gassmann, 'Market versus Technology Drive in R&D Internationalization: Four Different Patterns of Managing Research and Development', *Research Policy*, 31 (2002), 569-588.

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 emphasize the terms of "knowledge clusters" and "innovation networks".[61] Clusters, from an ultimate perspective, 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 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, i.e. co-opetition.[62] When we speak of competition, it often will be a contest between different network configurations.

4. *Knowledge fractals:* "Knowledge fractals" emphasize the continuum-like bottom-up and top-down progress of complexity. Each subcomponent (sub-element) of a knowledge cluster and innovation network can be displayed as a micro-level sub-configuration of knowledge clusters and innovation networks (see Figure III.2). At the same time, one can also move upward. Every knowledge cluster and innovation network can also be understood as a subcomponent (sub-element) of a larger macro-level knowledge cluster or innovation network in other words, innovation meta-networks and knowledge meta-clusters (see again Figure III.2).[63]

5. *The adaptive integration and co-evolution of different knowledge and innovation modes:* "Mode 3" allows and emphasizes the co-existence and co-evolution of different knowledge and innovation paradigms. In fact, a key hypothesis is: *The*

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[61] Carayannis and Sipp, *op. cit.* note 59.
[62] Brandenburger and Nalebuff, *op. cit.* note 57.
[63] Perhaps, only when the whole world is being defined as ***one global knowledge cluster and innovation network***, then, for the moment, we cannot aggregate and escalate further to a mega-cluster or mega-network.

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 of knowledge stock and flow dynamics (for example, 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 (see Figure III.3). What results is an emerging fractal knowledge and innovation ecosystem (***"MODE 3" INNOVECO***), 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 regards 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 (see Figure III.3).

The societal embeddedness of knowledge represents a theme that already Mode 2 and Triple Helix explicitly acknowledge. As a last thought for this article we want to underscore *the potentially beneficial cross-references between democracy and knowledge* for a better understanding of knowledge. In an attempt to define democracy, democracy could be shortcut as an interplay of two principles:[64] (1) *Democracy can be seen as a method or procedure,* based on the application of the rule of the majority.[65] This acknowledges the "relativity of truth" and "pluralism" in a society, implying that

[64] David F. J. Campbell, *Demokratie, Demokratiequalität und Grundrechte: Ein Vergleich der Fiedler- und EU-Verfassung* (Vienna: Unpublished Manuscript, 2005).
[65] For example, Schumpeter emphasized this method-based criterion for democracy; see: Joseph A. Schumpeter, *Capitalism, Socialism and Democracy* (New York: Harper & Brothers, 1942), especially chapter XX-III.

decisions are carried out, not because they are "true" (or truer), but because they are backed and legitimised by a majority. Since, over time, these majority preferences normally shift, 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 substance, for example, represents an evolutionary manifestation of fundamental rights.[66] Obviously, the method/procedure and the substance approach overlap. Without fundamental rights, the majority rule could neutralize or even abolish itself. On the other hand, the practical "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 want to highlight the following aspects (see Figure III.4 for a suggested first-attempt graphical visualization):[67]

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, paraphrased, "21st 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

[66] Guillermo O'Donnell, 'Human Development, Human Rights, and Democracy', in Guillermo O'Donnell, Jorge Vargas Cullell, and Osvaldo M. Iazzetta (eds.), *The Quality of Democracy. Theory and Applications* (Notre Dame, Indiana: University of Notre Dame Press, 2004), 9-92, especially 26-27, 47, 54-55.
[67] Figure III.4 is based on: Helge Godo, 'Doing Innovative Research: "Mode 3" and Methodological Challenges in Leveraging the Best of Three Worlds', in Elias G. Carayannis and Chris Ziemnowicz (eds.), *Re-discovering Schumpeter* (London: MacMillan, 2006) (forthcoming); in general, see: Elias G. Carayannis and Chris Ziemnowicz (eds.), *Re-discovering Schumpeter* (London: MacMillan, 2006) (forthcoming).

which has made the United States great – that new frontiers shall be made accessible for development by all American citizens".[68]

2. *Pluralism of knowledge modes:* Democracy's strength lies exactly in its capacity for allowing and balancing different parties, politicians, ideologies, values and policies, and this ability was discussed by Lindblom as *disjointed incrementalism*[69]: "… 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. Under many conditions, in fact, 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".[70] [71] Similarly, democracy enables the integrating, co-existence and co-evolution of 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.

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[68] Bush, *op. cit.* note 33, especially on 10.

[69] The *disjointed incrementalism approach* to decision making (also known as *partisan mutual adjustment*) was developed by Lindblom (1959, 1965) and Linblom and Cohen (1979) and found several fields of application and use: "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].

[70] http://www.rpi.edu/~woodhe/docs/redner.724.htm.

[71] See, in particular: Charles E. Lindblom, 'The Science of Muddling Through', *Public Administration Review*, 19 (1959), 79-88; Charles E. Lindblom, *The Intelligence of Democracy* (New York: The Free Press, 1965); Charles E. Lindblom and David K. Cohen, *Usable Knowledge: Social Science and Social Problem Solving* (New Haven: Yale University Press, 1979).

3. *"Knowledge swings":* Through political cycles or *political swings*[72] a democracy ties together different features: (a) decides, who currently governs; (b) gives the opposition a chance, to come to power in the future; (c) and acknowledges pluralism.[73] 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"*[74] position; however, also the pool of non-hegemonic knowledge modes is necessary, for allowing alternative approaches in the long run, adding crucially to the variability of the whole system.

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" INNOVECO** is at its foundation an open, adaptive, learning-driven knowledge and innovation ecosystem reflecting the philosophy of *Strategic or Active Incrementalism*[75] and the strategic management of technological learning (ibid): "The *Strategic Management of Technological Learning* concept motivates the decision making model or style of *Strategic Incrementalism* which emanates from the Meta-Cognitive paradigm: 'When people play with [mental models of the world], they are actually creating a *new language* among themselves that expresses the knowledge they have acquired. And here we come to the most important aspect of institutional learning, whether it be achieved through teaching or through play as we have defined it: *the institutional learning process is a process of language development. As the implicit knowledge of each learner becomes explicit, his or her mental model becomes a building block of the institutional model.*' (de Geus, 1988).[76] The main attributes of this model are a *dynamically adaptive* nature and an emphasis on *continuous learning and unlearning* from experience, as well as a simultaneous awareness of both, the short

[72] David F. J. Campbell, 'Die Dynamik der politischen Links-Rechts-Schwingungen in Österreich: Die Ergebnisse einer Expertenbefragung', *Österreichische Zeitschrift für Politikwissenschaft*, 21 (1992), 165-179.

[73] In that context it could be further discussed, how the concepts of "political swings" and the "quality of democracy" relate; for example, see: David F. J. Campbell and Christian Schaller (eds.), *Demokratiequalität in Österreich. Zustand und Entwicklungsperspektiven* (Opladen: Leske + Budrich, 2002) [http://www.oegpw.at/sek_agora/publikationen.htm].

[74] "Studies have shown that the early period of a new area of technology is often characterized by technological ferment but that the pace of change slows after the emergence of a dominant design" [http://www.findarticles.com/p/articles/mi_m4035/is_1_45/ai_63018122/print].

[75] Carayannis, *op. cit.* note 5.

[76] A. De Geus, 'Planning as Learning', *Harvard Business Review*, (1988), 70.

and the long term. It accounts for the weaknesses associated with incrementalism (such as short-sightedness and excessive conservatism) through its inherent dynamism and its readiness for radical change. It is inspired from the Meta-Cognitive paradigm, where *technology acquires an increasingly important role in redefining at an increasing frequency the concepts of corporate strategy and the points on which competitive advantage is built*'.[77] 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 of as a pendulum with a shifting pivot point reflecting the evolving, adapting dominant worldviews of the polity as they are being shaped by the mutually interacting and influencing citizens and the dominant designs of the underlying cultures and technological paradigms.[78]

In conclusion, we have attempted to provide an emerging conceptual framework to serve as the "intellectual sandbox" and "creative whiteboard space" of the mind's eyes of "knowledge weavers" (***Wissensweber***)[79] across disciplines and sectors as they strive to tackle the 21st century challenges and opportunities for socio-economic prosperity and cultural renaissance based on knowledge and innovation: "As a result of the glocalized nature and dynamics of state-of-the-art, specialized knowledge … one needs to cope with and leverage two mutually-reinforcing and complementary trends: (a) the symbiosis and co-evolution of top-down national and multi-national science, technology and innovation public policies … and bottom-up technology development and knowledge acquisition private initiatives; and (b) the leveling of the competitive field across regions of the world via technology diffusion and adoption accompanied and complemented by the formation and exacerbation of multi-dimensional, multi-lateral, multi-modal and multi-nodal divides (cultural, technological, socio-economic, …) …In closing, being able to practice these two functions—being able to be a superior manager and policy-maker in the 21st century—relies on a team's, firm's, or society's capacity to be superior learners … in terms of both learning new facts as well as adopting new rules for learning-how-to-learn and establishing superior strategies for learning to learn-how-to-learn. Those superior

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[77] Elias G. Carayannis, 'Knowledge Transfer through Technological Hyperlearning in Five Industries', *International Journal of Technovation*, 19 (1999), 141-161.
[78] Carayannis, *op. cit.* note 5, especially 26-27.
[79] The term constitutes the brainchild or *conceptual branding* of the authors as part of this journey of discovery and ideation.

learners will, by necessity, be both courageous and humble as these virtues lie at the heart of successful learning".[80]

[80] Elias G. Carayannis and Jeffrey M. Alexander, *Global and Local Knowledge in Trans-national, Public-Private, Research and Technological Development Partnerships* (London: MacMillan, 2006) (forthcoming).

FIGURE I.1

**Creativity – Innovation - Competitiveness (CIC) Linkages:
A System Dynamics Approach**

Source: Elias G. Carayannis and Edgar Gonzàlez, 'Creativity and Innovation = Competitiveness? When, How, and Why', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003), 587-606.

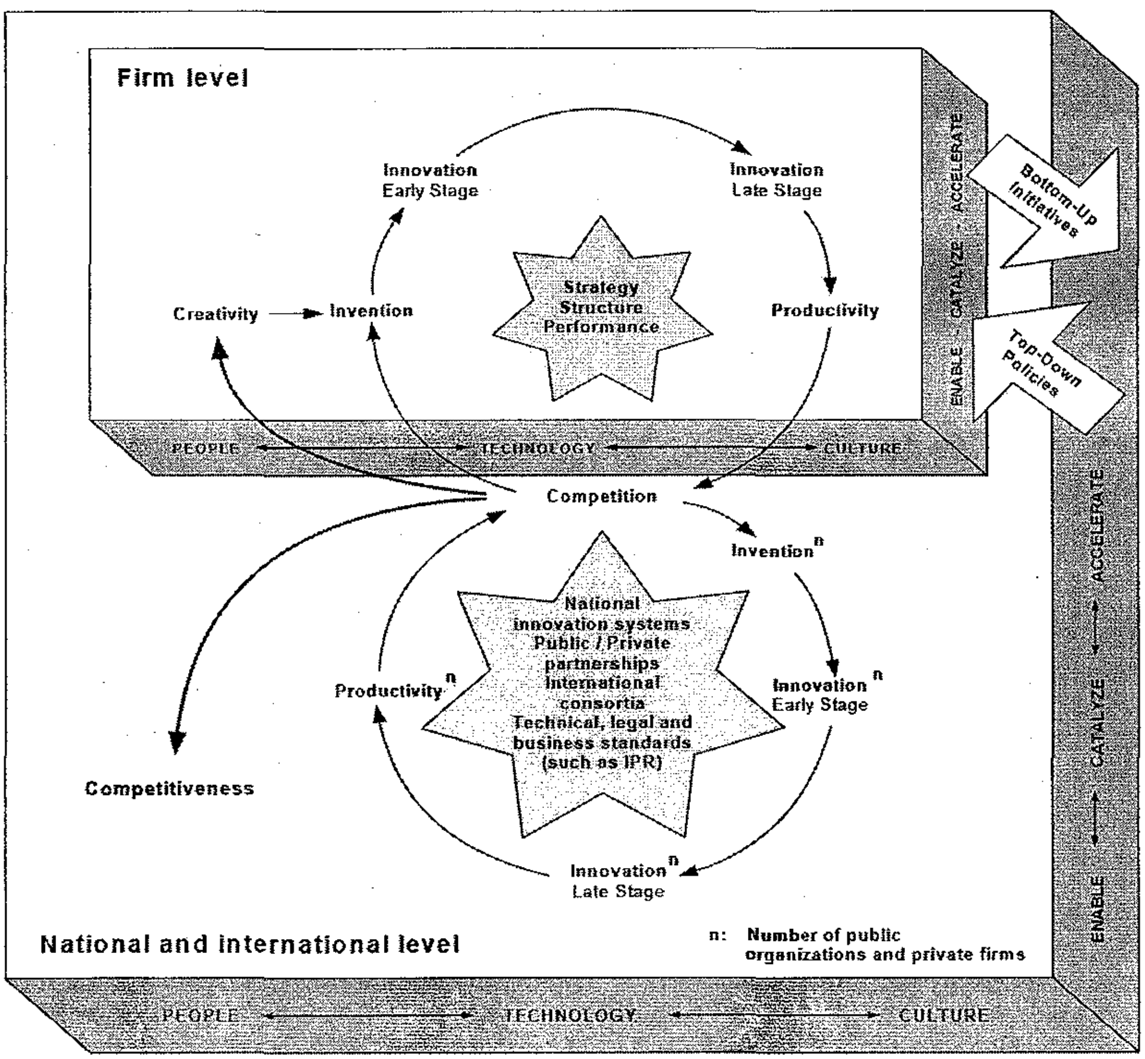


FIGURE I.2

FACTORS AFFECTING INNOVATIVE PERFORMANCE

Source: Elias G. Carayannis and Edgar Gonzalez, 'Creativity and Innovation = Competitiveness? When, How, and Why', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003), 587-606.

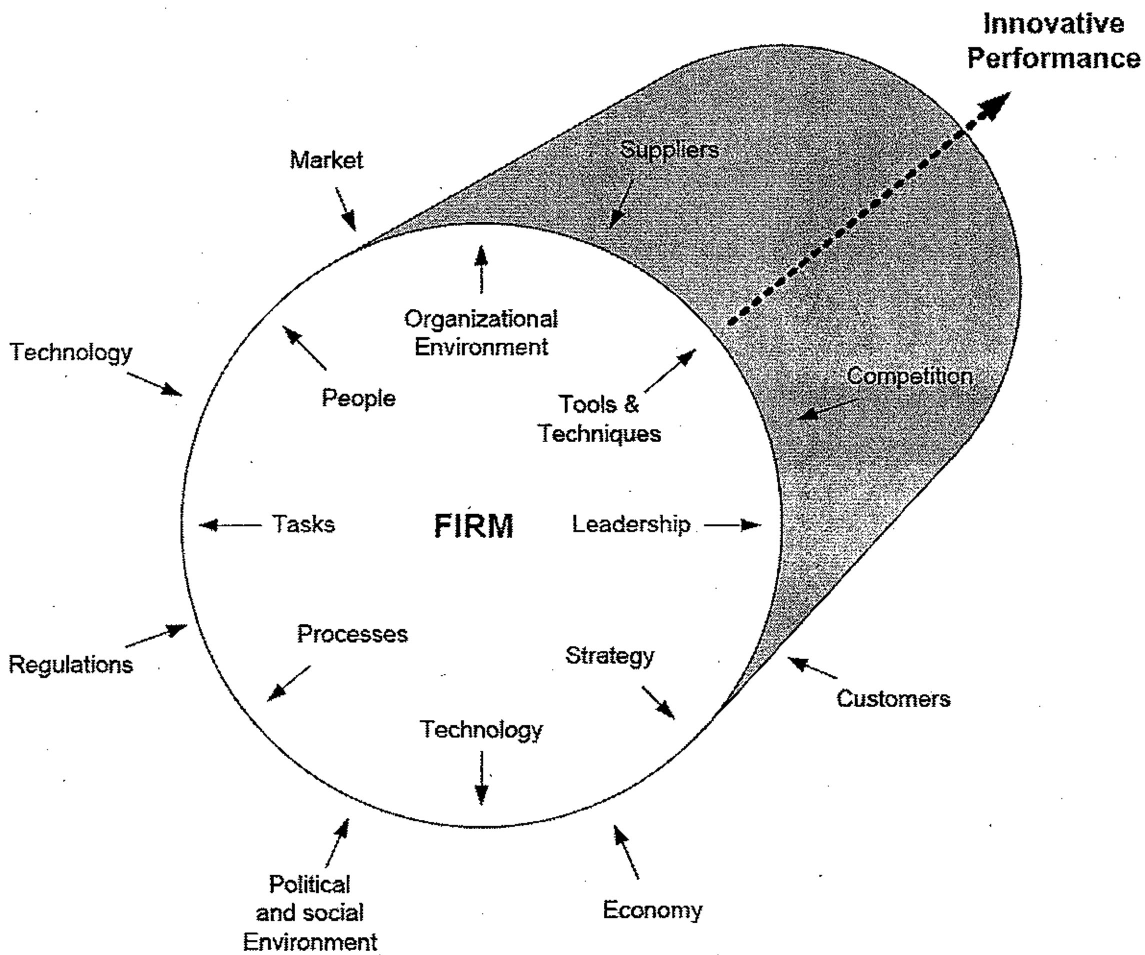


FIGURE I.3
CIC LEARNING & INSTITUTIONAL LINKAGES

Source: Elias G. Carayannis and Edgar Gonzalez, 'Creativity and Innovation = Competitiveness? When, How, and Why', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003), 587-606.

See next page!

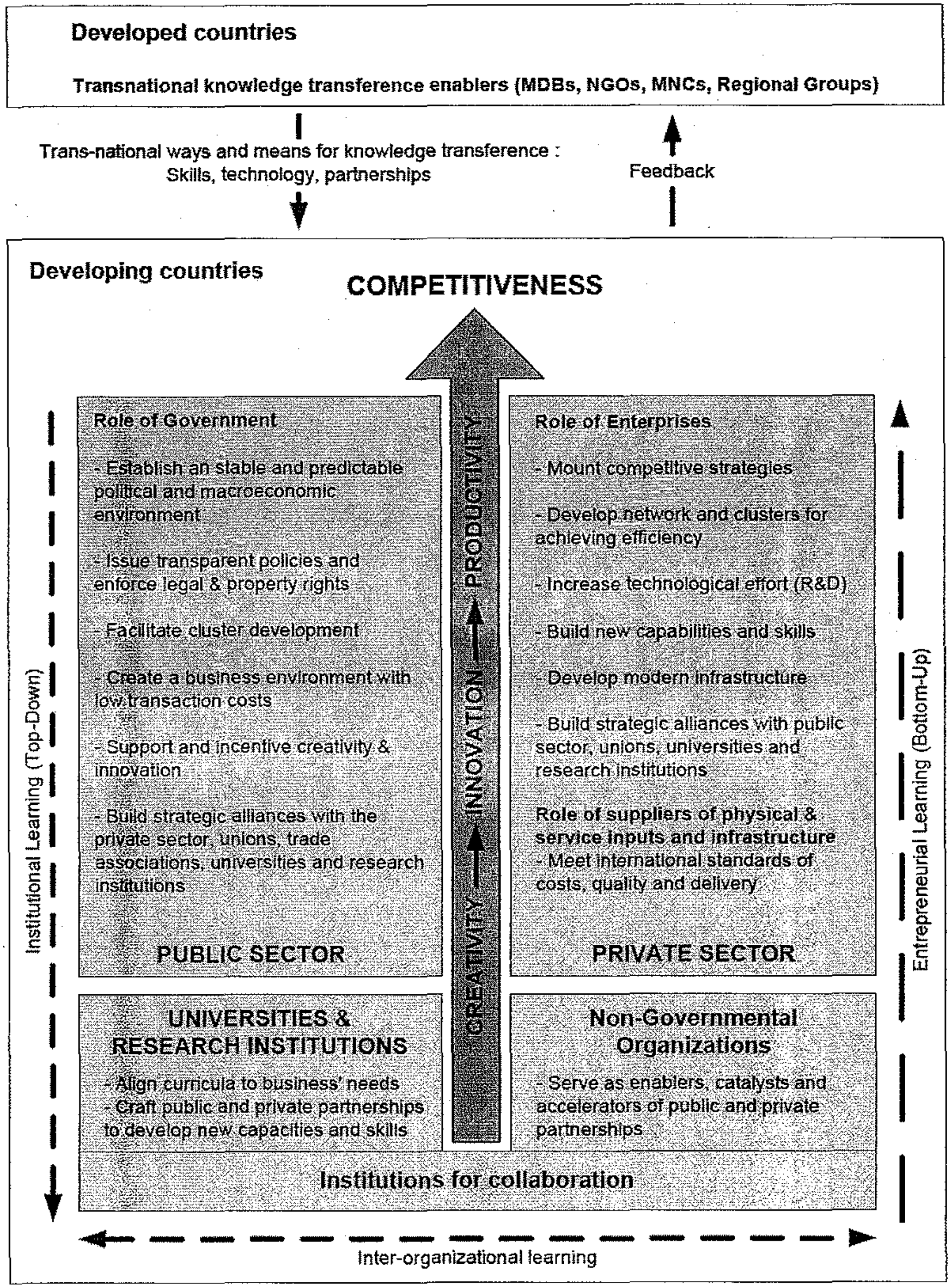

Developed countries
Transnational knowledge transference enablers (MDBs, NGOs, MNCs, Regional Groups)
Trans-national ways and means for knowledge transference :
Skills, technology, partnerships
Feedback
Developing countries
COMPETITIVENESS
Role of Government
- Establish an stable and predictable political and macroeconomic environment
- Issue transparent policies and enforce legal & property rights
- Facilitate cluster development
- Create a business environment with low transaction costs
- Support and incentive creativity & innovation
- Build strategic alliances with the private sector, unions, trade associations, universities and research institutions
PUBLIC SECTOR
CREATIVITY → INNOVATION → PRODUCTIVITY
Role of Enterprises
- Mount competitive strategies
- Develop network and clusters for achieving efficiency
- Increase technological effort (R&D)
- Build new capabilities and skills
- Develop modern infrastructure
- Build strategic alliances with public sector, unions, universities and research institutions
Role of suppliers of physical & service inputs and infrastructure
- Meet international standards of costs, quality and delivery
PRIVATE SECTOR
UNIVERSITIES & RESEARCH INSTITUTIONS
- Align curricula to business' needs
- Craft public and private partnerships to develop new capacities and skills
Non-Governmental Organizations
- Serve as enablers, catalysts and accelerators of public and private partnerships
Institutions for collaboration
Institutional Learning (Top-Down)
Entrepreneurial Learning (Bottom-Up)
Inter-organizational learning

TABLE I.1

TANGIBLE AND INTANGIBLE ASSETS TYPOLOGY

Source: Elias G. Carayannis, 'Measuring Intangibles: Managing Intangibles for Tangible Outcomes in Reserch and Innovation', *International Journal of Nuclar Knowledge Management*, 1 (2004).

Type of Capital	Type of Asset	Examples
Financial	Tangible	Monetary Investment Land and Buildings Equipment
Human	Tangible	Manual Labor Repetitive Tasks Low-Tech Skills Process Execution
Intellectual	Intangible	Process Generation Best Practices Experience Intuition Wisdom
Social	Intangible	Internal Networks External Relationships Communities of Practice Goodwill Shared Values Internalized Standards

TABLE I.2
COMPETITIVENESS, PRODUCTIVITY AND INNOVATION MEASURES

Source: Elias G. Carayannis and Edgar Gonzalez, 'Creativity and Innovation = Competitiveness? When, How, and Why', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation* (Amsterdam: Pergamon, 2003), 587-606.

	Competitiveness	Productivity	Innovation
National	▪ Standards of Living ▪ Gross Domestic Product (GDP) ▪ Expenditures ▪ Gross National Product (GNP) ▪ World Economic Forum 8 Factors ▪ Unemployment ▪ Exchange Rate ▪ Purchasing Power Parity ▪ Equity Markets ▪ Bond Markets ▪ Interest Rates ▪ LIBOR & Money Rates ▪ Dow Jones Global Indexes	▪ GDP/worker ▪ BW Production Index ▪ Total Factor Productivity (TFP) ▪ Compensation/Hour ▪ Tornqvist and Fisher Indexes	▪ Research & Development (R&D) as % GDP ▪ R&D ▪ National Labs ▪ Nobel Prizes
Industry	▪ Sales ▪ Market Share ▪ Dow Jones US ▪ Dow Jones Global ▪ Inventories ▪ Profitability	▪ Output/worker ▪ Profitability ▪ Industry Groups ▪ Compensation/Hour ▪ Tornqvist Sector Output ▪ Federal Reserve Board Index ▪ Bureau of Labor Statistics KLEMS	▪ R&D as % GDP ▪ Patents ▪ Scientists ▪ R&D Expenditure ▪ R&D Personnel ▪ R&D % of Profit
Firm	▪ Sales ▪ Market Share ▪ Equity ▪ Profitability	▪ Output/worker ▪ Profitability ▪ Output/hour ▪ Standard Costs	▪ R&D as % Sales ▪ R&D Expenditure ▪ Patents ▪ Scientists ▪ R&D Personnel ▪ National Labs

Figure I.4: Theoretical equivalents between conceptual attributes of systems and clusters/networks.

	Systems	**Clusters / Networks**
Attribute "one" (component "one")	Elements, parts.	Clusters.
Attribute "two" (component "two")	Rationale, self-ratinale, logic, self-logic, function, relationship bertween elements and/or systems.	Networks

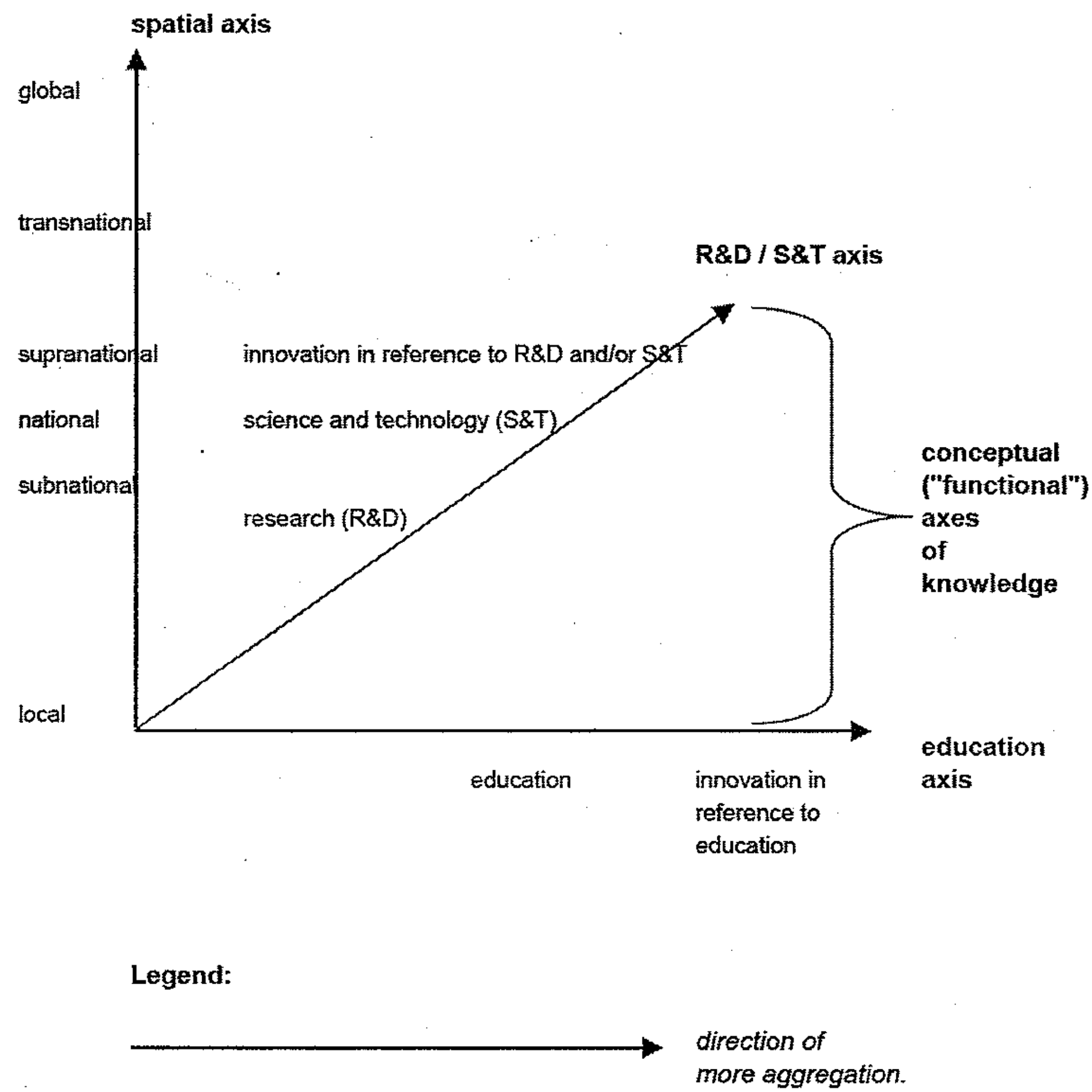
Source: Authors' own conceptualization.

Figure II.1: A four-fold typology about possible cross-references and interactions between "knowledge" and "innovation".

		Knowledge	
		yes	*no*
Innovation	*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: Authors' own conceptualization.

Figure II.2: A "tree-dimensional" modelling of knowledge in a multi-level system understanding: axis of spatial aggreagation, axis of R&D aggregation, axis of education aggregation.



Source: Authors' own conceptualization.

Figure III.1: The conceptual tree of "Mode 3" (horizontal arrangement).
Mode 3 = Interactive co-existence and co-evolution of different knowledge modes.

Concept	Attributes	Components
Mode 3	**Mode 1**	linear model of innovation: first basic research, then applied research and experimental development; first university research, then business R&D; codified (explicit) knowledge; technology life cycles; long-time horizons.
	Mode 2	interaction of knowledge production and knowledge use; knowledge production and knowledge use as the two referential key benchmarks; paralleling of basic research, applied research and experimental development; paralleling of university research and business R&D; chain-linked model; overalpping of different technology life cycles in different stages; shortening time horizons.
	Mode 2 and Triple Helix overlap area	codified (explicit) and tacit (implicit) knowledge; networks; R&D and S&T networks; communication and negotiation; public/private partnerships; hybridity: hybrid institutions, functions and markets; competition and cooperation: "co-optition"; "entrepreneurial university" and "academic firm".
	Triple Helix	three helices: academia (universities), state (public), industry (business); communication within and between the helices; non-linear dynamics, no a priori synchronization of the helices; university-industry-government relations; tri-lateral networks and hybrid organizations; "third mission" and "second academic revolution"; increasing complexity of recombination; three helices: basic research, applied research and experimental development (*).
	Multi-level systems: spatial aggregation	national, regional and global innovation systems; "gloCal" (global/local) innovation systems → sub-national / local — national — supra-national / trans-national — global
	Multi-level systems: conceptual aggregation	knowldge-based innovation systems; the leveraging of knowledge for the economy, society and politics through knowledge-based innovation systems; knowledge management and knowledge policy; partial replacement of economic policy by innovation policy. *for example: the research-axis of knowledge* → R&D — S&T — knowledge-based innovation

(*): *External interpretation.*

Source: Authors' own conceptualization.

FIGURE III.2.

THE 21ST CENTURY FRACTAL INNOVATION ECOSYSTEM

Source: Derived from authors' unpublished notes and lectures at George Washington University (GWU).

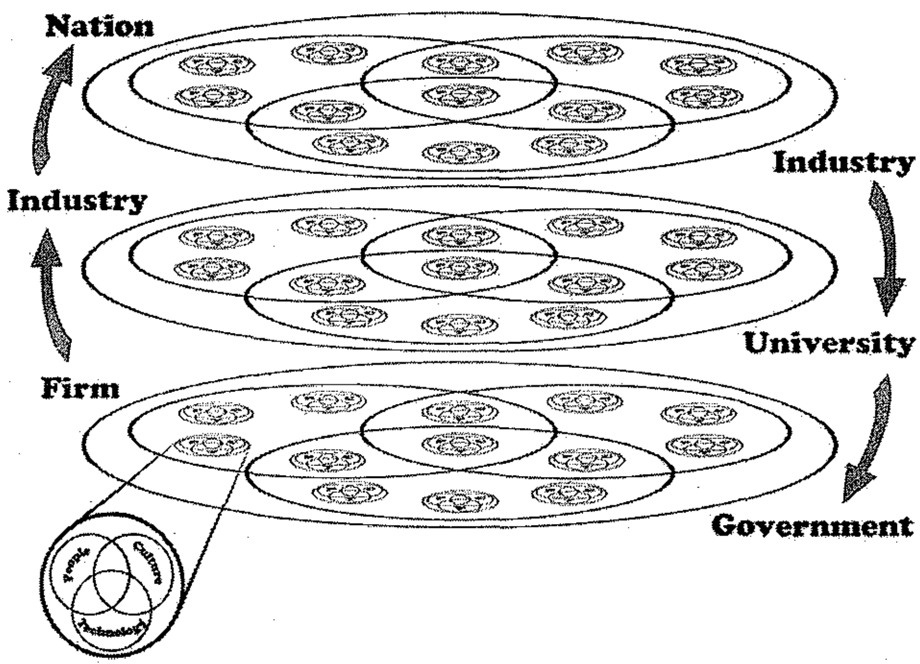


FIGURE III.3

Source: Adapted from Elias G. Carayannis, 'Measuring Intangibles: Managing Intangibles for Tangible Outcomes in Reserch and Innovation', *International Journal of Nuclar Knowledge Management*, 1 (2004).

Knowledge Management Value Chain

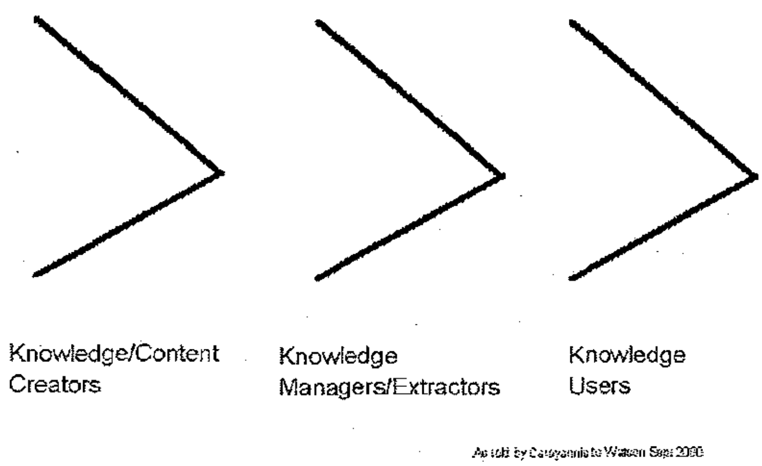
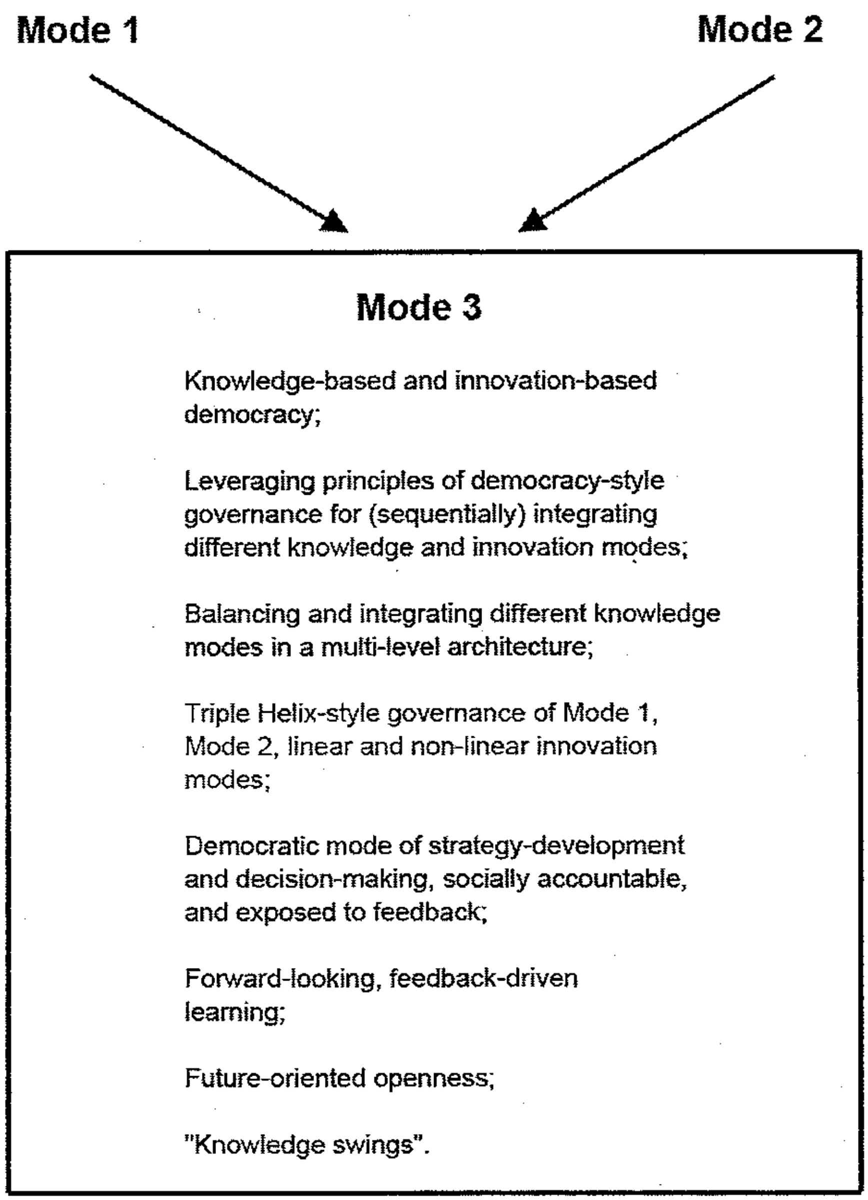


Figure III.4: Knowledge, innovation and democracy.



Source: Authors' own conceptualization based on Godo (2006).