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Quadruple Helix

▶ Quality of Democracy and Innovation

Quadruple Helix Extended

▶ Quintuple Innovation Helix and Global Warming: Challenges and Opportunities for Policy and Practice

Quadruple Helix Model

▶ Innovation System of India

Quadruple Helix Structure of Democracy

▶ Quality of Democracy and Innovation

Quadruple Innovation Helix Systems

▶ Epidemiology of Innovation: Concepts and Constructs

Quadruple-Dimensional Structure of Democracy

▶ Quality of Democracy and Innovation

Quality Assurance

▶ Epistemic Governance and Epistemic Innovation Policy

Quality Assurance and Quality Enhancement in Higher Education and Innovation

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Synonyms

Quality evaluation at universities (of university tuition)

Difficulties in Defining "Quality" Within Higher Education

This entry gives an overview of the intersection of quality assurance/quality enhancement within the

sector of higher education and innovation. When focusing their function of creating knowledge, the institutions of higher education themselves can be taken as examples for organizations oriented toward innovation. Furthermore, measures of quality assurance and/or quality enhancement are – or at least should be – devised in a way that they foster continuous innovation of the organizations (by means of learning and improvement). This can be seen as a process of change management within institutions often appearing strongly stratified and where the complex interaction of external (e.g., stately) regulations and powerful internal resistance (e.g., of traditional academic demeanor) must be taken into account.

The distinction of "quality assurance" and "quality enhancement" was introduced to point to different aspects of procedures used during the evaluation of the quality of higher education (for the following definitions, cf. Harvey 2004–2012). Thus, quality assurance is supposed to concentrate on regulatory processes when reviewing quality so that external accountability of the institution is ascertained and that stakeholder confidence in the services provided is established. Quality enhancement (or, perhaps stated even more clearly: quality improvement) is meant to emphasize the formative function of such procedures and therefore includes feedback processes with the purpose of changing the practices reviewed to the better.

One of the major difficulties met when dealing with the assurance or enhancement of the quality of higher education is the definition of the quality in question: The kind of quality looked for may differ from the point of view of the different stakeholders (society, state, students, teachers, university management); the good or service delivered is of manifold nature (instruction for a job within professional life or science, creation of new knowledge, formation of reflected personalities and citizens that can make a valuable contribution to society, etc.); the use and value of the education for the ones experiencing it can only be assessed properly when using it; and the organizations supplying the education are complex and have different institutional setups according to their historical and political contexts. So it has

become topical within the literature of this subject to comment on that problem of definition, which does not hinder some fundamental understanding of the underlying notion of quality. In a seminal article, Harvey and Green (1993) highlighted the role of stakeholders in higher education (Harvey and Green 1993: 11) and came up with five possible definitions of quality in higher education, describing it as exceptional/excellence, as perfection, as fitness for purpose (one might add: and fitness of the purpose pursued), as value for money, and as transformation. Especially the last dimension of quality – that it had to embrace the potential of the services provided by an institution to change and to improve – became influential for the resulting discussion as Harvey and Knight (1996) made explicit. Furthermore, the three dimensions of quality as described by Donabedian (1980) – originally developed for the system of health care – were largely adopted: When talking about quality in higher education, it has been regarded as a valuable instrument for an analytical approach to differentiate between the quality of the structure (e.g., the institution and its facilities or staff), of the processes (e.g., of teaching or administrating), and of the outcomes (e.g., of numbers of graduates vs. dropouts, of exam results, of rates of employment of alumni within relevant professional fields, etc.). Due to this wide range of applicability of the term "quality" within higher education, some authors thought it more consequent and suitable to speak of different "qualities" rather than one single one.

Quality Assurance Within Higher Education: Path Dependency and Political Factors

In order to understand how the discussion of quality assurance and/or quality enhancement was introduced into higher education and how it was (and still is) led in different countries, one has to consider historical, regional, and political factors: The institutional status and the decisive contexts of the university sector will vary according to the evolution of tertiary education in the countries concerned – relatively young

university landscapes in countries still developing face different problems than well-established institutions in OECD countries; a university sector largely based on private institutions, like in the USA, has some characteristics different to a largely state-run system like in Continental Europe, and so on. For the following findings on the rise of the procedure of quality evaluation in higher education, one has to bear in mind the path dependency that policies are submitted to – in surroundings different to the ones outlined here, different discussions and results will be likely to be considered.

The rise of the quality regime within the sector of tertiary education is often associated with a lack of trust of the public (the state) regarding the educational standards held at a number of institutions. This can be read as a result of the massification of higher education when universities no longer host a small elite of their age cohort, but are frequented by large numbers of students, thereby generating a great number of study programs and/or new institutions that do not share the confidence traditionally attributed by the public to universities and their supply of education. Thus, the need for checking standards is incited by a factor that came about from the educational system as a consequence of a historical development of society (the emerging "knowledge-based society"). It is stimulated further by questions concerning the effective use of financial resources spent by the universities (do they offer adequate value for money?) and their capacity to adapt to the new challenges of an altered environment (are they able to innovate and fulfill the new tasks required of them in terms of content as well as organization?).

According to Jeliazkova and Westerheijden (2002), different phases can be discerned in quality assurance systems, which correspond to different measures taken to ensure the desired quality: After a first phase of doubts about educational standards gleaned from descriptive records or performance indicators and resulting in governmental accreditations or reports, there was arguably another phase of doubts regarding the efficiency of the educational system. The issue of public accountability is raised here;

by identifying good practices and/or rankings of institutions, the universities seek to make their point as being responsible and quality-oriented institutions. A third phase is identified when doubts about the capacity for innovation and the ability for securing quality have risen. This is another facet of public accountability and often encountered with governmental audit reports or within the institution. When the need to establish a sustainable quality culture is eventually perceived, the focus is widened from mere fulfillment of public demands of accountability (often felt as external to traditional academic tasks by many of the institutional actors) to an improvement-oriented approach that enhances self-regulation of the institution as a means of its active (and autonomous) shaping. As outlined by Vroejenstijn (1995), this relation of accountability and improvement is regarded as being strained by many of the protagonists involved, which is also expressed in the proposition of different concepts of quality assurance and quality enhancement: They seem to be "navigating between Scylla and Charybdis," as the title of Vroejenstijn's (1995) influential handbook suggests. It remains to be seen whether this widely perceived tension between improvement and accountability will be unveiled as an illusionary one, as argued by Harvey and Newton (2007).

Nonetheless, one has to admit that the issue of quality was introduced in the sector of higher education from the outside, due to a lack of trust that should be reestablished by quality assurance and/or quality enhancement systems that on the one hand secure the basic requirements of institutions and their study programs and on the other hand play an active role for their improvement and innovation. It is important to note that the actual establishment of these systems can be interpreted in a quite divergent way within different political contexts: They may be seen as a means of the state ruling the institutions when looking at educational systems with traditional high autonomy of the universities (as in the UK or the USA), thereby diminishing this autonomy. For educational systems that traditionally relied on state guidance of universities (like in many countries of Continental Europe), the opposite can be true: By defining

ex-post-standards of tertiary education instead of the former ex-ante-criteria of ministerial rule, the state would hand over greater autonomy to the single institution.

The Impact of Managerialism on Higher Education

Independent of the actual situation of a country's higher education system regarding the aforesaid aspect of institutional autonomy, there is another overlying trend to be observed when it comes to the explanation of the growing spread of the quality agenda within universities: An increasing weight of managerial governance in the running of universities (replacing the former power of the professorial estate) went along with the intrusion of managerial thinking. Thus, the quality discourse reached its peak with the adaptation of ideas of the so-called new public management. This did not only affect organizational structures or employment relations but also the methods thought to be adequate to form and improve universities. Then concepts of quality and quality assurance or quality enhancement became – as Stensaker (2007) put it – a "fashion" for the governance of universities. Management principles originally developed for enterprises, and profit organizations were taken over and/or accommodated in order to fit academic contexts. This could take the form of mere policy copying (like giving monetary incentives to professionals for special efforts, say in the field of research or – less frequent – teaching) or the form of translation (thereby paying more attention to the peculiarities of the academic organization). One might say that the older paradigm of effectiveness of organizations was superseded by that of quality at a certain point of time when the quality discourse leaned strongly toward management literature. Also it seemed to suit the purpose of academic organizations better than merely looking for efficiency, for example, in producing large numbers of graduates without investigating the nature of their acquired qualifications. It is the adaptability to academic contexts that explains to a large extent why certain

management ideologies were embraced more eagerly than others. So, for example, a concept like Total Quality Management (TQM) with its "quality chain" – considering aspects like a customer-driven definition of quality ("customer" here often being translated into "student"), cultural change, or organizational structure with the end of constant improvement – was often esteemed as one applicable to academia, albeit even here, the differences between an originally business-oriented thinking and the academic world are obvious. To name but an example given by Harvey and Green (1993): The measurement of results within TQM largely relies on quantitative performance measures – a restriction to such performance indicators (like financial resources or the ratios of students to teachers) is in danger of overlooking the qualitative performance aspects that make a noteworthy share when it comes to approaching "academic quality." Nonetheless, Management principles with a focus on quality – next to TQM, one might think of the model of the European Foundation for Quality Management (EFQM) – had and have a great impact on the governance of higher education institutions.

As not uncommon for management principles – or, in broader terms, for policies in general – changes of approach and methods of quality assurance/quality enhancement may be observed every now and again. Taking the example of the US higher education system, Ewell (2007) identified certain historical phases of what he calls the "quality game." After an era of "Pre-Quality" characterized by a high level of trust in higher education institutions by public officials, a first period of quality assessment took place during the 1980s when universities faced the first calls for accountability from politics, often answering it – still in a rather friendly public atmosphere – with assessment operations at institution level. In the 1990s, this was superseded by a notion of "value for money" in terms of public utility and the feeling of state authorities that they should engage themselves in actively steering higher education so that it served public purposes. The method of choice frequently used during this period was the application of

performance measures (a row of examples will follow below) and attaching money to the fulfillment of these indicators. After 2000, a second period of quality orientation took a somewhat different approach in emphasizing issues of institutional improvement and adopting more and new methods of quality review (like academic audits), especially with the participation of third party reviewers. From then on, the process of teaching and learning was the main focus when inquiring about the outcomes of that central activity of universities.

It is important to notice that these changes in policies and methods were mostly stimulated by external events of national or international politics (and/or economy). Also it should be pointed out that the increased burden for the institutions – the rising costs of maintaining and developing sophisticated systems of quality assurance and quality enhancement – may lead to evasive reactions on behalf of the institutions. Especially smaller universities without the necessary financial resources, but also institutions where the leaders are not convinced of the eventual beneficial effects of quality enhancement, the temptation may be great to signal only compliance to external-driven quality evaluation while letting the core functions of academic life remain as protected and unaltered as possible. It is evident that quality assurance merely practiced as a kind of ritual – as enforced by some state authority – has little or no impact on the innovation of institutions.

Conclusion and Future Directions

Although it has been found that the concept of "quality" in higher education in many respects still remains vague to some extent, this has not impeded its career as a paradigm notion for shaping and innovating higher education institutions. As a general observation, it can be stated that measures and programs of quality assurance and quality enhancement have diversified and grown in importance as a consequence of shifts in educational politics (especially the often-quoted "lack of trust") and the intrusion of management

principles into academia. The following list – not claiming to be comprehensive – is meant to give an overview on the array of approaches used by giving examples for some of the most popular tendencies:

(a) Accountability and performance indicator reports focus on a variety of factors like: factors of input (e.g., staff-student ratios, staff qualifications, student selectivity, funding, facilities, curriculum plans), process factors (e.g., student and alumni feedback on courses and study programs respectively, hours per course unit, etc.), factors of throughput (intermediate results of exams, resits, grade point averages), and output factors (final results of graduation rates vs. dropouts, the time needed to reach the degree, employment rates).

(b) A movement of assessment-and-outcomes tries to develop performance measures by calling attention to questions of value and learning outcomes.

(c) Total Quality Management focuses on continuous improvement and customer satisfaction.

(d) External Quality Monitoring delegates accountability to third parties (also including measurements of assessment-and-outcomes).

Quality assurance in general uses measures like (all following citations taken from Harvey 2004–2012): accreditation ("establishment of the status, legitimacy or appropriateness of an institution, program or module of study"), audit ("process for checking that procedures are in place to assure quality, integrity, or standards of provision and outcomes"), assessment ("all methods used to judge the performance of an individual, group, or organization"), and external examination ("uses people external to the program or institution to evaluate quality or standards," which can also include techniques of benchmarking, ranking, or report cards). Due to the variety of procedures, the term quality "monitoring" sometimes takes the place of "assurance." A regulatory component is felt within the use of this concept which is not present in the term quality enhancement (described as a "process of augmentation and improvement") that stresses

the formative component. Among the teaching and learning activities often encompassed by quality enhancement, there are also qualitative elements like curriculum development to communities of practice.

As can be seen from this short listing of methods, indicators, and procedures, the fields of quality assurance and quality enhancement yield a wide spectrum of activities and practices with sometimes divergent theoretical backgrounds. What seems one of the consequences of the increasingly refined applications of quality-oriented procedures within higher education and the yet ongoing movement toward an improvement-driven concept of quality enhancement is the growing understanding for the necessity of an outcome-based education. That postulated "shift from teaching to learning" will operate by means of an expressed learning intent; it is supposed to result in a process that enables the intended learning to be achieved, and it has to lead to the formulation of criteria for assessing learning.

It is clear that such ambitious goals implying a serious change of academic teaching and learning activities not only rely on the active support of the institutional leaders (which is true for any action of management change) but have to be based on a well-defined analytical framework of the policies of quality assurance chosen. Perellon (2007: 161) suggests five dimensions concerning the choices to be made within quality assurance in higher education:

– *Objectives*: What should be the aims and objectives of quality assurance policy?
– *Control*: Who should control the process of quality assurance?
– *Areas*: What are the domains covered by quality assurance procedures setup?
– *Procedures*: How are the quality assurance procedures set up?
– *Use*: How is the information collected used?

Quality assurance and quality enhancement within higher education claiming to be more than the mere fulfillment of ritualism or tokenism driven by external pressure of public accountability will have to show accountability itself by reflecting on the methods and the outcomes of their activities and procedures. Accordingly, the argument of Harvey and Newton (2007: 235) on behalf of a "research-informed, improvement-led approach to quality evaluation" should be considered if quality assurance and quality enhancement are to make a contribution toward the innovation of the higher education sector. The advantages of this concept seem obvious: A research-informed approach will choose and improve procedures in terms of better efficacy of quality assurance; also it can hope for increased acceptance from academics as it reflects on its methodology in a scientifically valid way; finally, it is appropriate for self-regulating institutions as it largely relies on internal processes and internal motivators (which should motivate the institutional actors, allowing for greater autonomy). However, due to the contingencies of political and economic contexts, it remains an unanswered question if and to what extent such a transformation of quality evaluation procedures toward an improvement-led, self-regulating system within higher education institutions is to be realized in different countries during the coming years.

Cross-References

► Global University System
► Higher Education and Innovation
► Innovations of and in Organizations
► Knowledge Society, Knowledge-Based Economy, and Innovation
► University Research and Innovation

References

Donabedian A. The definition of quality and approaches to its assessment. Explorations in quality assessment and monitoring. Ann Arbor/Michigan: Health Administration; 1980.

Ewell P. The 'Quality Game': external review and institutional reaction over three decades in the United States. In: Westerheijden DF, Stensaker B, Rosa MJ, editors. Quality assurance in higher education: trends in regulation, translation and transformation. Dordrecht: Springer; 2007. p. 119–53.

Harvey L. Analytic quality glossary. Quality Research International; 2004–2012. http://www.qualityresearch international.com/glossary/. Accessed 27 Feb 2012.

Harvey L, Green D. Defining quality. Assess Eval High Educ. 1993;18(1):9–34.

Harvey L, Knight PT. Transforming higher education. Buckingham: Society for research into Higher Education and Open University Press; 1996.

Harvey L, Newton J. Transforming quality evaluation: moving on. In: Westerheijden DF, Stensaker B, Rosa MJ, editors. Quality assurance in higher education: trends in regulation, translation and transformation. Dordrecht: Springer; 2007. p. 225–45.

Jeliazkova M, Westerheijden DF. Systemic adaptation to a changing environment: towards a next generation of quality assurance models. High Educ. 2002;44 (3/4):433–48.

Perellon JF. Analysing quality assurance in higher education: proposals for a conceptual framework and methodological implications. In: Westerheijden DF, Stensaker B, Rosa MJ, editors. Quality assurance in higher education: trends in regulation, translation and transformation. Dordrecht: Springer; 2007. p. 155–78.

Stensaker B. Quality as fashion: exploring the translation of a management idea into higher education. In: Westerheijden DF, Stensaker B, Rosa MJ, editors. Quality assurance in higher education: trends in regulation, translation and transformation. Dordrecht: Springer; 2007. p. 99–118.

Vroejenstijn AI. Improvement and accountability: navigating between Scylla and Charybdis: guide for external quality assessment in higher education. London: Jessica Kingsley; 1995.

Quality Dimensions

▶ Epistemic Governance and Epistemic Innovation Policy

Quality Enhancement

▶ Epistemic Governance and Epistemic Innovation Policy

Quality Evaluation at Universities (of University Tuition)

▶ Quality Assurance and Quality Enhancement in Higher Education and Innovation

Quality Management

▶ Epistemic Governance and Epistemic Innovation Policy

Quality of Democracy

▶ Quality of Democracy and Innovation

Quality of Democracy and Innovation

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Synonyms

Basic dimensions of democracy; Coevolution; Conceptualization of democracy; Democracy; Democracy, Theory; Democratic innovation; Democratizing innovation; Development; Innovation of democracy; Innovative democracy; Knowledge democracy; Model of quadruple helix structures; Quadruple helix; Quadruple helix structure of democracy; Quadruple-dimensional structure of democracy; Quality of democracy; Sustainable development

The Conceptual Definition of Democracy and of the Quality of Democracy

How can democracy and the quality of democracy be conceptualized? Such a (theoretically justified) conceptualization is necessary in order

**Basic Dimensions of Democracy
and the Quality of Democracy:**
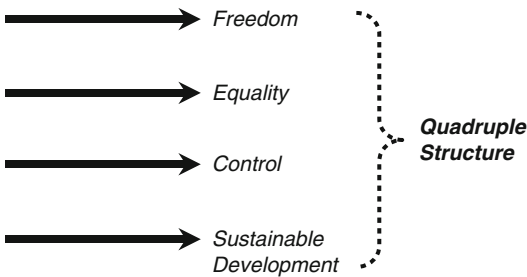
Quality of Democracy and Innovation, Fig. 1 The basic quadruple-dimension structure of democracy and the quality of democracy (Source: Author's own concoptualization and visualization, based on Campbell (2008, p. 32) and for the dimension of "control" on Lauth (2004, pp. 32–101))

for democracy and the quality of democracy to be subjected to a democracy measurement, *whereby democracy measurement, in this case, can be examined along the lines of conceptually defining democracy (thus democracy measurement is also to be utilized to improve the theory of democracy)* (see Campbell 2012). Hans-Joachim Lauth (2004, pp. 32–101) suggests in this context a "three-dimensional concept of democracy," which is composed of the following (conceptual) dimensions: *equality, freedom, and control* (see Fig. 1). These dimensions can be interpreted as "basic dimensions" of democracy and of the quality of democracy. Lauth (2004, p. 96) underlines that these dimensions are "sufficient" to obtain a definition of democracy. The term "dimension" offers a conceptual elegance that can be applied "trans-theoretically," meaning that different theories of democracy may be put in relation and may be mapped comparatively in reference to those dimensions. Metaphorically formulated, dimensions behave like "building blocks" for theories and theory development. With regard to democracy and the quality of democracy, every interest in analysis and assessment is confronted with the following point-of-departure question and challenge: whether (1) democracy exclusively refers or should refer to the political system (political dimension) or whether (2) democracy should also include social (societal), economic, and ecological

contexts (nonpolitical dimensions) of the political system. This produces implications on the selection of indicators to be used for democracy measurement. How "limited" or "broadly" focused should be the definition of democracy? This is also reflected in the *minimalistic (minimalist)* versus *maximalistic (maximalist)* democracy theory debate (see Sodaro 2004, pp. 168, 180, and 182). In this regard, various theoretical positions elaborate on this concept. Perhaps, it is (was) from an orthodox point of view of theory to limit democracy to the political system (Munck 2009, pp. 126–127). More recent approaches are more sensitive for the contexts of the political system, however, still must establish themselves in the political mainstream debates (see, e.g., Stoiber 2011). Nevertheless, explicit theoretical examples are emerging for the purpose of incorporation into the democracy models the social (societal), economic, and ecological contexts. The theoretical model of the "democracy ranking" is an initiative that represents such an explicit example (Campbell 2008).

Over time, democracy theories are becoming more complex and demanding in nature, regardless, whether the understanding of democracy refers only to the political system or includes also the contexts of the political system. This also reflects on the establishment of democracy models. The most simple democracy model is that of the "electoral democracy" (Helms 2007, p. 19), also known as "voting democracy" ("*Wahldemokratie*," Campbell and Barth 2009, p. 212). An electoral democracy focuses on the process of elections, highlights the political rights, and refers to providing minimum standards and rights, however, enough to be classified as a democracy. Freedom House (2011a) defines electoral democracy by using the following criteria: "a competitive, multiparty political system"; "universal adult suffrage for all citizens"; "regularly contested elections"; and "significant public access of major political parties to the electorate through the media and through generally open political campaigning." The next, qualitatively better level of democracy is the so-called liberal democracy. A liberal democracy is characterized by political rights and more importantly

also by civil liberties as well as complex and sophisticated forms of institutionalization. The liberal democracy does not only want to fulfill minimum standards (thresholds) but aims on ascending to the quality and standards of a developed, hence, an advanced democracy. Every liberal democracy is also an electoral democracy, but not every electoral democracy is automatically a liberal democracy. In this regard, Freedom House (2011a) states: "Freedom House's term 'electoral democracy' differs from 'liberal democracy' in that the latter also implies the presence of a substantial array of civil liberties. In the survey, all the 'Free' countries qualify as both electoral and liberal democracies. By contrast, some 'Partly Free' countries qualify as electoral, but not liberal, democracies." Asserting different (perhaps ideal-typical) conceptual stages of development for a further quality increasing and progressing of democracy, the following stages may be put up for discussion: *electoral democracy*, *liberal democracy*, and *advanced (liberal) democracy* with a *high quality of democracy*.

In *Polyarchy*, Robert A. Dahl (1971, pp. 2–9) comes to the conclusion that mostly two dimensions suffice in order to be able to describe the functions of democratic regimes: (1) *contestation* ("public contestation," "political competition") and (2) *participation* ("participation," "inclusiveness," "right to participate in elections and office"). Also relevant are Anthony Downs' (1957, pp. 23–24) eight criteria in *An Economic Theory of Democracy*, defining a "democratic government," but it could be argued that those are affiliated closer with an electoral democracy. In the beginning of the twenty-first century is the conceptual understanding of democracy and the quality of democracy already more differentiated, it can be said that crucial conceptual further developments are in progress. Larry Diamond and Leonardo Morlino (2004, pp. 22–28) have come up with an "eight dimensions of democratic quality" proposal. These include (1) *rule of law*, (2) *participation*, (3) *competition*, (4) *vertical accountability*, (5) *horizontal accountability*, (6) *freedom*, (7) *equality*, and (8) *responsiveness*. Diamond and Morlino (2004, p. 22)

further state: "The multidimensional nature of our framework, and of the growing number of democracy assessments that are being conducted, implies a pluralist notion of democratic quality." These eight dimensions distinguish themselves conceptually with regard to procedure, content, and results as the basis (conceptual quality basis) to be used in differentiating the quality of democracy (see Diamond and Morlino 2004, pp. 21–22; 2005; see also Campbell and Barth 2009, pp. 212–213). The "eight dimensions" of Diamond and Morlino may be interpreted as "secondary dimensions" of democracy and the quality of democracy for the purpose of democracy measurement.

"Earlier debates were strongly influenced by a dichotomous understanding that democracies stood in contrast to non-democracies" (Campbell and Barth 2009, p. 210). However, with the quantitative expansion and spreading of democratic regimes, it is more important to differentiate between the qualities of different democracies. According to Freedom House (2011b), in the year 1980 no less than 42.5 % of the world population lived in "not free" political contexts; by 2010, this share dropped to 35.4 %. Democracies themselves are subject to further development, which is a continuous process and does not finish upon the establishment of a democracy. Democracies have to find answers and solutions to new challenges and possible problems. Democracy is in a constant need to find and reinvent itself. Observed over time, different scenarios could take place and could keep a democracy quality going on constantly; however, democracy quality could erode, but also improve. *A betterment of the quality of democracy should be the ultimate aim of a democracy. Earlier ideas about an electoral democracy are becoming outdated and will not suffice in today's era.*

Gillermo O'Donnell (2004a) developed a broad theoretical understanding of democracy and the quality of democracy. In his theoretical approach, quality of democracy develops itself further through an interaction between human development and human rights: "True, in its origin the concept of human development focused mostly on the social and economic context, while

the concept of human rights focused mostly on the legal system and on the prevention and redress of state violence" (O'Donnell 2004a, p. 12). The human rights differentiate themselves in civil rights, political rights, and social rights, in which O'Donnell (2004a, p. 47) assumes and adopts the classification of T. H. Marshall (1964). Human development prompts "…what may be, at least, a minimum set of conditions, or capabilities, that enable human beings to function in ways appropriate to their condition as such beings" (O'Donnell 2004a, p. 12), therefore in accordance with human dignity and, moreover, the possibility of participating realistically in political processes within a democracy. O'Donnell also refers directly to the *Human Development Reports* with the *Human Development Index (HDI)* that are being released and published annually by the United Nations Development Program (UNDP) (for a comprehensive website address for all *Human Development Reports* that is publicly accessible for free downloads, see: http://hdr. undp.org/en/reports/global/hdr2011/). Explicitly, Gillermo O'Donnell (2004a, pp. 11–12) points out: "The concept of human development that has been proposed and widely diffused by UNDP's *Reports* and the work of Amartya Sen was a reversal of prevailing views about development. . . . The concept asks how every individual is doing in relation to the achievement of 'the most elementary capabilities, such as living a long and healthy life, being knowledgeable, and enjoying a decent standard of living'" (O'Donnell 2004a, pp. 11–12; UNDP 2000, p. 20). *If the implementation of O'Donnell is reflected upon the initial questions asked in this contribution for the conceptualization of democracy and the quality of democracy, it can be interpreted but also convincingly argued that "sustainable development" can be suggested as an additional dimension ("basic dimension") for democracy, which would be important for the quality of democracy in a global perspective* (for a systematic attempt of empirical assessment on possible linkages between democracy and development, see Przeworski et al. 2003). As a result of the

distinction between dimensions (basic dimensions) for democracy and the quality of democracy, the following proposition is put up for debate: in addition to the dimensions of *freedom, equality, and control* as being suggested by Lauth (2004, pp. 32–101), *the dimension of sustainable development should be introduced as a fourth dimension* (see again Fig. 1). Regarding suggestions for defining sustainable development, Verena Winiwarter and Martin Knoll (2007, pp. 306–307) commented: "In the meantime, as described, multiple definitions for sustainability exist. A fundamental distinction within the definition lies in the question whether only the relation of society with nature or if additionally social and economic factors should be considered."

In political context and in political competition, equality often is associated closer with left-wing political positions and freedom with right-wing (conservative) positions (e.g., see Harding et al. 1986, p. 87). *A measure of performance of political and nonpolitical dimensions in relation to sustainable development has the advantage (especially in the case where sustainable development is understood comprehensively) that this procedure is mostly (often) left–right neutral. Such a measure of performance as a basis of the assessment of democracy and quality of democracy offers an additional reference point ("meta-reference point") outside of usual ideologically based conflict positions* (Campbell 2008, pp. 30–32). It can be argued in a similar manner that the dimension of control mentioned by Lauth (2004, pp. 77–96) positions itself as left–right neutral as well. The definition developed by the "democracy ranking" for the quality of democracy is "Quality of Democracy = (freedom & other characteristics of the political system) & (performance of the nonpolitical dimensions)" (Campbell 2008). *This definition is interpreted as a further empirical operationalization step and as a practical application for the measurement of democracy and the quality of democracy, respectively, which is based on the theory about the quality of democracy by Guillermo O'Donnell*

(see also O'Donnell 2004b). However, the conceptual democracy formula of the "democracy ranking" has been developed independently (Campbell and Sükösd 2002).

Conclusion and Future Directions

There are different theories, conceptual approaches, and models for knowledge production and innovation systems. In the Triple Helix model of innovation, Etzkowitz and Leydesdorff (2000, p. 112) developed a conceptual architecture for innovation, where they tie together the three helices of academia (higher education), industry (business), and state (government). This conceptual approach was extended by Carayannis and Campbell (2009; 2012, p. 14) in the so-called Quadruple Helix model of innovation systems by adding as a fourth helix the "media-based and culture-based public" as well as "civil society." *The Quadruple Helix, therefore, is broader than the Triple Helix and contextualizes the Triple Helix*, by interpreting Triple Helix as a core model that is being embedded in and by the more comprehensive Quadruple Helix. *Furthermore, the next-stage model of the Quintuple Helix model of innovation contextualizes the Quadruple Helix, by bringing in a further new perspective by adding the "natural environment" (natural environments) of society*. The Quintuple Helix represents a "five-helix model," "where the environment or the natural environments represent the fifth helix" (Carayannis and Campbell 2010, p. 61). In trying to emphasize, compare, and contrast the focuses of those different Helix innovation models, it can be asserted that the Triple Helix concentrates on the knowledge economy, the Quadruple Helix on knowledge society and knowledge democracy, while the Quintuple Helix refers to socio-ecological transitions and the natural environments (Carayannis et al. 2012, p. 4; see also Carayannis and Campbell 2011; European Commission 2009; Fischer-Kowalski and Haberl 2007). *For explaining and comparing democracy and the quality of democracy, a "quadruple-dimensional structure" has been proposed here that refers to four different "basic dimensions" of democracy that are being called freedom, equality, control, and sustainable development* (Fig. 1 offers a visualization on these). Here, actually a line of comparison may be drawn between concepts and models in the theorizing on democracy and democracy quality and the theorizing on knowledge production and innovation systems. This opens up a window of opportunity for an interdisciplinary and transdisciplinary approaching of democracy as well as of knowledge production and innovation, also of "democratic innovation" (Saward 2000) and "democratizing innovation" (Von Hippel 2005). *In conceptual terms, the quadruple-dimensional structure of democracy could also be rearranged (re-architectured) in reference to helices, by this creating a "model of Quadruple Helix structures" for democracy and the quality of democracy*. The metaphor and visualization in reference to terms of *helices* emphasizes the fluid and dynamic interaction, overlap, and coevolution of the individual dimensions of democracy. As basic dimensions for democracy were proposed to identify freedom, equality, control, and sustainable development. Figure 2 introduces a possible visualization from a helix perspective for a theoretical framing of democracy.
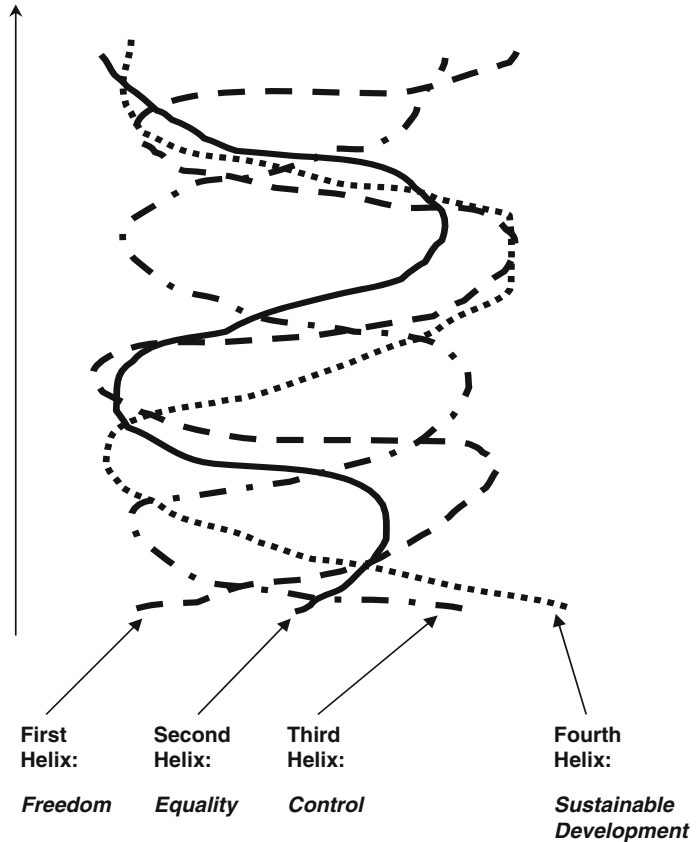
Specific challenges for future research but also for future reform and development are as follows:

1. Is there an unfolding relationship, perhaps also coevolution, between democracy, knowledge democracy, and the quality of democracy?
2. Do innovations in and of democracy produce and create an innovative democracy?
3. Does innovative democracy support knowledge production and knowledge application (innovation) in the knowledge society and knowledge economy?
4. Is sustainable development, in the long run, only possible, when democracy, innovation, and entrepreneurship find together by forming in balance a complex and sensitive interaction and coevolution?

Quality of Democracy and Innovation, Fig. 2 The quadruple helix structure of the basic dimension of democracy and the quality of democracy (Source: Author's own conceptualization based on Etzkowitz and Leydesdorff (2000, p. 112), Carayannis and Campbell (2012, p. 14), Danilda et al. (2009), Campbell (2008, p.32) and for the dimension of "control" on Lauth (2004, pp. 32–101))

Direction of time

First Helix: **Freedom**

Second Helix: **Equality**

Third Helix: **Control**

Fourth Helix: **Sustainable Development**

Cross-References

References

Campbell DFJ. The basic concept for the democracy ranking of the quality of democracy. Vienna: Democracy Ranking (2008). http://www.democracyranking.org/downloads/basic_concept_democracy_ranking_2008_A4.pdf. Accessed 1 Dec 2012.

Campbell DFJ. Die österreichische Demokratiequalität in Perspektive. In Helms L, Wineroither DM, editors.

Die österreichische Demokratie im Vergleich. Baden-Baden: Nomos; 2012.

Campbell DFJ, Sükösd M, editors. Feasibility study for a quality ranking of democracies. Vienna: Global Democracy Award (2002). http://www.democracyranking.org/downloads/feasibility_study-a4-e-01.pdf. Accessed 1 Dec 2012.

Campbell DFJ, Barth TD. Wie können Demokratie und Demokratiequalität gemessen werden? Modelle, Demokratie-Indices und Länderbeispiele im globalen Vergleich. SWS-Rundschau. 2009;49(2):208–33. http://www.sws-rundschau.at/archiv/SWS_2009_2_Campbell.pdf and http://www.ssoar.info/ssoar/View/?resid=12471.

Carayannis EG, Campbell DFJ. "Mode 3" and "Quadruple Helix": toward a 21st century fractal innovation ecosystem. Int J Technol Manag. 2009;46(3/4):201–34. http://www.inderscience.com/browse/index.php?journalID=27&year=2009&vol=46&issue=3/4 and http://www.inderscience.com/search/index.php?action=record&rec_id=23374&prevQuery=&ps=10&m=or.

Carayannis EG, Campbell DFJ. Triple helix, quadruple helix and quintuple helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. Int J Soc Ecol Sustain Dev. 2010;1(1):41–69. http://www.igi-global.com/bookstore/article.aspx?titleid=41959.

Carayannis EG, Campbell DFJ. Open innovation diplomacy and a 21st century fractal research, education and innovation (FREIE) ecosystem: building on the quadruple and quintuple helix innovation concepts and the "Mode 3" knowledge production system. J Knowl Econ. 2011;2(3):327–72. http://www.springerlink.com/content/d1lr223321305579/.

Carayannis EG, Campbell DFJ. Mode 3 knowledge production in quadruple helix innovation systems. 21st-century democracy, innovation, and entrepreneurship for development, Springer briefs in business, vol. 7. New York: Springer; 2012. http://www.springer.com/business+%26+management/book/978-1-4614-2061-3.

Carayannis EG, Barth TD, Campbell DFJ. The quintuple helix innovation model: global warming as a challenge and driver for innovation. J Innov Entrep. 2012;1(1):1–12. http://www.innovation-entrepreneurship.com/content/pdf/2192-5372-1-2.pdf.

Dahl RA. Polyarchy. Participation and opposition. New Haven: Yale University Press; 1971.

Danilda I, Lindberg M, Torstensson B-M. Women Resource Centres. A quattro helix innovation system on the European agenda (2009). Paper http://www.hss09.se/own_documents/Papers/3-11%20-%20Danilda%20Lindberg%20&%20Torstensson%20-%20paper.pdf. Accessed 1 Dec 2012.

Diamond L, Morlino L. The quality of democracy. An overview. J Democr. 2004;15(4):20–31.

Diamond L, Morlino L, editors. Assessing the quality of democracy. Baltimore: The John Hopkins University Press; 2005.

Downs A. An economic theory of democracy. Boston: Addison-Wesley; 1957.

Etzkowitz H, Leydesdorff L. The dynamics of innovation: from national systems and "Mode 2" to a triple helix of university-industry-government relations. Res Policy. 2000;29:109–23.

European Commission. The world in 2025. Rising Asia and socio-ecological transition. Brussels: European Commission (2009). http://ec.europa.eu/research/social-sciences/pdf/the-world-in-2025-report_en.pdf. Accessed 1 Dec 2012.

Fischer-Kowalski M, Haberl H, editors. Socioecological transitions and global change. Trajectories of social metabolism and land use. Cheltenham: Edward Elgar; 2007.

Freedom House. Freedom in the world 2011. Methodology. Washington, DC: Freedom House (2011a). http://www.freedomhouse.org/template.cfm?page=351&ana_page=379&year=2011. Accessed 1 Dec 2012.

Freedom House. Freedom in the world – population trends. Washington, DC: Freedom House (2011b). http://www.freedomhouse.org/images/File/fiw/historical/PopulationTrendsFIW1980-2011.pdf. Accessed 1 Dec 2012.

Harding S, Phillips D, Fogarty M. Contrasting values in Western Europe. Unity, diversity and change, Studies in the contemporary values of modern society. London: Macmillan; 1986.

Helms L. Die Institutionalisierung der liberalen Demokratie. Deutschland im internationalen Vergleich. Frankfurt: Campus; 2007.

Lauth H-J. Demokratie und Demokratiemessung. Eine konzeptionelle Grundlegung für den interkulturellen Vergleich. Wiesbaden: VS Verlag für Sozialwissenschaften; 2004.

Marshall TH. Class, citizenship, and social development. Essays. Garden City: Doubleday; 1964.

Munck GL. Measuring democracy. Baltimore: The Johns Hopkins University Press; 2009.

O'Donnell G. Human development, human rights, and democracy. In: O'Donnell G, Vargas Cullell J, Iazzetta OM, editors. The quality of democracy. Theory and applications. Notre Dame: University of Notre Dame Press; 2004a. p. 9–92.

O'Donnell G. Why the rule of law matters. J Democr. 2004b;15(4):32–46.

Przeworski A, Alvarez ME, Antonio Cheibub J, Limongi F. Democracy and development. Political institutions and well-being in the world, 1950–1990. Cambridge: Cambridge University Press; 2003.

Saward M, editor. Democratic innovation. Deliberation, representation and association. London: Routledge; 2000.

Q

Sodaro MJ. Comparative politics. A global introduction. Boston: Mc Graw Hill; 2004.

Stoiber M. Die Qualität von Demokratien im Vergleich Zur Bedeutung des Kontextes in der empirisch vergleichenden Demokratietheorie. Nomos: Baden-Baden; 2011.

UNDP/United Nations Development Program. Human development report 2000. Human rights and human development. Oxford: Oxford University Press; 2000. http://hdr.undp.org/en/reports/global/hdr2000/.

Von Hippel E. Democratizing innovation. Cambridge, MA: MIT Press; 2005.

Winiwarter V, Knoll M. Umweltgeschichte. Cologne: Böhlau; 2007.

Quintuple Innovation Helix and Global Warming: Challenges and Opportunities for Policy and Practice

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Synonyms

Quadruple helix extended; Social ecology

Introduction

Due to the escalation of "global warming," it is time for humanity to think and act responsibly and determine sustainable solutions. Global warming, in addition to climate change, has caused the world to undertake new responsibilities (see IPCC 2007a), which not only include further climate change but in the long term also hold humanity accountable in the prevention of new political and/ or social conflicts, war on resources, new environmental catastrophes, as well as serious crises in the market economies (see UNDP 2007; UNEP 2008). The special challenge of global warming can be tackled by "sustainable development." The definition of the Brundtland Commission states that sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987a, b). Sustainable development concerns us all and takes place on the local as well as global level. Hence, sustainable development has to be understood in the context of "gloCal knowledge economy and society" (see Carayannis and Campbell 2011; Carayannis and von Zedwitz 2005; Carayannis and Alexander 2006). Therefore, we must perceive global warming not as a challenge, but rather as an opportunity to live innovatively and effectively in union with nature for a better tomorrow.

To a large extent, humanity itself has caused the climate change; therefore, something must be done (see IPCC 2007b; Le Monde diplomatique 2009, pp. 72–73; Friedman 2008). However, there are hardly any comprehensive models or concepts to answer the "WHY" that truly show "HOW" we can act and learn accordingly, or provide any demonstrative methods, suggestions, and examples "HOW" we can improve our actions in the present. Our analysis presented here suggests understanding the "WHY" and consequently offers a "model of innovation," which demonstrates a feasible, step-by-step method to tackle the "HOW."

In the current academic debate, it is undisputed that a solution or a suitable answer regarding the challenge of global warming can only be found through utilizing the asset of human knowledge (see Carayannis and Campbell 2010, p. 42; Bhaskar 2010, p. 1). The key to success, as is being determined by our propositions, lies in using the available and newly created "knowledge" in correspondence with the *Quintuple Helix Model* (Carayannis and Campbell 2010, p. 62). The *Quintuple Helix* is

a model of innovation that can tackle existing challenges of global warming through the application of knowledge and know-how as it focuses on the social (societal) exchange and transfer of knowledge inside subsystems of a specific state, nation-state (see Barth 2011a, pp. 5–7). The "nonlinear" innovation model of the *Quintuple Helix*, which combines knowledge, know-how, and the natural-environment system together into one "interdisciplinary" and "transdisciplinary" framework, can provide a step-by-step model to comprehend the quality-based management of effective development, to recover a balance with nature, and to allow future generations a life of plurality and diversity on earth (see Carayannis and Campbell 2010, p. 42; Barth 2011a, p. 2). To sum up, our thesis is as follows: The *Quintuple Helix* represents a suitable model in theory and practice offered to society, to understand the link between knowledge and innovation, in order to promote lasting development. This contribution, under the aspect of global warming, focuses on the potential of a nation-state in the twenty-first century and on the following pivotal question: *How can sustainable development, with regard to global warming, be practiced step by step with and within a quintuple helix model?*

The structure of our analysis is as follows. Section "The Challenge of Global Warming and the Resource of Knowledge" is a short delineation about challenges of global warming and the organization of the resource of knowledge. In Sect. "What is a Quintuple Helix Innovation Model?", the *Quintuple Helix* Model is defined. Next comes Sect. "The Challenge of Global Warming in a Quintuple Helix Innovation Model" that visualizes the *Quintuple Helix Model* as a "nonlinear" model of innovation in correspondence with social (societal) subsystems and along with a descriptive step-by-step example of how the challenge of sustainable development (under the aspect of global warming) may be adopted. Section "Conclusion and Future Directions" offers a conclusion in reference to the *Quintuple Helix Innovation Model*.

The Challenge of Global Warming and the Resource of Knowledge

The challenge of sustainable development (under the aspect of global warming) proves that there are currently several crucial questions that need to be answered (see Carayannis 2011): So new political goals must be formulated, in reference with CO_2 emission limits, in the quest for a long-term sustainability. Furthermore, there is rising demand for "new green" knowledge solutions and know-how in order to utilize resources innovatively for society and the economy in an environmentally conscious manner. Moreover, our present way of life and lifestyle must be scrutinized under a sustainable impact assessment. Apart from environmental protection, it also demands the protection of biodiversity (see Barth 2011a; Bhaskar 2010; Le Monde diplomatique 2009, pp. 22–23, 72–73, 92–93; UNDP 2007). Global warming concerns us all as it takes place on a "local" as well as "global" level and implies ramifications for the "gloCal knowledge economy and society" (see Carayannis and Campbell 2011; Carayannis and von Zedwitz 2005; Carayannis and Alexander 2006). It is clear that the challenge of global warming is accompanied with the challenge of sustainability (for the world) in the twenty-first century (see Carayannis 2011). Therefore, there are nine areas, of which Carayannis and Kaloudis write about, that require "sustained action," political and economical "leadership" or "empowerment," and "intelligent use of technology" (Carayannis and Kaloudis 2010, p. 2):

1. "Financial/economic system": The area of "financial and economic system" refers to financial and economic aspects of the effects of climate change. The following question arises (among other things): How should the two systems effectively change or adapt with each other in order to reduce or exclude crises in consequence of climate change (see, e.g., Barbier 2009; Barth 2011a; Green New Deal Group 2008; Hufbauer et al. 2009; Meyer 2008; OECD 2010; Sen 2007)?

2. "Environmental challenges": The area of "environmental challenges" has to do with causes and effects of climate change and which political and social measures should be taken to increase environmental conservation and sustainability (see, e.g., IPCC 2007a, b; Giddens 2009; Høyer 2010a; Müller and Niebert 2009; Stern 2009).

3. "Feed and heal the world challenges": The area "feed and heal the world challenges" emphasizes new and solution-oriented approaches under the aspect of knowledge and care in the course of climate change (see Parker 2010; Höll et al. 2006).

4. "Energy challenges": The area of "energy challenges" highlights new green technologies and renewable energy, which lead to sustainable development (see also Barbier 2009; Green New Deal Group 2008; Høyer 2010b; UNEP 2008).

5. "Educational challenges": The area "educational challenges" is based on a better education as a key for empowerment, equality of chances, and new knowledge for sustainability and development (see, e.g., OECD 2009; O'Donnell 2004; Sen 2007; UNDP 2010).

6. "Political democratic reform across the world": The area "political democratic reform across the world" promotes democracy as being a local and global key for sustainable development. Here, also the themes of democratization, freedom, equality, policy making, gender, and political culture are relevant (see, furthermore, Barth 2011b; Biegelbauer 2007b; Campbell 2007; Campbell and Schaller 2002; Kreisky and Löffler 2010; Otzelberger 2011; Ulram 2006).

7. "Transformative government across the world": The area "transformative government across the world" has to do with the political standing or rating of a nation-state. Examples here are the search for democracy, quality of democracy, types of political systems, etc. (see also Barth 2010, 2011a, b, c; Campbell 2008; Campbell and Barth 2009; Campbell et al. 2010; Diamond and Morlino 2005; O'Donnell 2004; Rommetveit et al. 2010; Schumpeter 1976; Tilly 2007).

8. "Equity and security across the world": The area "equity and security across the world" refers to equity and security as being basic prerequisites to foster and support sustainable development (see, e.g., UNDP 2011; Barth 2011a).

9. "Technology, innovation, and entrepreneurship as drivers of knowledge societies": The area of "technology, innovation, and entrepreneurship as drivers of knowledge societies" emphasizes the fact that a sustainable development in knowledge societies can only be achieved when new knowledge is promoted and produced and when innovations (with a new entrepreneurship) are developed further (see here the idea and concept of the "Academic Firm," Campbell and Güttel 2005; see also and furthermore Bhaskar 2010; Biegelbauer 2007a; Campbell 2006; Carayannis and Campbell 2006, 2009, 2010, 2011; Dubina 2009; Dubina et al. 2012; Kuhlmann 2001; Lundvall 1992; Nowotny et al. 2003).

Let us consider now in greater detail the production of the resource of knowledge. Knowledge (e.g., the advancement of green technology) can act as key to success for sustainable development. Essentially, it should be understood today that nation-states that concentrate on progress of society, a higher competitiveness of their economies or a better and sustainable quality of life, have to apply the resource of knowledge. In the transformation to a knowledge-based society, knowledge-based economy, or knowledge-based democracy (see Carayannis and Campbell 2009, p. 224), also under the aspect of climate change, it is possible to generate new and usable knowledge in conjunction with sustainable development. The resource of knowledge, therefore, turns into the "most fundamental resource" (Lundvall 1992, p. 1), with qualities of a "knowledge nugget" (Carayannis and Formica 2006, p. 152). Knowledge, as a resource, is created through creative processes, combinations, and productions in so-called Knowledge Models or Innovation Models and thus becomes available for society: "We can also call this the creativity of knowledge creation" (Carayannis and Campbell 2010, p. 48). We want to refer here specifically to six currently existing

Quintuple Innovation Helix and Global Warming: Challenges and Opportunities for Policy and Practice, Fig. 1 The evolution of the models of knowledge creation (Source: Authors' own conceptualization)
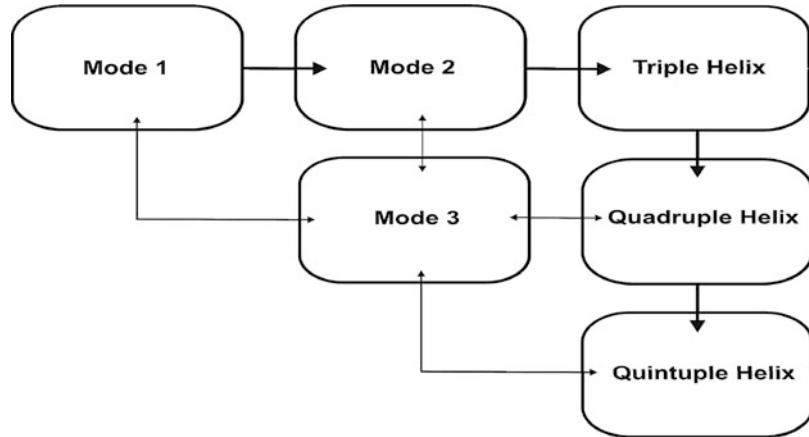
models of knowledge creation and innovation creativity (see also Fig. 1, below):

"**Mode 1**" (see Gibbons et al. 1994): Mode 1 "focuses on the traditional role of university research in an elderly 'linear model of innovation' understanding," and success in mode 1 "is defined as a quality or excellence that is approved by hierarchically established peers" (Carayannis and Campbell 2010, p. 48).

"**Mode 2**" (see Gibbons et al. 1994): Mode 2 can be characterized by the following five principles: (1) "knowledge produced in the context of application," (2) "transdisciplinarity," (3) "heterogeneity and organizational diversity," (4) "social accountability and reflexivity," (5) and "quality control" (Gibbons et al. 1994, pp. 3–4).

"**Triple Helix**" (see Etzkowitz and Leydesdorff 2000): 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," and it is a "model of 'tri-lateral networks and hybrid organizations' of 'university-industry-government relations'" (Etzkowitz and Leydesdorff 2000, pp. 118, 111–112).

"**Mode 3**" (see Carayannis and Campbell 2006): "The concept of Mode 3 is more inclined to emphasize the co-existence and co-evolution of different knowledge and innovation modes. Mode 3 even accentuates such a pluralism and diversity of knowledge and innovation modes

as being necessary for advancing societies and economies. This pluralism supports processes of a mutual cross-learning from the different knowledge modes. Between Mode 1 and Mode 2 manifold creative arrangements and configurations are possible, linking together basic research and problem-solving" (Carayannis and Campbell 2010, p. 57). Mode 3 "encourages interdisciplinary thinking and transdisciplinary application of interdisciplinary knowledge" as well as "allows and emphasizes the co-existence and co-evolution of different knowledge and innovation paradigms" (see Carayannis and Campbell 2010, pp. 51–52).

"**Quadruple Helix**" (see Carayannis and Campbell 2009): The *Quadruple Helix Model* is based on the *Triple Helix Model* and adds as fourth helix the "public," more specifically being defined as the "media-based and culture-based public" and civil society. This "fourth helix associates with 'media,' 'creative industries,' 'culture,' 'values,' 'life styles,' 'art,' and perhaps also the notion of the 'creative class'" (Carayannis and Campbell 2009, pp. 218, 206).

"**Quintuple Helix**" (see Carayannis and Campbell 2010): The *Quintuple Helix Innovation Model* is based on the *Triple Helix Model and Quadruple Helix Model* and adds as fifth helix the "natural environment." "The Quintuple Helix can be proposed as a framework for transdisciplinary (and interdisciplinary)

analysis of sustainable development and social ecology" (Carayannis and Campbell 2010, pp. 51 and 62) (see also later our analysis in Sect. "What is a Quintuple Helix Innovation Model?").

About these six briefly described models can be concluded that in a *knowledge society*, at the national level, a network-style linkage of knowledge is being processed, and each model fulfills a specific contribution for the "creation, diffusion and use of knowledge" (see Carayannis and Campbell 2006 and 2010). In reference to sustainable development, under the aspect of global warming, we should add whether in future a state (nation-state) leading in world politics as well as in the world economy is also being determined by its social (societal) potential to balance new knowledge, know-how, and innovation with nature. Hence, for more detail, we look in the following Sect. "What is a Quintuple Helix Innovation Model?" at the *Quintuple Helix Model*.

What Is a *Quintuple Helix Innovation Model*?

Knowledge in a *Quintuple Helix Model* is the pivotal force and driver for progress. The *Quintuple Helix* is a model, which grasps and specializes on the sum of the social (societal) interactions and the academic exchanges in a state (nation-state) in order to promote and visualize a *"cooperation system"* of knowledge, know-how, and innovation for more sustainable development (see Carayannis and Campbell 2010, p. 62). The specialty of the *Quintuple Helix Model* can thus be described in the following way:

> The Quintuple Helix Model is interdisciplinary and transdisciplinary at the same time: the complexity of the five-helix structure implies that a full analytical understanding of all helices requires the continuous involvement of the whole disciplinary spectrum, ranging from the natural sciences (because of the natural environment) to the social sciences and humanities (because of society, democracy and the economy). (Carayannis and Campbell 2010, p. 62)

Thus, the goal of the *helix conception* is accomplished through the resource of knowledge, which produces additional value for society in order to lead in the field of sustainable development. The pivotal question of the *Quintuple Helix* defines itself in the following way:

> How do knowledge, innovation and the environment (natural environment) relate to each other? (Carayannis and Campbell 2010, p. 42)

The analytical point of origin of the *Quintuple Helix*, as described in Sect. The Challenge of Global Warming and the Resource of Knowledge, is the *"Triple Helix Model"* of Etzkowitz and Leydesdorff (2000) and is the *"Quadruple Helix Model"* of Carayannis and Campbell (2010). The social (societal) cooperation system defines itself based on the model of a *Triple Helix*, which consists of a combination of university (= *education system*), industry (= *economic system*), and government (= *political system*) (see Etzkowitz and Leydesdorff 2000, pp. 111–112). To this combination, the authors (Etzkowitz and Leydesdorff) refer to as "university-industry-government relations," linking together the creation and exchange of knowledge between these three subsystems. Carayannis and Campbell acknowledged the "nonlinear" dynamics within *Triple Helix* and extended this to the *"Quadruple Helix"* (see Carayannis and Campbell 2009, p. 218): The *Triple Helix* is broadened within the *Quadruple Helix* through a *"media-based and culture-based public"* subsystem. The purpose of this extension is to include the public as well as civil society as a fourth subsystem. The *media-based public* supports the diffusion of knowledge in a state (nation-state), but also the *culture-based public* with its values, experience, traditions, and visions promotes knowledge for the knowledge society (Carayannis and Campbell 2009, pp. 217–227). Let us now have a closer look at the *Quintuple Helix Model*. In the year 2010, the authors Carayannis and Campbell developed the *"Quadruple Helix"* further by adding a fifth helix to the modeling of knowledge and innovation, being the *natural environment*. The *"Quadruple Helix"* developed into the *"Quintuple Helix"* (see Fig. 2) (Carayannis and Campbell 2010, p. 62).
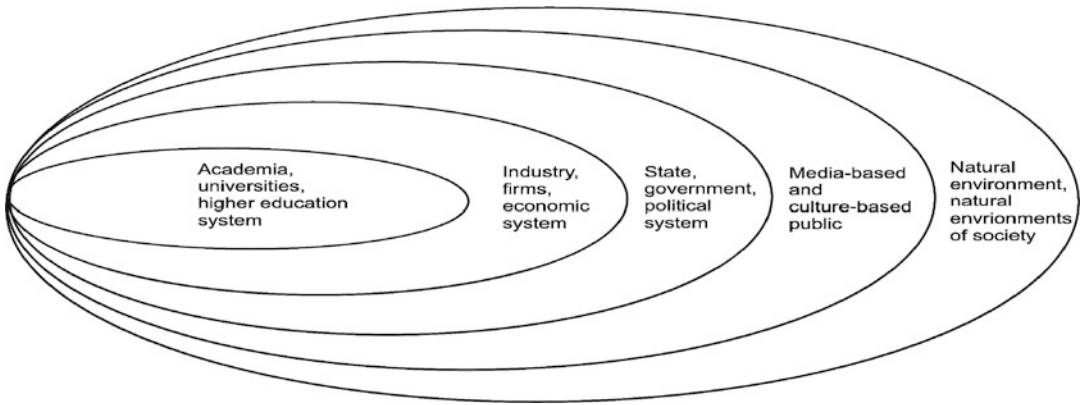
Quintuple Innovation Helix and Global Warming: Challenges and Opportunities for Policy and Practice, Fig. 2 The subsystems of the Quintuple Helix Model (Source: Authors' own conceptualization based on Etzkowitz and Leydesdorff (2000, p. 111) and on Carayannis and Campbell (2009, p. 207, 2010, p. 62))

The goal and interest of the *Quintuple Helix* are to include "*natural environment*" as a new subsystem for knowledge and innovation models, so that "nature" becomes established as a central and equivalent component of and for knowledge production and innovation. The *natural environment* is for the process of knowledge production and the creation of new innovation particularly important because it serves for the preservation, survival, and vitalization of humanity, the making-possible of new green technologies, and humankind, after all, should learn more from nature (especially in times of climate change). With the *helix of natural environment*, "sustainable development" and "social ecology" become constituent for social (societal) innovation and knowledge production (Carayannis and Campbell 2010, pp. 58–62):

> The Quintuple Helix furthermore outlines what sustainable development might mean and imply for 'eco-innovation' and 'eco-entrepreneurship' in the current situation and for our future. (Carayannis and Campbell 2010, pp. 62–63)

The most important constituent element of the *Quintuple Helix* – apart from the active "human agents" – is the resource of "knowledge," which, through a circulation (= *circulation of knowledge*) between social (societal) subsystems, changes to innovation and know-how in a society and for the economy (see Barth 2011a, p. 6). The *Quintuple Helix*, thereby, visualizes the

collective interaction and exchange of "knowledge" in a state (nation-state) by means of the following five subsystems (= *Helices*): (1) *education system*, (2) *economic system*, (3) *natural environment*, (4) *media-based and culture-based public (also civil society)*, (5) and the *political system* (see Carayannis and Campbell 2010, pp. 46–48, 62). To analyze sustainability in a *Quintuple Helix* and to make sustainable development determining for progress therefore means that each of the five described subsystems (*Helices*) has a special and necessary asset at its disposal, with a social (societal) and academic (scientific) relevance for use (see Fig. 3, below; see also Barth 2011a, p. 6 and 2011b, pp. 30–31; Meyer 2008, pp. 89–95; Carayannis 2004, pp. 49–50):

1. The *education system*: The *education system*, as the first subsystem, defines itself in reference to "academia," "universities," "higher education systems," and schools. In this helix, the necessary "human capital" (e.g., students, teachers, scientists/researchers, academic entrepreneurs, etc.) of a state (nation-state) is being formed by diffusion and research of knowledge.

2. The *economic system*: The *economic system*, as the second subsystem, consists of "industry/ industries," "firms," services, and banks. This helix concentrates and focuses the "economic capital" (e.g., entrepreneurship, machines,
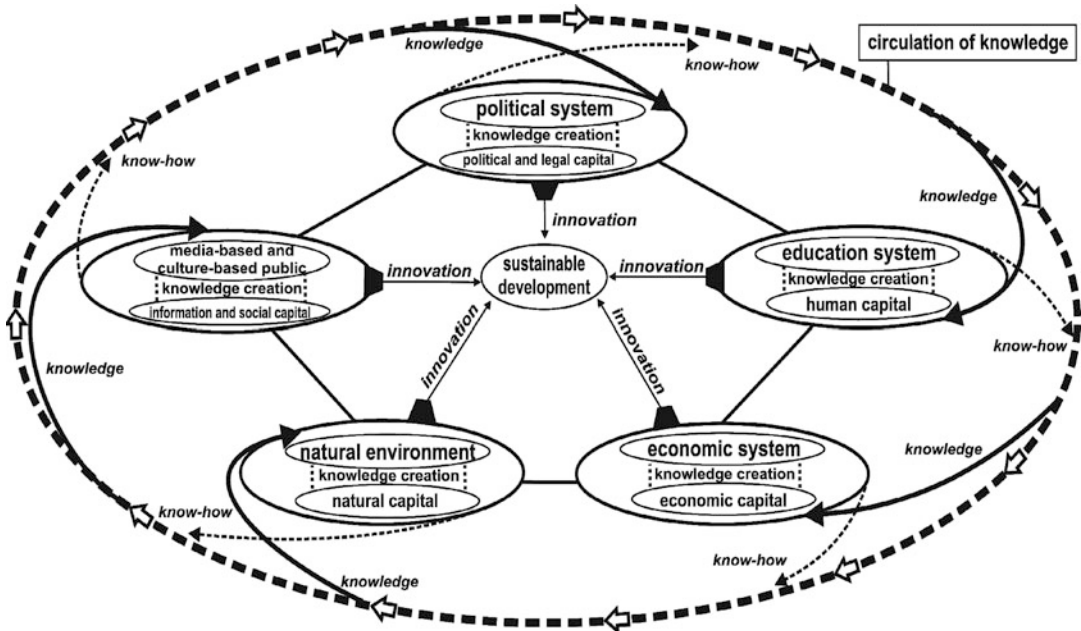
Quintuple Innovation Helix and Global Warming: Challenges and Opportunities for Policy and Practice, Fig. 3 The Quintuple Helix Model and its function (functions) (So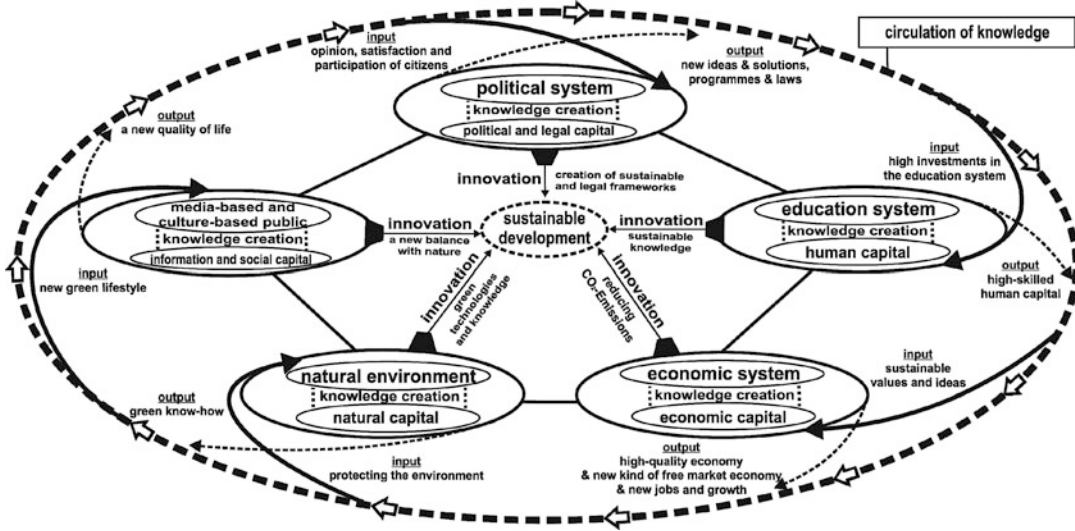urce: Authors' own conceptualization based on Etzkowitz and Leydesdorff (2000), on Carayannis and Campbell (2006, 2009, 2010), and on Barth (2011a))

products, technology, money, etc.) of a state (nation-state).

3. The *natural environment*: The *natural environment* as third subsystem is decisive for a sustainable development and provides people with a "natural capital" (e.g., resources, plants, variety of animals, etc.).

4. The *media-based and culture-based public*: The fourth subsystem, *media-based and culture-based public*, integrates and combines two forms of "capital." On the one hand, this helix has, through the *culture-based public* (e.g., tradition, values, etc.), "social capital." On the other hand, the helix of *media-based public* (e.g., television, Internet, newspapers, etc.) contains also "capital of information" (e.g., news, communication, social networks).

5. The *political system*: The *political system*, as a fifth subsystem, is also of crucial importance because it formulates the "will," where to the state (nation-state) is heading toward in the present and future, thereby also defining,

organizing, as well as administering the general conditions of the state (nation-state). Therefore, this helix has a "political and legal capital" (e.g., ideas, laws, plans, politicians, etc.).

In summary, the *Quintuple Helix Model* can be described in the following way (see Figs. 2 and 3, above): It is a theoretical and practical model for the exchange of the resource of "knowledge," based on "five" social (societal) subsystems with "capital" at its disposal, in order to generate and promote a sustainable development of society (Carayannis and Campbell 2010, pp. 60–62). In this *Cumulative Model of Quintuple Helix*, the resource of "knowledge" moves through a "*circulation of knowledge*" from *subsystem to subsystem* (see Barth 2011a, p. 6). This *circulation of knowledge* from subsystem to subsystem implies that knowledge has qualities of an *input* and *output* of and for subsystems within a state (nation-state) or also between states. If an *input* of knowledge is contributed into one of the five subsystems, then a *knowledge creation* takes place.

Quintuple Innovation Helix and Global Warming: Challenges and Opportunities for Policy and Practice, Fig. 4 Effects of investments in education for sustainability (Source: Authors' own conceptualization)

This *knowledge creation* aligns with an exchange of basic knowledge and produces new inventions or knowledge as *output*. The *output* of *knowledge creation* of a subsystem has therefore two routes (ways): (1) The first route leads to an *output* for the production of innovations for more sustainability in a state (nation-state); (2) the second route leads to an *output* on new know-how back into the *circulation of knowledge*. Through the *circulation of knowledge*, the new *output* of newly created know-how of a subsystem changes into *input* of knowledge for a different subsystem of the *Quintuple Helix* (see Carayannis and Campbell 2010; Barth 2011a). About the *input* and *output* of knowledge, it can be said consequently:

> On the one hand, knowledge serves as an input or resource for advanced societies and economies, which increasingly depend on knowledge. On the other hand, knowledge production (knowledge creation) also generates knowledge as an output, which then is being fed back (recycled) as a knowledge input. (Carayannis and Campbell 2006, p. 4)

Therefore, in a *Quintuple Helix* by and with the means of five *helices*, the exchange of knowledge in a state (nation-state) is being dealt with all its conjunctions, in order to promote knowledge-production-based sustainable development.

The Challenge of Global Warming in a *Quintuple Helix Innovation Model*

This brings us to the main question of our analysis: *How can sustainable development, with regard to "Global Warming," be practiced step-by-step within a Quintuple Helix Model?* As we have seen, the resource of knowledge is the most important "commodity" in a *Quintuple Helix*. The *circulation of* knowledge continually stimulates new knowledge. As a result, all systems in a *Quintuple Helix* influence each other with knowledge, in order to promote sustainability through new, advanced, and pioneering innovations. With the example of a targeted investment into the *education system* of the *Quintuple Helix Model*, we will describe "how" more sustainable development can be considered feasible, in reference to "global warming," for the national level and for positive effects that may arise for society (see Fig. 4, below):

Step 1: When more investments flow into the *helix* of the education system to promote sustainable development under the aspect of global warming, the *Quintuple Helix Model* shows and demonstrates that, as an *input*, investments create new impulses and suggestions for *knowledge creation* in the *education system*.

For example, targeted investments produce new equipment, new places for scientists and teachers, and a higher research opportunity. Therefore, a larger *output* of innovations from science and research can be obtained. At the same time, teaching and training can improve their effectiveness. Particularly, the investment in education should have a positive impact on "human capital" as a manifestation of *output* of the *education system:* because of more resources, teaching and training should be more effective, allowing "human capital" to realize chances and to target uses more directly. The *output* that arises from "human capital" for a greener development or sustainable development is in turn also an *input* in the *helix* of the *economic system.*

Step 2: By means of *input* of new knowledge through "human capital" in the *helix* of the *economic system,* the "value" (*values*) of the *knowledge economy* or of an *advanced knowledge economy* consequently increases. Through the enhancement of knowledge, important further production facilities and development opportunities for a sustainable, future-oriented (future-sensitive) green economy, based on *knowledge creation,* can be stimulated and achieved. Not only that such a *knowledge creation* realizes in the *economic system* new types of jobs, new green products, and new green services, also new and decisive impulses for *"green and greener economic growth"* are possible. In this subsystem, new values (like *corporate social responsibility*) are being demanded, enabling and supporting a new *output* of know-how and innovations by the *economic system.* Thus, in addition, Barth writes:

> The economic capital of know-how is in this context sustainability. Here, the output of economic know-how will be a high-quality and sustainable economy, but in fact, the special know-how which the economic system implies now, is probably a new harmony of human beings with nature. (Barth 2011a, p. 8)

Step 3: This new sustainability as an *output* of the *economic system* will be a new input of knowledge in the *helix* of *natural environment.*

This new knowledge "communicates" to nature that it will be increasingly protected, as lesser exploitation, destruction, contamination, and wastefulness (extravagance) is taking place. The *natural environment* can, thus, regenerate itself and strengthen its "natural capital," and humanity can also learn again and further more from nature (= *knowledge creation*). The goal of this *helix* should be to live in balance with nature, to develop regenerative technologies, and to use the available, finite resources sustainably and in a sensitive approach. Here, particularly natural science disciplines come into play to form new green know-how for humans. This know-how as *output* of the subsystem of the *natural environment* can provide more environmental protection and a superior quality of life to people. Moreover, the development of new environmentally friendly technologies can reduce the CO_2 emissions more effectively and can aid in diminishing climate change. In summary, the following can be explained in context with Barth about the *helix* of *natural environment*: "The output of the natural environment hence is a green know-how" (Barth 2011a, p. 9).

Step 4: The *output* of the *natural environment* is followed by an *input* of new knowledge about nature and a green (greener) lifestyle for the subsystem of *media-based and culture-based public.* In this *helix,* it is of crucial importance to communicate and to live a green lifestyle. Here, the *media-based public* receives a new and crucial function (= *"information capital"*), which is spreading through the media the information about a new green consciousness and the new human lifestyle. This capital should provide incentives, how a green lifestyle can be implemented in a simple, affordable, and conscious way (= *knowledge creation*). This *knowledge creation* promotes the necessary "social capital" of the *culture-based public,* on which a society depends for sustainable development. This "social capital," therefore, must pass on information about wishes, needs, problems, or satisfaction of citizens as *output* into politics or the *political system.* The know-how *output* of the

media-based and culture-based public serves thereby as new *input* for the *helix* of the *political system*.

Step 5: The *input* of knowledge into the *political system* is the know-how from the *media-based and culture-based public* and represents also the collective knowledge from the three other subsystems of society. The important discussions on this new knowledge in the political systems are necessary impulses for *knowledge creation*. The goal of this *knowledge creation* is a "political and legal capital," which makes the *Quintuple Helix* more effective, more high quality, and more sustainable. Consequently, the newly obtained know-how is an *output* of suggestions, sustainable investments and objectives. The new *output* of knowledge and know-how of the *political system* leads across the *circulation of knowledge* back again into the *education system, economic system, natural environment*, and *media-based and culture-based public*.

Conclusion and Future Directions

In summary, as we illustrated by the example of the discussion in Sect. "The Challenge of Global Warming in a Quintuple Helix Innovation Model" ("five-step flow analysis"), it should be clear that all systems in a *Quintuple Helix* perform a pivotal function, influencing each other. If more sustainable development is being considered (and demanded) on a national level, as a result of "global warming," and if, for instance, more targeted investments in a specific *Helix* of the *Quintuple Helix* start flowing, then there will be a positive impact on all other subsystems and on the society as a whole. The *Quintuple Helix Innovation Model* demonstrates that an investment in knowledge and a promotion of knowledge production brings into play new and crucial impulses for innovation, know-how, and the advancement of society. By initiating small steps toward sustainability, *long-term and leading knowledge societies* can emerge, which will live in balance with nature and ultimately, perhaps, lead to a *"green economic wonder."*

To conclude, the *Quintuple Helix Innovation Model* makes it clear that the implementation of thought and action in sustainability will have a positive impact on society as a whole. The new quality management for more sustainability lies therefore in the creation of new knowledge, know-how, and innovation in balance with nature (see Carayannis and Campbell 2010, pp. 58–62). One chief objective of the *Quintuple Helix* is to enhance *"value in society"* through the resource of knowledge. The discussion about the *Quintuple Helix Model* indicates that striving for the promotion of knowledge as a "knowledge nugget" should be regarded as being essential (see Carayannis and Formica 2006, p. 152): This means that knowledge is the key to and for more sustainability and to a new quality of life. Today, knowledge is the "most fundamental resource" (Lundvall 1992, p. 1). Nevertheless, whether a state (nation-state, beyond nation-state) is leading in different fields in the future will be primarily, if not even solely, be decided by its potential to develop new knowledge, know-how, and innovation in balance with nature. However, the improved exchange of knowledge and the striving for knowledge, new know-how, and innovations through the *Quintuple Helix Model* can be or at least offer a solution for the challenges of sustainable development under the aspect of "global warming" in the twenty-first century.

Cross-References

▶ Academic Firm
▶ Mode 1, Mode 2, and Innovation
▶ Mode 3
▶ Quadruple Helix
▶ Quality of Democracy and Innovation
▶ Triple Helics

References

Barbier EB. Rethinking the economic recovery: a global green new deal, United Nations Environment Program (UNEP); 2009. http://www.unep.org/greeneconomy/portals/30/docs/GGND-Report-April2009.pdf

Barth TD. Konzeption, messung und rating der demokratiequalität. Brasilien, südafrika, australien und die russische föderation 1997–2006. Saarbrücken: VDM-Verlag Dr. Müller; 2010.

Barth TD. The idea of a green new deal in a quintuple helix model of knowledge, know-how and innovation. International Journal of Social Ecology and Sustainable Development. 2011a;1(2):1–14.

Barth TD. Freiheit, Gleichheit, Demokratiequalität: Zur Qualitätsmessung in den Top 20 Demokratien des Democracy Rankings [Freedom, equality and the quality of democracy: measuring quality in the Top 20 democracies of the democracy ranking] [Dissertation (Doctoral Thesis)]. Vienna: University of Viennal; 2011b.

Barth TD. Die 20 besten demokratien der welt. Freiheit – gleichheit – demokratiequalität auf einen blick. Norderstedt: Books on Demand Verlag; 2011c.

Bhaskar R. Context of interdisciplinarity: interdisciplinarity and climate change. In: Bhasakar R, Frank C, Høyer KG, Næss P, Parker J, editors. Interdisciplinarity and climate change: transforming knowledge and practice for our global future. New York: Routledge; 2010. p. 1–24.

Biegelbauer P. Learning from abroad: the Austrian competence centre programme Kplus. Science and Policy. 2007a;34(9):606–18.

Biegelbauer P. Ein neuer blick auf politisches handeln: politik-lernansätze im vergleich. Österreichische Zeitschrift für Politikwissenschaft (ÖZP). 2007b;36(3):231–47.

Campbell DFJ. The university/business research networks in science and technology: knowledge production trends in the United States, European Union and Japan. In: Carayannis EG, Campbell DFJ, editors. Knowledge creation, diffusion, and use in innovation networks and knowledge clusters. A comparative systems approach across the United States, Europe and Asia. Westport, CT: Praeger; 2006. p. 67–100.

Campbell DFJ. Wie links Oder wie rechts Sind österreichs länder? eine komparative langzeitanalyse des parlamentarischen mehrebenensystems österreichs (1945–2007). SWS-Rundschau. 2007;47(4):381–404.

Campbell DFJ. The basic concept for the democracy ranking of the quality of democracy. Vienna: Democracy Ranking; 2008. http://www.democracyranking.org/downloads/basic_concept_democracy_ranking_2008_A4.pdf. Accessed 20 Oct 2011.

Campbell DFJ, Barth TD. Wie können demokratie und demokratiequalität gemessen werden? modelle, demokratie-indices und länderbeispiele im globalen vergleich. SWS-Rundschau. 2009;49(2):208–33.

Campbell DFJ, Güttel WH. Knowledge production of firms: research networks and the — scientification of business R&D. International Journal of Technology Management. 2005;31(1/2):152–75.

Campbell DFJ, Schaller C, editors. Demokratiequalität in österreich – zustand und entwicklungsperspektiven. Opladen: Leske + Budrich; 2002.

Campbell DFJ, Pölzlbauer P, Barth TD. Das "democracy ranking 2010 of the quality of democracy" – erstveröffentlichung (German). Vienna, Austria: Democracy Ranking; 2010. http://www.democracyranking.org/downloads/Democracy_Ranking_Concept_Earlyrelease_German_2010.pdf.

Carayannis EG. Measuring intangibles: managing intangibles for tangible outcomes in research and innovation. International Journal of Nuclear Knowledge Management. 2004;1(1/2):49–67.

Carayannis EG, editor. Planet earth 2011 – global warming challenges and opportunities for policy and practice. Rijeka: Open Access Publisher; 2011. http://www.intechopen.com/books/show/title/planet-earth-2011-global-warming-challenges-and-opportunities-for-policy-and-practice.

Carayannis EG, Alexander JM. Global and local knowledge. Glocal transatlantic public-private partnerships for research and technological development. Houndmills: Palgrave MacMillan; 2006.

Carayannis EG, Campbell DFJ. "Mode 3": meaning and implications from a knowledge systems perspective. In: Carayannis EG, Campbell DFJ, editors. Knowledge creation, diffusion, and use in innovation networks and knowledge clusters. A comparative systems approach across the United States, Europe and Asia. Westport, CT: Praeger; 2006. p. 1–25.

Carayannis EG, Campbell DFJ. "Mode 3" and "quadruple helix": toward a 21st century fractal innovation ecosystem. International Journal of Technology Management. 2009;46(3/4):201–34.

Carayannis EG, Campbell DFJ. Triple helix, quadruple helix and quintuple helix and how do knowledge, innovation and the environment relate to each other? a proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. International Journal of Social Ecology and Sustainable Development. 2010;1(1):41–69.

Carayannis EG, Campbell DFJ. Open innovation diplomacy and a 21st century fractal research, education and innovation (FREIE) ecosystem: building on the quadruple and quintuple helix innovation concepts and the "mode 3" knowledge production system. Journal of the Knowledge Economy. 2011;2(3):327–72. http://www.springerlink.com/content/d1lr223321305579/.

Carayannis E, Formica P. Intellectual venture capitalists: an emerging breed of knowledge entrepreneurs – viewpoint. Industry and Higher Education. 2006;20(3):151–6.

Carayannis EG, Kaloudis A. 21st century democratic capitalism: a time for action and a time to lead. International Journal of Social Ecology and Sustainable Development. 2010;1(1):1–13.

Carayannis EG, Zedtwitz Mv. Architecting GloCal (Global – Local), real-virtual incubator networks (G-RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies. Technovation. 2005;25:95–110.

Diamond L, Morlino L. Introduction. In: Diamond L, Morlino L, editors. Assessing the quality of democracy. Baltimore: The John Hopkins University Press; 2005. p. ix–xliii.

Dubina IN. Управление творчеством персонала в условиях инновационной экономики [Creativity management in the innovation economy]. Moscow: Academia; 2009.

Dubina IN, Carayannis EG, Campbell DFJ. Creativity economy and a crisis of the economy? Coevolution of knowledge, innovation, and creativity, and of the knowledge economy and knowledge society. Journal of the Knowledge Economy. 2012;3(1):1–24. http://www.springerlink.com/content/t5j8l12136h526h5/.

Etzkowitz H, Leydesdorff L. The dynamics of innovation: from national systems and "mode 2" to a triple helix of university-industry-government relations. Research Policy. 2000;29:109–23.

Friedman TL. Hot, flat and crowded: why we need a green revolution – and how we can renew our global future. London: Penguin; 2008.

Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott P, Trow M. The new production of knowledge. The dynamics of science and research in contemporary societies. London: Sage; 1994.

Giddens A. The politics of climate change. Cambridge/Malden: Polity Press; 2009.

Green New Deal Group. A green new deal: joined-up policies to solve the triple crunch of the credit crisis, climate change and high oil prices – The first report of the Green New Deal Group, London: New Economic Foundation; 2008. http://www.neweconomics.org/sites/neweconomics.org/files/A_Green_New_Deal_1.pdf

Höll O, et al. Entwicklungspolitik. In: Dachs H, editor. Politik in Österreich. Das Handbuch. Vienna: MANZ'sche Verlags- und Universitätsbuchhandlung; 2006. p. 884–904.

Høyer KG. Seven theses on CO_2 reductionism and its interdisciplinary counteraction. In: Bhasakar R, Frank C, Høyer KG, Næss P, Parker J, editors. Interdisciplinarity and climate change: transforming knowledge and practice for our global future. New York: Routledge; 2010a. p. 35–53.

Høyer KG. Technological idealism: the case of the thorium fuel cycle. In: Bhasakar R, Frank C, Høyer KG, Næss P, Parker J, editors. Interdisciplinarity and climate change: transforming knowledge and practice for our global future. New York: Routledge; 2010b. p. 164–82.

Hufbauer GC, Charnovitz S, Kim J. Global warming and the world trading system. Person Institute for International Economics: Washington DC; 2009.

IPCC. Climate change 2007: the physical science basis. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL, editors. The fourth assessment report of the intergovernmental panel on climate change. Cambridge, United Kingdom and New York, USA: Cambridge University Press; 2007a.

IPCC. Climate change 2007: the physical science basis – errata for the working group – fourth assessment report; 2007b. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf

Kreisky E, Löffler M. Demokratietheorieentwicklung im Kontext gesellschaftlicher Paradigmen. Österreichische Zeitschrift für Politikwissenschaft. 2010;39(1):89–104.

Kuhlmann S. Future governance of innovation policy in Europe – three scenarios. Research Policy. 2001;30: 953–76.

Le Monde diplomatique, editor. Atlas der globalisierung – sehen und verstehen, was die welt bewegt. Paris/Berlin: Le Monde diplomatique/taz; 2009.

Lundvall B-Å, editor. National systems of innovation. Towards a theory of innovation and interactive learning. London: Pinter Publishers; 1992.

Meyer B. Wie muss die Wirtschaft umgebaut werden? Perspektiven nachhaltiger Entwicklung, Lizenzausgabe für die Bundeszentrale für politische Bildung. Frankfurt am Main/Bonn: Fischer Taschenbuch Verlag; 2008.

Müller M, Niebert K. Epochenwechsel – Plädoyer für einen grünen New Deal. Munich: Oekom Verlag; 2009.

Nowotny H, Scott P, Gibbons M. Mode 2 revisited: the New production of knowledge. Minerva. 2003;41:179–94.

O'Donnell G. Human development, human rights, and democracy. In: O'Donnell G, Cullell JV, Iazzetta OM, editors. The quality of democracy. Theory and applications. Notre Dame, Indiana: University of Notre Dame Press; 2004. p. 9–92.

OECD. OECD-factbook 2009 – economic, environmental and social statistics – special focus: inequality. Paris: OECD Publishing; 2009.

OECD. OECD-factbook 2010 – economic, environmental and social statistics – special focus: the crisis and beyond. Paris: OECD Publishing; 2010.

Otzelberger A. Gender-responsive strategies on climate change: recent progress and ways forward for donors. BRIDGE: development – gender. Brighton: Institute of Development Studies; 2011. http://www.bridge.ids.ac.uk/vfile/upload/4/document/1107/Gender%20responsive%20strategies%20on%20climate%20change_progress%20and%20ways%20forward%20for%20donors.pdf.

Parker J. Towards a dialectics of knowledge and care in the global system. In: Bhasakar R, Frank C, Høyer KG, Næss P, Parker J, editors. Interdisciplinarity and climate change: transforming knowledge and practice for our global future. New York: Routledge; 2010. p. 205–26.

Rommetveit K, Funtowicz S, Strand R. Knowledge, democracy and action in response to climate change. In: Bhasakar R, Frank C, Høyer KG, Næss P, Parker J, editors. Interdisciplinarity and climate change: transforming knowledge and practice for our global future. New York: Routledge; 2010. p. 149–63.

Schumpeter JA. Capitalism, socialism and democracy. New York: Harper Perennial; 1976.

Sen A. Ökonomie für den menschen – wege zur gerechtigkeit und solidarität in der marktwirtschaft; Aus dem englischen von C. Goldmann. 4th ed. Munich: Deutscher Taschenbuch Verlag; 2007.

Stern N. The global deal – climate change and the creation of a new era of progress and prosperity. New York: Public Affairs; 2009.

Tilly C. Democracy. New York: Cambridge University Press; 2007.

Ulram PA. Politische Kultur der Bevölkerung. In: Dachs H et al., editors. Politik in Österreich. Das Handbuch. Vienna: MANZ'sche Verlags- und Universitätsbuchhandlung; 2006. p. 513–24.

UNDP. Human development report 2007/2008. Fighting climate change: Human solidarity in a divided World. New York: United Nations Development Program; 2007. http://hdr.undp.org/en/reports/global/hdr2007-2008

UNDP. Human development report 2010 (20th anniversary edition) – The real wealth of nations: pathways to human development. New York: United Nations Development Program; 2010. http://hdr.undp.org/en/media/HDR_2010_EN_Complete_reprint.pdf

UNDP. Human development report 2011 – sustainability and equity: a better future for all. New York: United Nations Development Program; 2011. http://hdr.undp.org/en/reports/global/hdr2011/

UNEP. Green jobs: towards decent work in sustainable, low-carbon world, Washington/New York: United Nations Environment Program; 2008. http://www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf 2011

United Nations. Report of the World commission on environment and development (42/187). New York: United Nations; 1987a. http://www.un-documents.net/a42r187.htm

United Nations. Report of the World commission on environment and development: "Our common future." New York: United Nations; 1987b. http://worldinbalance.net/pdf/1987-brundtland.pdf