Chapter 5
Innovation Systems in Conceptual Evolution: Mode 3 Knowledge Production in Quadruple and Quintuple Helix Innovation Systems

Triple Helix Innovation Systems and Mode 1 and Mode 2 of Knowledge Production

Universities, or higher education institutions (HEIs) in more general, have three main functions: teaching and education, research (research and experimental development, R&D), and the so-called "third mission" activities, for example, innovation (Campbell & Carayannis, 2013b, p. 5). In reference to "arts universities" now, the question and challenge arise, whether to which extent and in which way the arts universities differ from the (more traditional) universities in the sciences. Arts universities obviously place an emphasis on the arts, and the arts are not identical with the sciences. However, also arts universities frequently make references to the sciences; thus also arts universities can express competences in teaching and in carrying out research in the sciences. *The other major challenge of arts universities is to engage in "artistic research" and "arts-based innovation." By this, arts universities (and other higher education institutions in the arts) are also being linked to and are being interlinked with national innovation systems and multilevel innovation systems.* This widens the whole interdisciplinary and transdisciplinary spectrum of higher education systems. *"Artistic research" furthermore complements the "teaching of arts" at arts universities* (see also the propositions formulated by Bast, 2013). Hybrid and innovative combinations of universities of arts and universities of the sciences are possible and indicate organizational opportunities for promoting creativity (Campbell, 2013b).

University research, in a traditional understanding and in reference to universities in the sciences, focuses on basic research, often framed within a matrix of academic disciplines, and without a particular interest in the practical use of knowledge and innovation. This model of university-based knowledge production also is being called "Mode 1" of *knowledge production* (Gibbons et al., 1994). Mode 1 is also compatible with the linear model of innovation, which is often being referred to Vannevar Bush (1945). The linear model of innovation asserts that first there is basic

E. G. Carayannis, D. F. J. Campbell, *Smart Quintuple Helix Innovation Systems*, SpringerBriefs in Business, https://doi.org/10.1007/978-3-030-01517-6_5

research in university context: gradually, this university research will diffuse out into society and the economy. It is then the economy and the firms that pick up the lines of university research and develop these further into knowledge application and innovation, for the purpose of creating economic and commercial success in the markets outside of the higher education system. Within the frame of linear innovation, there is a sequential "first-then" relationship between basic research (knowledge production) and innovation (knowledge application).

The Mode 1-based understanding of knowledge production has been challenged by the new concept of "Mode 2" of knowledge production, which was developed and proposed by Michael Gibbons et al. (1994, p. 3–8, 167). Mode 2 emphasizes a knowledge application and a knowledge-based problem-solving that involves and encourages the following principles: "knowledge produced in the context of application," "transdisciplinarity," "heterogeneity and organizational diversity," "social accountability and reflexivity," and "quality control" (see furthermore Nowotny et al., 2001, 2003, 2006). Key in this setting is the focus on a knowledge production in contexts of application. Mode 2 expresses and encourages clear references to innovation and innovation models. The linear model of innovation also has become challenged by nonlinear models of innovation, which are interested in drawing more direct connections between knowledge production and knowledge application, where basic research and innovation are being coupled together not in a first-then but in an "as well as" and "parallel" (parallelized) relationship (Campbell & Carayannis, 2012). Mode 2 appears also to be compatible with nonlinear innovation and its ramifications.

The Triple Helix model of knowledge, innovation, and university-industry-government relations, which was introduced and developed by Henry Etzkowitz and Loet Leydesdorff (2000, p. 111–112), asserts a basic core model for knowledge production and innovation, where three "helices" intertwine, by this creating a national innovation system. The three helices are identified by the following systems or sectors: academia (universities), industry (business), and state (government). In the current innovation discourses, the "Triple Helix" model represents something like a "standard model" of (and for) innovation (by this being something like a "null hypothesis"). Etzkowitz and Leydesdorff refer to "university-industry-government relations" and networks, putting, a particular, emphasis on "trilateral networks and hybrid organizations," where those helices overlap in a hybrid fashion. Etzkowitz and Leydesdorff (2000, p. 118) also explain, how, in their view, the Triple Helix model relates to Mode 2: the "Triple Helix overlay provides a model at the level of social structure for the explanation of Mode 2 as a historically emerging structure for the production of scientific knowledge and its relation to Mode 1." More recently, Leydesdorff (2012) also introduced the notion of "N-Tuple of helices" (Park, 2014).

Quadruple and Quintuple Helix Innovation Systems and Mode 3 of Knowledge Production

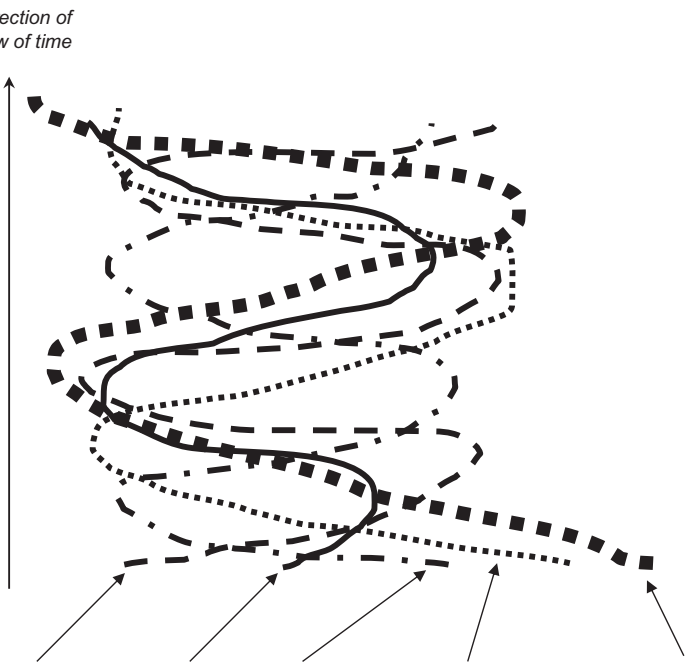
Mode 1 and Mode 2 may be characterized as "knowledge paradigms" that underlie the knowledge production (to a certain extent also the knowledge application) of higher education institutions and university systems. Success or quality, in accordance with Mode 1, may be defined as "academic excellence, which is a comprehensive explanation of the world (and of society) on the basis of 'basic principles' or 'first principles', as is being judged by knowledge producer communities (academic communities structured according to a disciplinary framed peer review system)." Consequently, success and quality, in accordance with Mode 2, can be defined as "problem-solving, which is a useful (efficient, effective) problem-solving for the world (and for society), as is being judged by knowledge producer and knowledge user communities" (Campbell & Carayannis, 2013b, p. 32; see furthermore Campbell & Carayannis, 2013c, 2016a). A "Mode 3" university, higher education institution, or higher education system would represent a type of organization or system that seeks creative ways of combining and integrating different principles of knowledge production and knowledge application (e.g., Mode 1 and Mode 2), by this encouraging diversity and heterogeneity and by this also creating creative and innovative organizational contexts for research and innovation (Carayannis & Campbell, 2006; Carayannis, Campbell, & Rehman, 2016). Mode 3 encourages the formation of "creative knowledge environments" (Hemlin, Allwood, & Martin, 2004). "Mode 3 universities," Mode 3 higher education institutions and systems, are prepared to perform "basic research in the context of application" (Campbell & Carayannis, 2013b, p. 34). This has furthermore qualities of nonlinear innovation. Governance of higher education and governance in higher education must also be sensitive, whether a higher education institution operates on the basis of Mode 1, Mode 2, or a combination of these in Mode 3. The concept of "epistemic governance" emphasizes that the underlying knowledge paradigms of knowledge production and knowledge application are being addressed by quality assurance and quality enhancement strategies, policies, and measures (Campbell & Carayannis, 2013b, 2013c).

Emphasizing again a more systemic perspective for the Mode 3 knowledge production, a focused conceptual definition may be as follows (Carayannis & Campbell, 2012, p. 49): Mode 3 "… allows and emphasizes the co-existence and co-evolution of different knowledge and innovation paradigms. In fact, a key hypothesis is: *The competitiveness and superiority of a knowledge system or the degree of advanced development of a knowledge system are highly determined by their adaptive capacity to combine and integrate different knowledge and innovation modes via co-evolution, co-specialization and co-opetition knowledge stock and flow dynamics*" (see Carayannis & Campbell, 2009; on "co-opetition," see Brandenburger & Nalebuff, 1997). Analogies are being drawn and a coevolution is being suggested between diversity and heterogeneity in advanced knowledge society and knowledge economy, and political pluralism in democracy (knowledge democracy), and the

quality of a democracy. The "democracy of knowledge" refers to this overlapping relationship. As it is being asserted, "The *Democracy of Knowledge*, as a concept and metaphor, highlights and underscores parallel processes between political pluralism in advanced democracy, and knowledge and innovation heterogeneity and diversity in advanced economy and society. Here, we may observe a hybrid overlapping between the *knowledge economy, knowledge society and knowledge democracy*" (Carayannis & Campbell, 2012, p. 55). The "democracy of knowledge," therefore, is further reaching then the earlier idea of the "Republic of Science" (Michael Polanyi, 1962). This is because there can be a republic that is not democratic, but there cannot be a democracy that is not a democracy (to put here forward a statement in metaphorical terms).

Democracy may be defined as a system that is based on the following principles: freedom, equality, control, and sustainable development (Campbell, Carayannis, & Rehman, 2015). We postulated a coevolution between political systems and innovation systems. Therefore, in this understanding, innovation systems in democracies will differ from innovation systems in nondemocracies. Is there even an expectation of a certain *coevolution between knowledge economy and knowledge democracy*, this ultimately means that certain higher levels of innovation and innovation system are not possible without a context of a democracy (Carayannis & Campbell, 2014). Advanced knowledge economies and knowledge societies require knowledge and innovation pluralism, and this meets with political pluralism in advanced democracies.

The main focus of the Triple Helix innovation model concentrates on university-industry-government relations (Etzkowitz & Leydesdorff, 2000). In that respect, Triple Helix represents a basic model or a core model for knowledge production and innovation application. The models of the Quadruple Helix and Quintuple Helix innovation systems are designed to comprehend already and to refer to an extended complexity in knowledge production and knowledge application (innovation); thus, the analytical architecture of these models is more broadly conceptualized. To use metaphoric terms, the Quadruple Helix embeds and contextualizes the Triple Helix, while the Quintuple Helix embeds and contextualizes the Quadruple Helix (and Triple Helix). The Quadruple Helix adds as a fourth helix the "media-based and culture-based public," the "civil society," and "arts, artistic research, and arts-based innovation" (Campbell, 2018; Carayannis & Campbell, 2009, 2012, p. 14; Carayannis & Campbell, 2018; Carayannis & Pirzadeh, 2014; Campbell & Carayannis, 2016b; see also: Bast, Carayannis, & Campbell, 2015; Danilda, Lindberg, & Torstensson, 2009; De Oliveira Monteiro & Carayannis, 2017; Eigelsreiter, 2017; Hemlin et al., 2004; Mitterlehner, 2014). *The Quadruple Helix also could be emphasized as the perspective that specifically brings in the "dimension of democracy" or the "context of democracy" for knowledge, knowledge production, and innovation.* The Quintuple Helix Innovation Model even is more comprehensive in its analytical and explanatory stretch and approach, adding furthermore the fifth helix (and perspective) of the "natural environments of society" (Carayannis & Campbell, 2010, p. 62) (see Figs. 5.1 and 5.2).

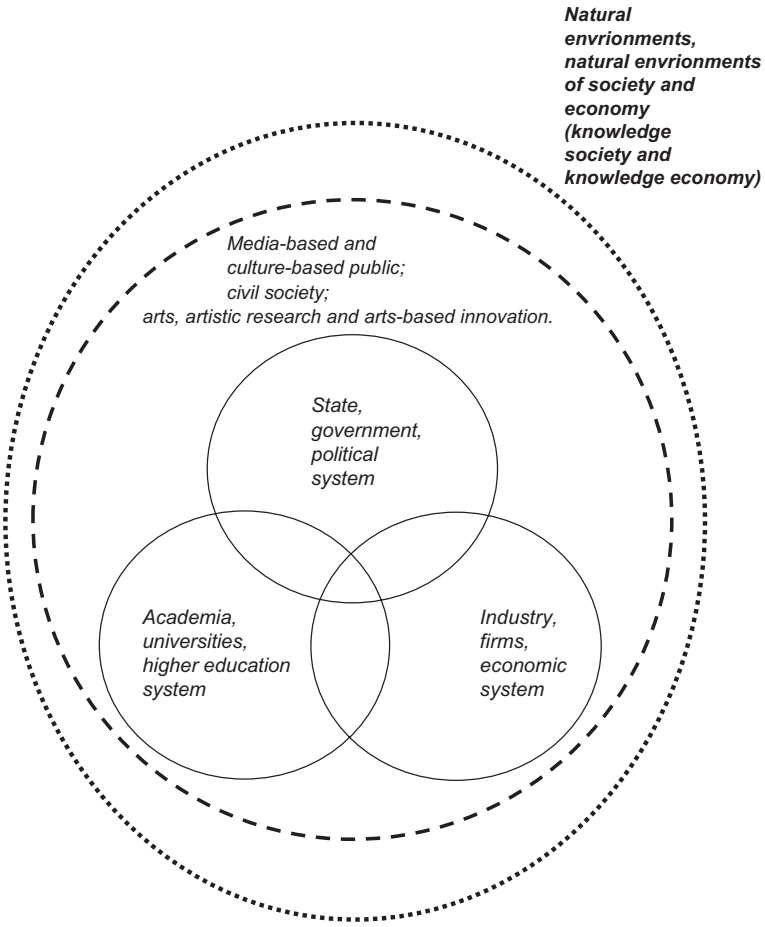


First Helix: Academia / universtities	Second Helix: Industry / business	Third Helix: State / government	Fourth Helix: Media-based and culture-based public; civil society; arts, artistic reseach and arts-based innovation /	Fifth Helix: Natural environment, natural environments of society and economy /
Universities (higher education institutions) of the sciences and of the arts.	Also: creativity economy and creative industries.		culture and innovation culture, knowledge of culture and culture of knowledge, values and life styles, multi-culturalism and creativity, media, arts and arts universities, multi-level innovation systems with universities of the sciences and arts.	social ecology, society-nature interactions, socio-ecological transition.

Triple Helix:	**University-industry-government relations (helices).**
Quadruple Helix, Fourth Helix:	**"Media-based and culture-based public", "civil society" and "arts, artistic research and arts-based innovation" (helix).**
Quintuple Helix, Fifth Helix:	**Natural environment, natural environments of society and economy (helix).**

Source: Authors' own conceptualization based on Etzkowitz and Leydesdorff (2000, p. 112), Carayannis and Campbell (2009, p. 207; 2012, p. 14; 2014) and Danilda et al. (2009).

Fig. 5.1 The Quadruple and Quintuple Helix innovation systems. Source: Authors' own conceptualization based on Etzkowitz and Leydesdorff (2000, p. 112), Carayannis and Campbell (2009, p. 207, 2012, p. 14, 2014) and Danilda et al. (2009)



Source: Authors' own conceptualization based on Carayannis and Campbell (2010, p. 62; 2014).

Fig. 5.2 The Quintuple Helix (five-helix model) innovation system more advanced. Source: Authors' own conceptualization based on Carayannis and Campbell (2010, p. 62, 2014)

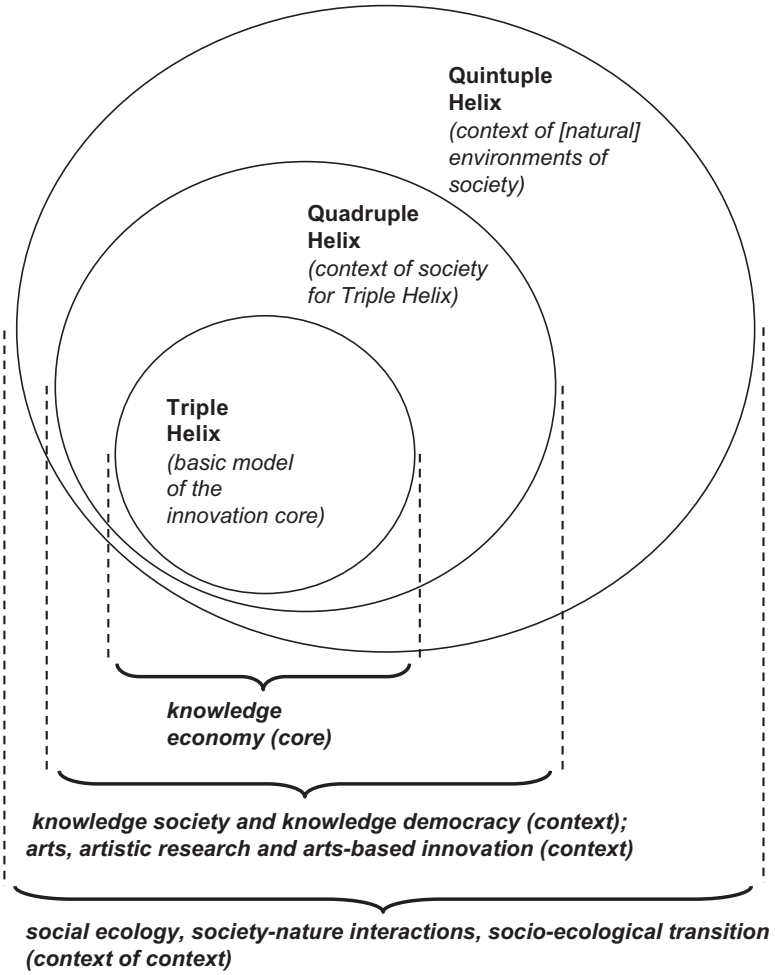
The introduction of the arts has here two implications: (1) the arts act as a source of creativity, which qualifies as a further necessary input to advance innovation and (2) the different disciplines of the arts extend the established disciplines in the sciences, social sciences, and humanities and by this promoting an extended understanding and new and innovative format of interdisciplinarity but also transdisciplinarity.

The Triple Helix is explicit in acknowledging the importance of higher education for innovation. However, it could be argued that the Triple Helix sees knowledge production and innovation in relation to economy; thus the Triple Helix models first of all (primarily) the economy and economic activity. In that sense, the Triple Helix frames the knowledge economy. The Quadruple Helix brings in the

additional perspective of society (knowledge society) and of democracy (knowledge democracy). The Quadruple Helix Innovation System understanding emphasizes that sustainable development of and in economy (knowledge economy) requires that there is a coevolution of knowledge economy and knowledge society and knowledge democracy. The Quadruple Helix even encourages *the perspectives of knowledge society and of knowledge democracy* for supporting, promoting, and advancing knowledge production (research) and knowledge application (innovation). Furthermore, the Quadruple Helix is also explicit that not only universities (higher education institutions) of the sciences but also universities (higher education institutions) of the arts should be regarded as decisive and determining institutions for advancing next-stage innovation systems: the interdisciplinary and transdisciplinary connecting of sciences and arts creates crucial and creative combinations for promoting and supporting innovation. Here, in fact, lies one of the keys for future success. The concept and term of "social ecology" refer to "society-nature interactions" between "human society" and the "material world" (see, e.g., Fischer-Kowalski & Haberl, 2007). The European Commission (2009) identified the necessary socio-ecological transition of economy and society not only as one of the great next-phase challenges but also as an opportunity, for the further progress and advancement of knowledge economy and knowledge society. The Quintuple Helix refers to this socio-ecological transition of society, economy, and democracy, and the Quintuple Helix innovation system is therefore ecologically sensitive. Quintuple Helix bases its understanding of knowledge production (research) and knowledge application (innovation) on social ecology (see Fig. 5.3). Environmental issues (such as global warming) represent issues of concern and of survival for humanity and human civilization. But the Quintuple Helix translates environmental and ecological issues of concern also in potential opportunities, by identifying them as possible drivers for future knowledge production and innovation (Carayannis et al., 2012). This, finally, defines also opportunities for the knowledge economy. "The Quintuple Helix supports here the formation of a win-win situation between ecology, knowledge and innovation, creating synergies between economy, society and democracy" (Carayannis et al., 2012, p. 1).

Summary of the Quadruple and Quintuple Helix Innovation Systems

The terms and concepts of Mode 3 knowledge production and Quadruple Helix innovation systems were first introduced to international academic debate by Carayannis & Campbell (2006, 2009) and were later developed further (Carayannis & Campbell, 2012). The same applies to the Quintuple Helix (Carayannis & Campbell, 2010). From the beginning, the "media-based and culture-based public" as well as universities and other higher education institutions of the arts were being regarded as crucial attributes and components of the Quadruple and Quintuple Helix



Source: Authors' own conceptualization based on
Carayannis, Barth and Campbell (2012, p. 4)
and Carayannis and Campbell (2014).

Fig. 5.3 The Quadruple and Quintuple Helix innovation systems in relation to society, economy, democracy, and social ecology. Source: Authors' own conceptualization based on Carayannis et al. (2012, p. 4) and Carayannis and Campbell (2014)

innovation systems, *implying that arts are essential for the progress and evolution of innovation systems* (see again Figs. 5.1 and 5.2). *In our analysis here, we developed more specifically the Quadruple and Quintuple Helix innovation systems in terms and in favor of arts, artistic research, and arts-based innovation. We wanted to demonstrate the full momentum and flexibility of the Quadruple and Quintuple Helix for conceptually addressing and integrating art and arts*.

In the future, what are further challenges for innovation systems? Which issues should be addressed for the design, design evolution, and governance of (and within) innovation systems? More generally speaking, further ramifications of Mode 3 knowledge production in Quadruple Helix and Quintuple Helix innovation systems are (see also Carayannis et al., 2018a, 2018b):

1. *Multilevel innovation systems, the global and the local (GloCal)*: Lundvall was pivotal for introducing the concept of the "national innovation system." Lundvall (1992, p. 1, 3) explicitly acknowledges that national innovation systems are challenged in permanence (but are also extended) by regional as well as global innovation systems. Here, Kuhlmann (2001, p. 960–961) could be paraphrased and the assertion that as long as nation-states and nation-state-based political systems exist, it is plausible to use the concept of the national innovation system. More comprehensive in its analytical architecture than the national innovation system is the concept of the "multilevel innovation system" (Carayannis & Campbell, 2012, p. 32–35). In a spatial understanding, multilevel innovation systems not only compare the national with the sub-national (regional, local) but also with the transnational and global levels (see, e.g., Kaiser & Prange, 2004; furthermore, see Pfeffer, 2012, and Merz & Sormani, 2016). However, it is also important to extend multilevel innovation systems to the challenges and potential benefits and opportunities of a nonspatial meaning, understanding, and "mapping": "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*" (Carayannis & Campbell, 2012, p. 35).
2. *Linear and nonlinear innovation*: Knowledge application and innovation are being challenged and driven out of an interest of combining and integrating linear and nonlinear innovation. Key to here are diversity, heterogeneity, and pluralism of different knowledge and innovation modes and their linking together via an architecture of coevolving networks. Firms, universities, and other organizations can engage (at the same) in varying and multiple technology life cycles at different levels of maturity. Another way, how to think nonlinear innovation, is being suggested by the concept of cross-employment (Campbell, 2011, 2013). As a form and type of multi-employment, cross-employment emphasizes that the same individual person may be employed by two (or more) organizations at the same time, where one organization could be located closer to knowledge production and the other to knowledge application (innovation): should those organizations also be rooted in different sectors, then cross-employment acts also as a trans-sectoral networking (Campbell & Carayannis, 2013b, p. 65, 68). *Cross-employment can furthermore bridge different sectors and disciplines in the sciences with different disciplines in the arts.* What results is a "Mode 3 Innovation Ecosystem": "This parallel as well as sequentially time-lagged unfolding of technology life cycles also expresses characteristics of Mode 2 and of nonlinear innovation, because organizations (firms and universities) 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" (Carayannis & Campbell, 2012, p. 37; see furthermore Dubina, Carayannis, & Campbell, 2012). The "academic firm" (Campbell & Carayannis, 2016b) may also be compared with attributes of the so-called network firm (Laperche & Uzunidis, 2018). The relationship between networks, "cooperation and competition" ("co-opetition"), represents a challenge and sensitive issue and allows for different creative answers in organizational representation and manifestation.

3. *Twenty-first century fractal research, education, and innovation ecosystem (FREIE)*: Here, the understanding of FREIE is: "This is *a multilayered*, *multimodal*, *multinodal, and multilateral system*, encompassing mutually complementary and reinforcing innovation networks and knowledge clusters consisting of human and intellectual capital, shaped by social capital and underpinned by financial capital" (Carayannis & Campbell, 2012, p. 3).
4. *Linear and nonlinear innovation, and the causality of "if-then" and of "if-if" relations*: The hybrid overlapping of linear innovation and of nonlinear innovation displays also possible ramifications and draws associations to models of causality and their remodeling. "We can speculate, whether this parallel integration of linearity and nonlinearity not also encourages a new approach of paralleling in our theorizing and viewing of causality: *in epistemic (epistemological) terms, the so-called if-then relationships could be complemented by (a thinking in) 'if-if' relations*" (Carayannis & Campbell, 2012, p. 24; see also Campbell, 2009, p. 123).

The Quadruple Helix regards itself to be "human-centered" oriented. While for the Triple Helix model the existence of a democracy is not (per se) necessary for knowledge production and innovation, the Quadruple Helix is here more explicit. With the way how the Quadruple Helix is being engineered, designed, and "architected" from that, it is clear that there cannot be a Quadruple Helix Innovation System without democracy or a democratic context. The following attributes and components define the fourth helix in the Quadruple Helix: "media-based and culture-based public," "civil society," and "arts, artistic research, and arts-based innovation." By this the fourth helix in the Quadruple Helix represents the perspective of the "dimension of democracy" or the "context of democracy" for knowledge, knowledge production, and innovation. This is particularly true when democracy is being understood to transcend the narrow understanding of being primarily based *on* or being primarily rooted *in* government institutions (within Triple Helix). Civil society, culture-based public, quality of democracy, and sustainable development convincingly demonstrate what the rationales and requirements are for conceptualizing democracy broader (Campbell & Carayannis, 2013a). To turn this line of thinking, autocracies are not interested to allow the development of a free and mature civil society. On the contrary, autocracies want to control and suppress the rise of an independent civil society. *Political pluralism in a democracy coevolves with the pluralism, diversity, and heterogeneity of knowledge, knowledge production,*

and innovation ("democracy of knowledge"; see Carayannis & Campbell, 2009, 2012, p. 55). *We postulate here a congruence of structures and processes in democracy and in innovation systems*. The Quintuple Helix extends the Quadruple Helix by aspects of the "natural environments of society and economy," "social ecology," and the "socio-ecological transition." Also, this environmental context of society can be better addressed in a democracy than in a nondemocracy. *The current world appears to be challenged by a race between developing democracies versus emerging autocracies over knowledge production and innovation*.

Cyber development can be defined as a development in terms of a sustainable development of knowledge economy, knowledge society, and knowledge democracy that is knowledge-based and knowledge-driven and where innovation is playing a crucial role. In this understanding, the Quadruple and Quintuple Helix Innovation System and systems provide a model and conceptual framework for theory and practice, strategy, and policy for progress and advancement exactly in knowledge economy, knowledge society, and knowledge democracy. This introduces new perspectives for a new type of governance and a new set of policies for problem-solving and further evolution.