

# Extension of the Triple Helix to Quadruple to Quintuple Helix Model

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Science speaks to society, and society speaks back to science (Nowotny, Scott, & Gibbons 2001; Liyanage & Netswera, 2021)

## **Abstract**

*This study explores the multiple helices extended from the Triple Helix (TH) Model of innovation. Describing what Triple Helix, Quadruple Helix and Quintuple Helix Model as well as Mode3 is the primary motive of this paper. This study is solely based on secondary sources and the research is exploratory as well as descriptive in its nature. Originally proposed by Henry Etzkowitz and Loet Leydesdorff (1995), the TH Model elucidated innovation dynamics stemming from interactions among academia, industry, and government. Building upon this foundation, the Quadruple Helix Model was introduced as the fourth helix, emphasizing basically on the role of civil society in innovation processes, thus highlighting aspects of social inclusion, public engagement, and ethical considerations. Likewise, the Quintuple Helix*

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*Model incorporates socio-ecological interactions, emphasizing the generation and dissemination of knowledge impacting the natural environment. This framework basically depicts opportunities for addressing new challenges such as climate change through innovation for sustainable development within the knowledge society and economy. Similarly, exploring the implications of Mode 1, Mode 2, and Mode 3 knowledge on economy, society and democracy, this study also attempts to investigate the evolution of innovation helix models and their impact on fostering inclusive, collaborative, and sustainable innovation ecosystems. In course of studying the model of innovation system, there come simple question about how the Triple Helix Model of innovation has been extended up to Quintuple Helix via Quadruple Helix Model of innovation. This is a policy-based research which will help to the stakeholders like academics, planners, researchers, industry leaders, entrepreneurs, and governing bodies for understanding Triple Helix, Quadruple Helix and Quintuple Helix model in better way.*

## **Introduction**

The Triple Helix (TH) Model emphasizes the symbiotic relationship between academia, industry and government in knowledge production which has become integral to driving innovation and significant progress globally. Academia serves as the foundation for knowledge creation and industry applies this knowledge to innovate new products and technologies. Likewise, government provides support, funding and regulations that help to facilitate these interactions and ensure sustainability. Understanding the importance of this global model which is based on partnership and knowledge exchange, it enables stakeholders to overcome the challenges and to ensure economic and social development (Hattangadi, 2022). For the sustainability of academia, industry, science, technology, innovation, entrepreneurship, economy, society, culture, media, etc., there has been invention and extension of helices by different renowned scholars of different disciplines since 1995. Hence, this study is gradually becoming popular in different parts of the world and its adoption by both developed and developing countries underscores its universal acceptance and applicability in shaping the future of knowledge production and collaboration.

Open innovation makes it easier for companies to cross their boundaries so that the creation of knowledge benefits both the organization itself and the ecosystem at the

same time. The current social interaction has taken on the following characteristics: Technologies such as big data, cloud computing, and AI have brought endless treasures of data and information. Knowledge, information, and data have become increasingly difficult to distinguish. At the same time, the problem of information overload has begun to emerge. The combination of the Internet, social media, and mobile technology has brought about a “Hyperlinked” world, in which everybody participates in others’ lives (Chen, 2022, p.6).

Today’s new challenges faced by human beings are climate change, globalization and economic crises on different geographical scales, from the regional and national to the supranational level. Environmental problems are becoming more complex, uncertain and multiscalar, affecting a variety of actors and agencies, demanding new technical solutions, societal transformation and new collaborations. A transformation into a more sustainable society calls for a larger transition of societal functions, including new innovations in technology, regulations, production and consumer patterns, values and norms and supply networks (Geels, 2005; in Grundel & Dahlström, 2016). It also requires a variety of knowledge and values in decision-making processes. Therefore, innovation, technology and knowledge have become an integral part of this study. Innovation policy is mainly driven by economic growth and economic development agendas, where new innovations are seen as drivers of economic growth and development. In this way, innovation policy is used as an important tool for governmental institutions to enhance and support innovations on different geographical scales to promote economic growth (Asheim & Coenen, 2005; Pettersson, 2007; Lindberg 2010; in Grundel & Dahlström, 2016).

The Industrial Revolution, spanning from the late 17th century to the early 19th century, marked a profound transformation in human society. This period of rapid industrialization laid the groundwork for the collaborative structures and systems that are prevalent in today's societies. The First Industrial Revolution (1760 to around 1840 as mentioned by Davis, 2016 & Schwab, 2016) is widely taken to be the shift from our reliance on animals, human effort and biomass as primary sources of energy to the use of fossil fuels and the mechanical power this enabled. The Second Industrial Revolution (1870) occurred between the end of the 19th century and the first two decades of the 20th century, and brought major breakthroughs in the form of electricity distribution, both wireless and wired communication, the

synthesis of ammonia and new forms of power generation. The Third Industrial Revolution (1969) began in the 1950s with the development of digital systems, communication and rapid advances in computing power, which have enabled new ways of generating, processing and sharing information (Davis, 2016; Schwab, 2016). In Germany there are discussions about “Industry 4.0”, a term coined at the Hannover Fair in 2011 to describe how this will revolutionized the organization of global value chains. This is the reason why Massachusetts Institutes of Technology (MIT) Professors Erik Brynjolfsson and Andrew McAfee have famously referred to this period as “the second machine age”(Schwab, 2016). The Fourth Industrial Revolution (2013) (Zhou, Liu & Zhou, 2015; Schwab, 2016) can be described as the advent of “cyber-physical systems” which is a digital revolution of this century involving entirely new capabilities for people and machines. While these capabilities are reliant on the technologies and infrastructure of the Third Industrial Revolution, the Fourth Industrial Revolution represents entirely new ways in which technology becomes embedded within societies and even our human bodies. Examples include genome editing, new forms of machine intelligence (mobile internet and artificial intelligence and machine learning) breakthrough materials and approaches to governance that rely on cryptographic methods such as the block chain.

When it comes to academic revolution, the “ivory tower” (first academic revolution) (Etzkowitz & Viale, 2010) is no longer a viable academic structure. Cracks in the framework of academic isolation have appeared in part due to the very success of a university research enterprise that has produced a cornucopia of results, many of which have been successfully translated into use. Not surprisingly, the benefits produced have led to increased interest on the part of government and industry in closer ties to the university (Etzkowitz et al., 1998, Foreword).

Universities produce knowledge and knowledge is indeed a key resource for companies. But the implementation and the consequences of strategies aimed to create, appropriate, protect and use knowledge, go far beyond their boundaries (Laperche, 2024). Knowledge is an ‘intellectual product’ or ‘something learned’ that is acquired by thinking, judging, reasoning, reading, observing, and testing (Demir et al., 2015). Innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes, efficiency, effectiveness or quality (Mulgary & Albury,

2003).

Before the concept of the Triple Helix Model of innovation, the scholars have discussed on the concept of ‘knowledge flow’. Knowledge flow as per Etzkowitz et al. (1998) is a contrasting model based on separation and the Triple Helix based on integration of institutional spheres (academia, industry and government collaboration) (Hessels & Lente, 2008). Knowledge flows indicate that universities produce knowledge which is transmitted through publication and ideally do not sell it. Linkages between the spheres and flows of knowledge across them are shaped, both organizationally and ideologically (Etzkowitz et al., 1998). Knowledge flows are a key element of university industry relations; some suggest it should be only the dimension! (Etzkowitz & Leydesdorff, 1997; in Etzkowitz et al., 1998). In essence, the evolution from the Single Helix to the Double Helix and finally to the TH Model reflects a deeper understanding of the complexities of innovation ecosystems and the necessity of multi-stakeholder collaboration for sustainable progress and growth (Hessels & Lente, 2008).

The approaches of the Quadruple Helix and Quintuple Helix innovation systems are designed to comprehend already and to refer to an extended complexity in knowledge production and knowledge application (innovation); thus, the analytical architecture of these models are broader conceptualized (Carayannis & Campbell, 2021). To use metaphoric terms, the Quadruple Helix transcends the Triple Helix, while the Quintuple Helix embeds and conceptualizes the Quadruple Helix. This study includes introduction, methodology and focuses majorly on Triple Helix, Quadruple Helix, Quintuple Helix, N-tuple Helices, Mode 3, transformation of science systems, knowledge economy, knowledge society, knowledge democracy, diplomacy, artificial intelligence, green knowledge and Greening University which are interrelated to each other representing their own values in this study.

### **Research Methodology**

As there are five helices, the Triple Helix Model has been recognized as one of the most important models; however, Quadruple and Quintuple Helix have authenticated the Triple Helix Model as a global model. While understanding this model, the research methodology adopted in this study is desktop research that includes reviews, critiques and analysis of literature based topics. Desktop research

involves research on existing literature to create new knowledge and insight on the relevant study (Toracco, 2016; Moodley & Naidoo, 2022, p.1044; in Kunwar & Ulak, 2023, p.5). Qualitative research methodology has become the key in this study.

In organized research, it is found that the researchers go through international data sources. For example, Mineiro and Castro (2021) searched articles in international and national bases, such as the main collection of the databases Web of Science (WOS), Scopus, Academic Search Premier–ASP (EBSCO), Science Direct, Scielo and Spell. They used “Quintuple\_Helix” or “Quadruple\_Helix” or “N-tuple Helix” or “Multiple\_Helix” and “Science\_Park” or “Technology\_Park” or “Research\_Park” or “Science\_and\_Technology\_Park” or “Science Technology Park” or “Incubator,” in the topic field; that is, they searched these words in the articles’ title, abstract and keywords. And such approach will make the study more valid. In this study, the present authors adopted narrative review which is unsystematic review in nature and has no specified search strategy, no specific protocol as such; only a topic of interest has been reviewed. Therefore, this is a simple review article that tries to explore how the Triple Helix Model has been extended to the Quadruple to the Quintuple Helix. This study is not commercial project and the authors decided to work on their own to understand these helices theories in better way.

### **Triple Helix Model**

Henry Etzkowitz and Loet Leydesdorff (1995, 1998, 2000) pioneered the TH Model in the 1990s. Their work, spanning from 1995 to 2000, focused on the interactions among university, industry, and government, elucidating the dynamics of their relationships. Over time, this theory has evolved into a significant area of research interest, as highlighted by Hattangadi (2022). Vladoš and Chatzinikolaou (2019) outlined the development of the TH Model into three distinct phases based on its publications: the phase of theoretical foundation (1995-2000), the phase of conceptual expansion (2001-2010) where all different helices were conceptualized, and the phase of recent developments and systematic implementation attempts (2011-2018). The TH Model, as described by Etzkowitz (2003; in Bouraoui et al., 2011) represents a spiral model of innovation that includes multiple reciprocal relationships throughout the process of knowledge capitalization. The model

consists of three dimensions. The first dimension of the TH Model is the internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances. The second is the influence of one helix upon another. The third dimension is the creation of a new overlay of trilateral networks and organizations from the interaction among the three helices Etzkowitz, (2002; in Bouraoui et al., 2011). Though Henry Etzkowitz, Loet Leydesdorff, Elias Carayannis and David Campbell are founding fathers of the Triple Helix Model and they are theoretically separated arguing their own perspectives as shown in table 1.

**Table 1**

*Different Understandings of the Helix Concept by the Originators of Helix Models of Innovation*

<b>Originators of helix models</b>	<b>Perspectives</b>	<b>Understandings of helices</b>
Henry Etzkowitz	Neo-institutional	The Triple Helix model is composed of the Triple Helix spheres of university, industry, government, which are parallel to the Triple Helix spaces of knowledge, innovation and consensus (Etzkowitz & Zhou 2017; Etzkowitz, 2008).
Loet Leydesdorff	Neo-evolutionary	The Triple Helix is perceived as three functions—namely, wealth creation, knowledge production, and normative control. The three helices also operate as selection mechanisms asymmetrically on one another, but mutual selections may shape a trajectory as in a co-evolution' (Leydesdorff, 2012, p.28).
Elias Carayannis & David Campbell	Eco-systemic	The government, university, industry and civil society represent four basic dimensions of a Quadruple Helix innovation system (Carayannis et al., 2018). However, the fourth helix, broadly understood as media-based and culture-based public or civil society, contextualize the Triple Helix (Carayannis & Campbell, 2021).

*Source:* Cai & Lattu, 2022, p.268

In recent times, policymakers have started exploring ways to expand the original Triple Helix Model by integrating the Quadruple Helix (QH) framework. Carayannis and Campbell (2021) expanded the TH Model to include the Quadruple Helix innovation system in 2009 and the Quintuple Helix innovation system in 2010. Despite the popularity of the Triple Helix Model and Quadruple Helix Model in innovation studies, Cai and Lattu (2022, p.257) note that the relations between them have not been extensively addressed.

### **Quadruple Helix Model**

In the year 2003, Leydesdorff and Etzkowitz discussed the possible option of adding fourth helix to the Triple Helix Model (Carayannis & Campbell, 2021). Carayannis and Campbell (2012) conceptualize the fourth helix as media, culture, and civil society (Mineiro & Castro, 2021), arguing that the fourth helix is human-centered and focuses on democratic knowledge, and in favor of arts, artistic research, and arts-based innovation (Carayannis & Campbell, 2014; in Hasche, Höglund, & Linton, 2020, p.524). In this regard, Carayannis and Campbell (2010) further argue that fourth helix the “public”, more precisely defined as the “media-based and culture-based public”: “The fourth helix associates with ‘media’, ‘creative industries’, ‘culture’, ‘values’, ‘lifestyles’, and perhaps also the notion of the ‘creative class’ (a term, coined by Richard Florida, 2004; in Carayannis & Campbell, 2010), “civil society,” “arts, artistic research and arts-based innovation,” but also “democracy and knowledge democracy” (Carayannis & Campbell, 2009, 2012; Carayannis et al., 2012; Carayannis et al., 2018a, 2018b; Bast, Carayannis & Campbell, 2015, 2019; Danilda et al., 2009; Park, 2014; in Carayannis & Campbell, 2021, p.2086). The transition from the Triple Helix to the Quadruple Helix Model was motivated by the incorporation of an additional actor, the public environment, which provided a new perspective on societal behavior through the concept of media-based democracy (Carayannis & Campbell, 2009). This inclusion emphasizes the importance of pluralism and diversity among various agents within the innovation ecosystem, such as universities, small and medium-sized enterprises, major corporations, consumers, NGOs, and the community (Carayannis & Campbell, 2009; Carayannis, Barth, & Campbell, 2012).

In this helix, civil society is also an innovative user (Cai & Lattu, 2022), acting as



a driver of innovation processes. In this sense, users are essential to the model and encourage the development of innovations that are relevant to them (Arnkil et al., 2010; Carayannis & Rakhmatullin, 2014; Mineiro & Castro, 2021, p.294). Arnkil et al. (2010; in Mineiro & Castro, 2021) observe four different types of approaches to the Quadruple Helix:

- (1) Innovation user (consumer who assists companies in developing and improving products and services);
- (2) Laboratory centered on the company (company owns the innovation process, but society or users participate in the new knowledge);
- (3) Laboratory centered on the public sector (public institutions develop the innovation processes, to produce better services to society); and
- (4) Citizen (community or society with an essential role in the beginning of the innovation process).

While reviewing the above mentioned approaches, Mineiro and Castro (2021, p.294) incorporated distinct entities of society with different studies carried out by different scholars such as financial organizations, citizens and workers (Grundel & Dahlström, 2016), non-governmental organizations or associations (Grundel & Dahlström, 2016), groups (Mineiro, Castro, & Amaral, 2019; in Mineiro & Castro, 2021) or an arena with multiple actors (Hasche et al., 2019; in Mineiro & Castro, 2021).

### **Quintuple Helix**

The Quintuple Helix innovation model (QHIM) consists of five spiral frameworks that are the education system, economic system, political system, civil society, and the natural environment. QHIM suggests that the constant engagement of the entire disciplinary spectrum is necessary for a thorough analytical comprehension of all spirals. Each helix represents a knowledge subsystem that connects to the other systems in a spiral fashion and, in turn, has a local, regional, and global impact (Lavrinenko, Ignatjeva, Ohotina, Rybajkin, & Lazdans, 2019; Barcellos-Paula, De la Vega, Gil-Lafuente, 2021; in Quacoe, Kong, & Quacoe, 2023). Therefore, The QHIM can be described as theoretical and practical model for the exchange of knowledge resources, based on the five social (societal) subsystems with capital at its disposal to generate and promote sustainable development of society- it is a

pivoted force and driver for progress (Grundel & Dahlström, 2016; Carayannis et al., 2012; in Quacoe et al., 2023, p.3).

In order to know about disciplinarity, first and foremost, it would be convenience for the researcher to understand what discipline is. Choi and Pak (2006) on the basis of English dictionaries define “discipline” as a branch of knowledge, instruction, learning, teaching or education; or a field of study or activity. Examples of a discipline include anthropology, architecture, biology, economics, engineering, history, science, and theology. The Quintuple Helix Model is transdisciplinary and interdisciplinary at the same time: the complexity of the five-helix structure namely the education system, the economic system, the natural environment, the media- and culture-based public and the political system (Carayannis, et al., 2012) 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).

Transdisciplinary, first coined in 1970s, orientations in research, education and institutions try to overcome the mismatch between knowledge production in academia, on the one hand, and knowledge request for solving societal problems, on the other. Gibbons et al.(1994, p.168) explain mode 2 knowledge in terms of transdisciplinarity- that is 'knowledge which emerges from a particular context of application with its own distinct theoretical structures, research methods and modes of practice but which may not be locatable on the prevailing disciplinary map'. However, it is proposed to use the term 'extradisciplinarity' to describe mode 2 knowledge production. This is because the term transdisciplinarity meaning 'across the disciplines') is easily confused with interdisciplinarity. Mode 2 knowledge is, however, being introduced outside the disciplinary framework, hence the term 'is seen extradisciplinarity' as being more appropriate (see in Kunwar, 2018). Transdisciplinary research, therefore, aims at identifying, structuring, analyzing and handling issues in problem fields with the aspiration '(a) to grasp the relevant complexity of the problem, (b) to take into account the diversity of live, world and scientific perception of problems, (c) to link abstract and case-specific knowledge, and (d) develop knowledge and practices that promote what is perceived to be the common good' (Pohl & Hirsch Hadorn, 2007; in Hoffmann-Riem, Biber-Klemm,

Gossenbacher-Mansuy, Hirsch Hadorn, Joye, Pohl, Weismann, & Zemp, 2008, p.4). Transdisciplinary research occurs when researchers collaborate with stakeholders from outside the academic world. Knowledge from outside the academic world as well as stakeholder values is integrated with academic knowledge. Together, these insights determine what problem is studied and how this is done, and which interventions are selected to address the problems (Pohl, 2010). As far as transdisciplinarity is concerned, the contested meaning of transdisciplinarity is relatively ironic for a community of scholars who sees the openness to other viewpoints as the fundamental prerequisite for doing transdisciplinarity (Giri, 2002; Loibl, 2006; Stokols, 2006; Pohl & Hirsch Hardon, 2007; in Pohl, 2010). “You might think: \ That is no problem for me; I am open to other viewpoints; I tolerate them” (Pohl, 2010). In study of Quintuple Helix Model as mentioned above, interdisciplinary research has been focused significantly. Interdisciplinary research is a research in which relevant concepts, theories, and/or methodologies from different academic disciplines, as well as the results or insights these disciplines generate, are integrated (Pohl, 2010). Aboelela et al. (2007) capture the essence of the generally accepted meaning: “Interdisciplinary research is any study or group of studies undertaken by scholars from two or more distinct scientific disciplines. The research is based upon a conceptual model that links or integrates theoretical frameworks from those disciplines, uses study design and methodology that is not limited to any one field, and requires the use of perspectives and skills of the involved disciplines throughout multiple phases of the research process” (p. 341; in Bardecki, 2019, p.1181).

With the adding of the “fifth helix of the (natural) environment/environments” to knowledge creation, production, application, diffusion and use, knowledge and innovation (advanced and pluralized Mode 3 knowledge and innovation systems) are transformed to a knowledge and innovation that is sensitive or at least potentially sensitive for “social ecology”: knowledge and innovation, contextualized by society, meets the context of society, the environment. Therefore, the Quintuple Helix has the potential to serve as an analytical framework for sustainable development and social ecology, by conceptually relating knowledge and innovation to the environment. Sustainable knowledge is a knowledge that reflects on the performance and quality of the environment, the natural environment. 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 & Campbell, 2010).

In this model, the Triple Helix system relates to the knowledge economy, the Quadruple Helix to the knowledge society and knowledge democracy and the Quintuple Helix to a broader perspective of socio-ecological transformations and natural environments (Carayannis et al., 2012). Carayannis and Campbell (2009, 2010) saw the importance of natural environments and the Quintuple Helix Model as a way towards sustainable development and social ecology that is the relationship between society and nature and their co-evolution. In this way, the expansion of the Triple Helix Model to include a fourth and fifth helix is interesting in relation to a transformation of society to a forest-based bio-economy. The Quintuple Helix innovation system is problem oriented and aims to function as a way towards socio-ecological transformation that is the transformation of society to a bio-economy or a circular economy and thereby towards sustainability (Carayannis et al., 2012). Ellen MacArthur Foundation (2013; Geissdoerfer et al., 2017; in Kunwar, 2020, p.130) defines circular economy as “an industrial economy that is restorative or regenerative by indentation and design”.

### **N-Tuple Helices**

Carayannis and Campbell (2021), Leydesdorff (2012, FN 24) finally introduced the concept of the N-tuple of Helices (Carayannis & Campbell, 2021) that argued an N-tuple of helices can be expected in a pluriform and differentiated society. Zhou and Etzkowitz (2021) argue the notion of N-tuple Helices, emphasizing that within the Triple Helix, the actors are inherently human beings situated within interacting institutional spheres, rather than mere elements within the innovation system. Their critique cautions against misinterpreting the role of the Triple Helix within the broader innovation ecosystem and highlights potential misunderstandings that may arise from more complex models such as the Quadruple, Quintuple, or N-tuple Helix (Zhou & Etzkowitz, 2021). Leydesdorff (2012; in Kolehmainen, Irvine, Stewart, Karacsonyi, Szabó, Alarinta, & Norberg, 2016) wrote the N-tuple of Helices have even been called a "paradigm" for the development of increasingly better models (Park 2014; in Kolehmainen et al., 2016). Business life and innovation are in a

constant flux, and the changes are reflected in new and emerging characteristics. Paradigms can be understood as basic fundamental, upon which a theory rest. In that sense paradigms are axiomatic premises which guide a theory, however, cannot be explained by the theory itself: but, paradigms add to the explanatory power of theories that are interested in explaining the (outside) world. Paradigms represent something like belief (Carayannis & Campbell, 2009, p.219).

### **Mode 3**

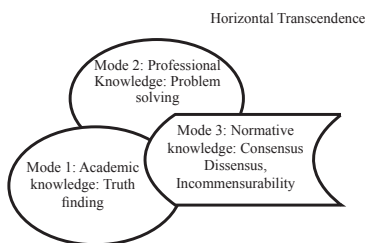
For the first time in the history of academia, the concept of Mode 1 and Mode 2 since 1994 came into existence that expanded to Mode 3 in different periods of time through conceptualization, invention and implementation in the academic world (Gibbons, Limoges, Nowotny, Schwartzman, Scott, & Trow, 1994; Carayannis & Campbell, 2006, 2009, 2010, 2012; Jacob, 2000) focusing on advancement and massification of research and education, the new production of knowledge and knowledge capitalism, innovation, three phases of science and technology and policy (policy for science, science in policy and policy for technological innovation) (Gibbons et al., 1994). Gibbons et al. (1994, p.267) highlight Mode 1 as the complex of ideas, methods values and norms that has grown up to control the diffusion of the Newtonian model of science to more and more fields of enquiry and ensure its compliance with what is considered sound scientific practice. Mode 1 represents traditional research conducted within disciplinary boundaries, emphasizing theoretical advancement through peer-reviewed publication. Mode 1 may be defined as: “academic excellence, which is a comprehensive explanation of the world (and of society) on the basis of ‘basic principles’ or ‘first principles’, as is being judged by knowledge producer communities (academic communities structured according to a disciplinary framed peer review system)” (Campbell & Carayannis 2013, p. 32). In contrast, Mode 2 is shifted from Mode 1 which represented disciplinarity into transdisciplinarity; homogeneity to heterogeneity; hierarchical to heterarchical and transient (Gibbons et al., 1994 Portegies, De Haan & Platenkamp, 2009, p.527; Kunwar, 2018; Carayannis & Campbell, 2010, 2018; in Kunwar & Ulak, 2023). Organizational diversity is also outcome of Mode 2 knowledge production (Gibbons et al., 1994). According to Gibbons et al. (1994, p.267), Mode 2 Knowledge production is carried out in the context of application marked by its: transdisciplinarity; heterogeneity; organisational heterarchy

and transience; social accountability and reflexivity; and quality control which emphasizes context and use-dependence which results from the parallel expansion of knowledge producers and users in society. Mode 2 can be defined as: “problem-solving, which is a useful (efficient, effective) problem-solving for the world (and for society), as is being judged by knowledge producer and knowledge user communities” (Campbell & Carayannis 2013, p. 32). The integration of Mode 1 basic research with Mode 2 problem-solving facilitates the widespread dissemination of high-quality knowledge, contextualized according to societal needs (Carayannis & Campbell, 2009).

Mode 3 “. . . allows and emphasizes the co-existence and co-evolution of different knowledge and innovation paradigms. In fact, a key hypothesis is: The competitiveness and superiority of a knowledge system or the degree of advanced development of a knowledge system are highly determined by their adaptive capacity to combine and integrate different knowledge and innovation modes via co-evolution, co-specialization and co-opetition knowledge stock and flow dynamics” (Carayannis & Campbell 2009; Brandenburger & Nalebuff 1997; in Carayannis & Campbell, 2013, p.1294).

**Figure 1**

*Hybriditized Network Society*



*Source:* Isaac & Platenkamp, 2013, p.178

Kunneman (2005; in Portegies et al., 2009, p.527; Isaac, 2014; Issac & Platenkamp, 2013, p.178) introduced Mode 3 Knowledge, recognizing the necessity to address "slow questions" concerning existential fulfillment, such as sickness, death, and repression, along with moral virtues like compassion, inner strength, and wisdom. These aspects were often overlooked in traditional knowledge production modes but remain crucial across generations and locations. Mode 3 knowledge acknowledges

the influential role of values and meaningful interpretations in addressing real-world problems, particularly in the context of Mode 2 applications. It signifies a shift from normal science to post-normal science, integrating descriptive and normative forms of quality control, and emphasizing ethical and moral values in governance (Issac & Platenkamp, 2013; Isaac, 2014). However, this overall study is based on the Triple Helix including other helices as mentioned above.

Mode 3 knowledge productions, in combination with the widened perspective of the Quadruple Helix and Quintuple Helix, emphasizes an Innovation Ecosystem (social and natural systems and environments) that encourages the co-evolution of different knowledge and innovation modes as well as balances nonlinear innovation modes in the context of multilevel innovation systems. Hybrid innovation networks and knowledge clusters tie together universities, commercial firms, and academic firms. Mode 3 may indicate an evolutionary and learning-based escape route for Schumpeter's "creative destruction" (Carayannis & Ziemnowicz 2007; in Carayannis & Campbell, 2010). Creative destruction, which was coined in 1942, refers to the incessant product and process innovation mechanism by which new production units replace outdated ones (Caballero, 2008).

In the helix studies, scholars have given attention on Mode 3 in different lines that extends beyond formal institutions, involving broader societal participation and prioritizing the democratization of knowledge production through interdisciplinarity and open innovation. Carayannis and Campbell (2010, 2012) propose Mode 3, emphasizing collaborative integration among stakeholders for co-creating knowledge to address societal challenges. This strategy promotes open innovation and diversity in knowledge modes, enabling different knowledge paradigms to evolve and specialize together, thus advancing knowledge-based societies and economies.

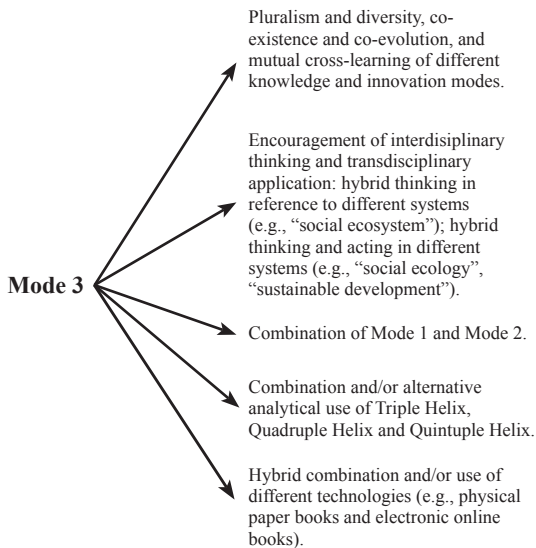
Until now, Mode 3 has been examined by two groups of scholars: one focusing on knowledge and innovation, and the other on tourism and hospitality. The first group Carayannis and Campbell (2006, 2009, 2010) have investigated Mode 3 in relation to knowledge and innovation. Similarly, the second group, represented by Isaac and Platenkamp (2013; Isaac, 2014) have explored responsible tourism within the context of Mode 3, although their focus differs from that of the knowledge

and innovation studies. The application of Mode 3 in responsible tourism could prove highly beneficial in shaping human values and upholding moral and ethical standards, thereby contributing to fostering harmony within the academic realm of tourism.

As a more far reaching conceptualization of knowledge production Carayannis and Campbell (2012) postulate and introduce a new approach that they called it as Mode 3 knowledge production system (expanding and extending the “Mode 1” and “Mode 2” knowledge production systems), which is at the heart of the Fractal Research, Education and Innovation Eco-system (FREIE), and consisting of “innovation networks” and “knowledge clusters” for knowledge creation and diffusion and use (Carayannis & Campbell, 2006a; in Carayannis & Campbell, 2012, p.3). The understanding of FREIE “...is multilayered, multimodal, multinodal, and multilateral system, encompassing mutually complementary and reinforcing innovation networks and knowledge clusters consisting of human and intellectual capital, shaped by social capital and underpinned by financial capital” (Carayannis & Campbell, 2012).

**Figure 2**

*Key Features and Propositions of Mode 3*



*Source:* Carayannis and Campbell, 2010, p.53



## **Transformation of Science Systems**

According to Hessels and Lente (2008), the transformation of science systems is focusing on the emergence of various trends and the prominent concept of "Mode 2" knowledge production. It discusses how Mode 2 knowledge production represents a shift towards a more interactive and socially distributed research system, characterized by factors such as context of application, trans-disciplinary, heterogeneity, reflexivity, and novel quality control criteria. Gibbons et al. (1994) are credited for introducing the Mode 2 concept, arguing that it complements traditional disciplinary structures rather than replacing them. However, the concept has generated both praise and criticism within the academic community. There are alternative approaches to understand science system changes that include: finalization science, strategic research/science, post-normal science, innovation systems, academic capitalism and post-academic science.

They were Bohme et al. (1983, 1973; in Hessels & Lente, 2008) who introduced the concept of 'finalization science', which outlines the progression of science and its interaction with society. 'Finalization' offers insights into the evolving science-society relationship and provides actionable recommendations (Bohme et al., 1983; Weingart, 1997; in Hessels & Lente, 2008). Similarly, the concept of strategic research or strategic science was introduced by Irvine and Martin (1984; in Hessels & Lente, 2008) that focus on shaping policy objectives by prioritizing elementary scientific inquiry to address practical challenges. Likewise, Funtowicz and Ravetz (1993; in Hessels & Lente, 2008) came up with the concept of "post-normal science" as a prescriptive approach addressing the limitations of rational decision-making, especially in policy-relevant fields. Innovation studies emphasize the importance of interactions among various stakeholders in innovation processes. Another concept of innovation systems within transformation of science systems serves as both a descriptive and prescriptive framework, aiming to elucidate the complexity of innovation systems and advocate for systemic innovation policies (Smits & Kuhlmann, 2004; in Hessels & Lente, 2008). Academic capitalism denotes market-driven activities within academic institutions (Slaughter & Leslie, 1997; in Hessels & Lente, 2008). They distinguish two types of such activities: the pursuit of external funding through competitive means, and market-oriented initiatives

like for-profit ventures and patenting endeavors. Ziman (2000; in Hessels & Lente, 2008) presents the concept of post-academic science, which integrates elements from various theoretical frameworks including Mode 2, academic capitalism, and post-normal science.

### **Knowledge Economy**

The concept of a knowledge economy comes from Fritz Machlup, the Austrian-born economist (Etzkowitz, 2003; Machlup, 1962; in Viale & Etzkowitz, 2010). The ‘knowledge-based economy’ was first introduced at a workshop of the Organization of Economic Cooperation and Development (OECD) in 1994 by Foray and Lundvall (1996; in Leydesdorff, 2010) which is only one of many conceptual framework developed over the last 60 years to guide policies and competes for influence with other frameworks such as national innovation system and Triple Helix. Abramowitz and David (1996; in Leydesdorff, 2010) suggested about the ‘codified knowledge’ in the same workshop. Codified knowledge as a basis for the organization and conduct of economic activities, including among the latter the purposive extension of the economically relevant knowledge base. While tacit knowledge continues to play critical roles, affecting individual and organizational competencies and the localization of scientific and technological advances, codification has been both the motive force and the favoured form taken by the expansion of the knowledge base (Abramowitz & David, 1996; in Leydesdorff, 2010). The majority of knowledge-based economies typically function within the framework of neoclassical economics, which often fails to fully acknowledge the significance of natural resources and sustainability beyond the scope of market dynamics (Liyanage & Netswera, 2021).

Knowledge-Based Economy has three main dimensions: production, distribution, and knowledge-information. Another description for knowledge-based economy was made by Powell and Snellman (2004; in Demir, GunerenGenc, Aykac Alp., ...Yildirim, 2015) in which they identified (i) new science-based industries, (ii) knowledge-based labor for the new industries existing in the knowledge society, and (iii) learning and continuing innovation by firms (Sharma, Ng, Dharmawirya, & Samuel, 2010; in Demir et al., 2015). According to Leydesdorff (2010), there are three sub-dynamics reproduced as functions of a knowledge-based economy and they are: (1) wealth generation in the economy, (2) novelty generation by organized

science and technology, and (3) governance of the interactions among these two sub-dynamics by policy-making in the public sphere and management in the private sphere. The economic system, the academic system and the political system can be considered as relatively autonomous subsystems of society which operate with different mechanisms. However, in order to describe their mutual interdependence and interaction with respect to knowledge creation, one first needs to distinguish these mechanisms.

The capitalization of knowledge comes from dynamics within knowledge production itself rather than financial capital invading and controlling knowledge (Etzkowitz, 2008). The capitalization of knowledge denotes the transformation of knowledge into capital and the processes through which this takes place, such as intellectual property rights and the patent system, corporate research labs and consortia, technology transfer and ---venture capital (private and public), incubators, etc. As the capitalization of knowledge occurs, capital also gains more knowledge capabilities (Etzkowitz, 2008). In course of studying knowledge economy, the term “knowledge industry” was also suggested by Malchup for the first time to describe knowledge industries in the context of his new idea of the knowledge economy (Nyiri, 2002). According to Nyiri (2002; Kunwar & Ulak, 2023), knowledge industries are those industries which are based on their intensive use of technology and/or human capital.

### **Knowledge Society**

The progression of this model can be related to the development of a knowledge society. Though Lane (1966, p.650; in Stehr, 1994, p.5) has define what knowledgeable society is; Bell (1973a, p.37; in Stehr, 1994) indicates that he could have substituted ‘knowledge society for ‘post industrial society’ because either the term, and others, for example’ intellectual society’ (Bell, 1964, p.49; in Stehr, 1994). As Bell (1968, p.198; in Stehr, 1994) indicates that post industrial society is clearly ‘a knowledge society in a double sense: first, the sources of innovation are increasingly derivative from research and development (and more directly, there is a new relation between science and technology because of the centrality of theoretical knowledge); and second, the “weight” of the society-measured by a larger proportion of the Gross National Product (GNP) and a larger share of employment-is increasingly in the

knowledge field' (Stehr, 1994).

Viale and Etzkowitz (2010) highlight that knowledge encompasses not only the representation of the physical and human world but also the ways in which we engage with it. They propose a categorization of knowledge into two distinct types: ontic and deontic. Ontic knowledge focuses on analyzing the world as it is, while deontic knowledge centers on how it can be altered or influenced. These categories of knowledge can be further understood through two primary modes: the analytical mode, which concerns the linguistic expressions used to convey knowledge, and the cognitive mode, which relates to the psychological processes involved in representing and processing knowledge. Viale and Etzkowitz (2010) suggest that two key epistemological factors, the level of generality and complexity, influence how knowledge is generated and transferred within organizations.

In a systematic (social, societal) understanding, knowledge creation and knowledge production often are associated more closely to research, basic research and sciences, thus a function of universities (HEIs), embedded in a national or multi-level innovation system, is to focus exactly on knowledge creation and knowledge production. Knowledge creation and production are being complemented by the concepts of knowledge application, knowledge diffusion and knowledge use (equivalent to innovation). This could imply to think of two sides of knowledge: knowledge creation and production on one hand, and knowledge application and use on the other (Carayannis & Campbell, 2010, p.44).

According to Ghisi (2010), the Knowledge society is a post capitalist society. Everything is changing in this new economy, but nobody tells us anything....(Ghisi, 2010). Ghisi (2010) has also mentioned about the trans-modern knowledge society. In course of analyzing the features of trans-modern knowledge society, Ghisi (2010) has highlighted ten major points of knowledge society which are as follows.

1. The value creation process is immaterial and post capitalist: The very core of any economy is the value creation process. The new value creation process no longer adds value to an object (like in industry), but applies knowledge to knowledge in order to create new knowledge (Drucker, 1994; in Ghisi, 2010, p.43). And knowledge is like Love. The more you share, the more you have.

This is exactly the opposite of capitalist logic (never share your capital!).

2. Post capitalist tool of production is human brain in networks: Every evening the tool of production goes back home. If management is not human centered, the people (the tool of production) go elsewhere with their knowledge and the company fails.
3. Post capitalist & post industrial management: Management Must become human centered, thus humanist. Hence the growing importance of HRD (Human relations departments). In the negative scenario, management will manipulate the employee's brains.
4. Post capitalist economy and society: Peter Drucker (2005; in Ghisi, 2010) explains that financial capital and technology are becoming less important than "human capital". According to him, we are already in a "post capitalist society". But nobody says anything and we continue to manage the new within the old industrial system. Hence the crisis.
5. Post capitalist qualitative Measurements: How do we measure knowledge? There is too much information and knowledge on the WEB. People look for quality of knowledge and wisdom. The stock markets now use qualitative tools of measurement called "intangible assets" (Sveiby, 1994; in Ghisi, 2010, p.44) in more than 50% of the cases.
6. Post capitalist exchange system and money: It is impossible to trade knowledge, because you keep the knowledge you are "trading". In the new knowledge society, you can only "share" knowledge. The "free trade" slogan is outdated in this new economy, as it becomes "free sharing of knowledge" ("Open source"). This means that it is possible to shift to a post industrial and post capitalist money system. The crisis of the industrial financial system is obvious.
7. Post capitalist strategy: from win-lose to win-win: In the new economy, competitors are collaborating in "communities of practice" (Verna, 2002; in Ghisi, 2010, p.44). The soft approach of a win-win strategy is much more efficient. Women are usually twice more efficient in this new type of Knowledge Society Management.

8. Post capitalist Patenting policy: It becomes almost impossible to patent knowledge, because knowledge always leaks (Cleveland, 1997; in Ghisi, 2010). Generic medicines are winning everywhere despite the big fight of the Pharmaceutical companies. Open Source programs are winning more space and importance as China has already chosen Linux and IBM has chosen "Open Source" policies. This induces more transparency in our societies.
9. Post capitalist structures in networks: It is impossible to create knowledge in a pyramidal structure, because information and knowledge do not circulate in a pyramid. Companies have thus to switch to a network structure. The patriarchal "command control and conquer" systems are completely obsolete as it is impossible to control a network.
10. Post capitalist concept of growth: This is one of the best pieces of news. What becomes crucial in this new economy is the quality of knowledge and of wise action. Those new important issues are qualitative. They give a precious indication that we are changing the cornerstone of the industrial-capitalist concept of growth. From quantitative growth we are shifting full speed to qualitative growth. This new growth could be oriented towards a genuine sustainable world economy because only qualitative growth is still possible in our finite world.

The constitution of what could it be called the “Knowledge Capital” of the enterprise, defined as “the set of scientific and technical information and knowledge produced, acquired, combined and systematized by one or more company within a particular productive aim, and more broadly, within a process of value creation” (Laperche, 2017, p.33; Laperche, 2024, p.321) is embedded in its social context. This means that the whole society contributes - this was true in the past and is most true in the current context of open innovation—to its formation (Uzunidis, 2018; in Laperche, 2024): the state through its industrial, territorial, financial, and innovation policies; the universities and other public institutions; all the innovative companies whatever their size that feed (through cooperation) the knowledge capital of the largest companies, organized in mature sectors into globalized oligopolies.

## **Knowledge Democracy**

The democracy of knowledge or knowledge democracy, as a concept and metaphor, highlights and underscores parallel processes between political pluralism in advanced democracy, and knowledge and innovation heterogeneity and diversity in advanced economy and society. There is found a hybrid overlapping between the knowledge economy, knowledge society, and knowledge democracy (Carayannis & Campbell, 2010, pp. 55-58, 60-61).

Knowledge democracy refers to an interrelationship of phenomena (Hall, & Tandon, 2007). “The concept of knowledge democracy acknowledges the importance of multiple knowledge systems (Hall & Tandon, 2007; Rowell & Call-Cummings, 2020). Carayannis (2020; in Carayannis & Campbell, 2021, p.2051) quotes that “Democracy and the Environment are Endangered Species”. According to Carayannis and Campbell (2021; Cai & Lattu, 2022), Quadruple and Quintuple Helix innovation systems are based on democracy and ecology. They further elaborate that knowledge and innovation evolution depend on democracy and knowledge democracy because it is difficult for further advancement of knowledge and innovation without democracy or knowledge democracy; likewise, ecology and environmental protection represent a necessity and challenge for humanity, but they also act as drivers for further knowledge and innovation. Carayannis and Campbell (2017; in Cai & Lattu, 2022, p.266) highlight knowledge democracy as an important dimension in understanding the context in which innovation players interact with each other for knowledge production and innovation. This corroborates Campbell’s (2019; in Cai & Lattu, 2022) proposition of the global quality of democracy as an innovation enabler.

While studying knowledge democracy in this modern era, E-democracy (a blend of the terms electronic and democracy) is a new concept based on digitalization of democracy also known as digital democracy or internet democracy, uses information and communication technology (ICT) in political and governance processes (Macintosh, 2004; Simone, 2017). Similarly, this concept was tested by Taiwan during Covid-19 pandemic to suppress panic buying behavior of their citizens by going beyond constitutional democracy through bottom-up sharing of information, participatory collective actions, and hacktivism (Liyanage & Netswera,

2021) The term is credited to digital activist Steven Clift (Liz, 3 August 2009). By using 21st-century ICT, e-democracy seeks to enhance democracy, including aspects like civic technology and e-government. According to Hosein, Sim, Saadatdoost, and Hee (January 2014), e-democracy has the potential to incorporate crowd sourced analysis more directly into the policy-making process. Democracy could be shortcut as interplay of two principles (Campbell, 2005; in Carayannis & Campbell, 2010): (1) democracy can be seen a method or procedure, based on the application of the rule of majority; and (2) democracy can also be understood as a substance (“substantially”), where substance, for example, is being understood as an evolutionary manifestation of fundamental rights (O’Donnell, 2004, pp. 26-27; in Carayannis & Campbell, 2010). Dimension of democracy as per Campbell (2008, p.41; in Carayannis & Campbell, 2010; Carayannis & Campbell, 2012) are: politics, gender, economy, knowledge, health and environment.

## **Diplomacy**

“Diplomacy is the art and practice of conducting negotiations between representatives of groups or states. It usually refers to international diplomacy, the conduct of international relations through the intercession of professional diplomats with regard to issues of peace-making, trade, war, economics, culture, environment and human rights. International treaties are usually negotiated by diplomats prior to endorsement by national politicians. In an informal or social sense, diplomacy is the employment of tact to gain strategic advantage or to find mutually acceptable solutions to a common challenge, one set of tools being the phrasing of statements in a non-confrontational or polite manner” (<http://en.wikipedia.org/wiki/Diplomacy>; in Carayannis & Campbell, 2012).

According to Carayannis and Campbell (2012), there are different types of diplomacy of knowledge and they are: science diplomacy, cultural diplomacy, economic diplomacy and innovation diplomacy.

Science Diplomacy (SD) is the exchange of science and technology across borders. A valuable resource and little understood tool of awareness, understanding, and capacity building, its power is not widely known or considered often enough” ([http://mountainrunner.us/2007/04/science\\_diplomacy.html](http://mountainrunner.us/2007/04/science_diplomacy.html); in Carayannis & Campbell,



2012). Likewise, cultural diplomacy specifies a form of diplomacy that carries a set of prescriptions which are material to its effectual practice. Milton C. Cummings Jr. explains cultural diplomacy as "... the exchange of ideas, information, art, lifestyles, values systems, traditions, beliefs and other aspects of cultures..." ([http://en.wikipedia.org/wiki/Cultural\\_diplomacy](http://en.wikipedia.org/wiki/Cultural_diplomacy); in Carayannis & Campbell, 2012). Similarly, Berridge and James (2003; in Carayannis & Campbell, 2012) state that "economic diplomacy is concerned with economic policy questions, including the work of delegations to conferences sponsored by bodies such as the World Trade Organization (WTO)" and include "diplomacy which employs economic resources, either as rewards or sanctions, in pursuit of a particular foreign policy objective". Rana (2007; in Carayannis & Campbell, 2012) defines economic diplomacy as "the process through which countries tackle the outside world, to maximize their national gain in all the fields of activity including trade, investment and other forms of economically beneficial exchanges, where they enjoy comparative advantage.; it has bilateral, regional and multilateral dimensions, each of which is important"([http://en.wikipedia.org/wiki/Economic\\_diplomacy](http://en.wikipedia.org/wiki/Economic_diplomacy); in Carayannis & Campbell, 2012). "The definition of science diplomacy varied widely among participants. Some saw it as a subcategory of "public diplomacy" (soft power). "Innovation diplomacy covers the politics of engagement in the familiar fields of international scientific exchange and technology transfer, but raising these to a higher level as a diplomatic objective" (Carayannis & Campbell, 2012, pp. 6-7).

### **Artificial Intelligence (AI) and Algorithm**

A technological innovation is basically information organized in a new way. So technology transfer amounts to the communication of information, usually from one organization to another". These above definitions reveal that there is found a close relationship between science and society for technological innovation. This will be justified by the statement of Nowotny et al. (2001, p.247). As they write the agora is the public space in which 'science meets the public', and in which the public 'speaks back' to science. Due to the influence of science and technology, the world is now predominated by Artificial Intelligence (AI) and new innovations are supported by AI.

AI is defined as the ability "to make appropriate generalizations in a timely fashion

based on limited data” (Kaplan, 2016, pp.5-6; in Stehr, 2022, p.143) exactly which goals, problem solutions and applications (choices) will be realized is open in principle. In other words, the application for repressive purposes is not excluded. AI can be used as a “less expensive” digital weapon; in fact, at lower cost in several respects compared to conventional methods of repression. In this regard, it could be applied the statement of Stuart Russell, the initiator of the Center for Human-Compatible Artificial Intelligence, clearly expects that “machines more intelligent than humans would be developed this century”; obviously Russell anticipates such an enlargement as a potential danger and therefore now calls for “international treaties to regulate the development of the technology” (Stehr, 2022, p.142). Similarly, the historian Yuval Noah Harari anticipates that “humans are at risk of becoming ‘hacked’ if artificial intelligence does not become better regulated”; to hack human beings means “to get to know that person better than they know themselves. And based on that, to increasingly manipulate you” (Stehr, 2022).

Kaplan (2016; in Stehr, 2022) shows algorithms as repositories of knowledge, that is, of human choices that have an elective affinity to AI; this becomes clear when AI is defined as the ability “to make appropriate generalizations in a timely fashion based limited data”. It is noteworthy to describe an algorithm while discussing AI. An algorithm is a bridge between knowledge as capacity to act and the solution to an issue at hand, or an algorithm represents the closure of the circle between knowledge and a goal. Finn (2019, p.561; in Stehr, 2022, p.140) quotes from a Google document that offers a similar definition: “Algorithms are the computer processes and formulas that take your questions and termed them into answers.” The ability to get something done is in fact accomplished by algorithms; and it is accomplished relentlessly, faster, and without deviating from the coded path. Algorithms apply to virtually all phenomena. The foundations on which algorithms operate are not objective or raw information. As in similar cases of decision-making, algorithms employ socially constructed information. Whether algorithms are capable of learning is a contentious issue, however, for some observers, “algorithms can learn by repeating the same task and improving” (Abiteboul & Dowek, 2020, p.16; in Stehr, 2022, p.141). The solution to the problem to which algorithms respond requires of course a judgment, possibly a series of compromises and presumptions about courses of action that may be available as solutions and their effectiveness.

But once the solution is taken on board, once you have acquired the ability to cook a meal, the bridge between knowledge and action can be passed many times if not indefinitely (Stehr, 2022).

Likewise, incubators and science and technology parks (STPs) are examples of these environments as well as mechanisms to support innovation and regional development that are integrated to regional innovation ecosystems, together with educational and research institutions, and the public and private sectors (Associação Nacional de Entidades Promotoras de Empreendimentos Inovadores (Anprotec, 2012; in Mineiro & Castro, 2021). Similarly, science and technology parks (STPs) are a special type of agglomeration which is part and parcel of innovation studies (Albahari, 2021). Technological innovation has been a powerful force for industrial development, productivity, growth and indeed, our rising standard of living throughout history, but intense study of its industrial role and influence is a relatively recent phenomenon (Abernathy & Clark, 1985, p.3).

### **Green Knowledge**

The main outcome of the Quintuple Helix is green knowledge, green economy, green growth and social ecology. Cabrita, Cruz-Machado, Matos and Safari (2016) use “green knowledge” as knowledge that is created, developed and applied in order to understand environmental problems and to deal creatively with their resolution. Green knowledge represents the fuel of green economy and eco-innovation (developing product and services with minimized impact on environment (OECD, 2007; in Cabrita et al., 2016) plays a crucial role as a driver of green and circular economy (Horbach, 2015; in Cabrita et al., 2016, p.129). Furthermore, the proposed green universities enable the production of green knowledge and innovation in their mainstream process (Liyanage & Netswera, 2021).

The green knowledge and innovation could be produced with six types of knowledge systems, they are: Mode 1, Mode 2, Mode 3, THMI, QuadHMI, and superior-quality QuinHMI. Therefore, it is essential that the conventional structure of the university should be reconfigured accordingly. In other words, the proposed green university system should enable the contextualization of other knowledge systems. In this regard, eight requisites for reconfiguration were identified as green

corporate governance, green corporate culture, three pillars of sustainability, green curriculum, green research, green community outreach, green internal environment, and green reporting (Liyanage & Netswera, 2021).

Green economy (GE) stands differently ‘as it accounts natural capital and ecological services as having economics value with a full cost accounting regime in which costs externalized onto society via ecosystems are reliably traced back to, and accounted for as liabilities of, the entity that does the harm or neglects an asset’ (Wikipedia, 2012; in Adhikary, 2012, p.77). United Nations Environment Program (UNEP) defines a green economy as one that results in “improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities”. Under this consideration ‘growth in income and employment are driven by investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services (UNEP, 2010; in Adhikary, 2012, p.79). In essence, green economy is low-carbon, resource efficient, and socially inclusive. Dahal (2012; in Adhikary, 2012, p.80) points out five key elements of green economy. They are: (1) generation and use of renewable energy, (2) energy efficiency, (3) waste minimization and management, (4) sustainable use of existing natural resources, and (5) green job creation.

Green growth is a method of resolving environmental issues that places trust in developing science and innovation. A few of the relationships it has are with the economy, resources, environment, technology, politics, market, culture, and people. It is a sustainable approach that puts resource conservation, economic growth, and environmental friendliness first (Gazzola, Dal Campo, & Onyango, 2019; Lingling, Chun-you, & Jing Tao, 2015; Zhou, Luo, Dong, & Zhao, & Wang, 2021; Stoica, Roman, & Rusu, 2020; in Quacoe et al., 2023).

Carayannis and Campbell (2009, 2010) saw the importance of natural environments and the Quintuple Helix Model as a way towards sustainable development and “social ecology” that is the relationship between “society and nature interactions” between “human society” and the “material world”(Fischer-Kowalski & Haberl, 2007; in Carayannis & Campbell, 2013, p.1296) and their coevolution. In this way, the expansion of the Triple Helix Model to include a fourth and fifth helix is interesting in relation to a transformation of society to a forest-based bioeconomy.

The Quintuple Helix innovation system is problem oriented and aims to function as a way towards socioecological transformation that is the transformation of society to a bioeconomy or a circular economy and thereby towards sustainability (Carayannis et al., 2012).

### **Greening University as a Proposed Model**

A proposed design named “green university system,” which integrates all essential elements of a green university, could be incorporated into the conventional structure of the universities so that they enable the production of high-skilled human capital with sustainable values to protect the ecology by being a green university in a KBE. Further, the universities designed for sustainable development enable collaboration, contextualization, and co-creation of green knowledge and innovation effectively and efficiently with all five helices. As far as green knowledge is concerned, Jamison (2001; in Cabrita et al., 2016, p.129) analyzes that green knowledge is not so much about the environmental conditions in which we live but more about how we should operate taking into account to pursuing more sustainable paths of socio-economic development.

Besides, universities those are not sustainable enable ascertaining their status quo and transform their universities into sustainable universities by adopting the proposed design. In support, Di Nauta et al. (2015; in Liyanage & Netswera, 2021) point out that universities are accountable for developing the country in which it operates. They have to offer solutions by collaboration and co-create developing instruments, tools, and models for social issues. Velazquez et al. (2006; in Liyanage & Netswera, 2021) define the sustainable university as “A higher educational institution, as a whole or as a part, is one that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in a ways to help society make the transition to sustainable lifestyles.”

In this endeavor of developing a purposeful design called Green University System, the definition of Velazquez et al. (2006; in Liyanage & Netswera, 2021) is a good starting point. They define the sustainable university as “A higher educational

institution, as a whole or as a part, is one that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles.” This definition reflects that the sustainability prevails in a socioeconomic and environmental relationship, the three pillars of sustainability.

The institutional logics by 2030 Agenda for 17 SDGs, Paris Climate Agreement, Nationally Determined Contribution of Botswana, and the helix models empower to shift from existing isomorphism to a contemporary isomorphism by contextualizing and producing green knowledge and innovation system with the other knowledge systems, Mode 2; THMI; Quad- HMI; in particular, Mode 3; and QuinHMI. These knowledge systems evolve from the knowledge-based society, knowledge-based democracy, and knowledge-based economy to the knowledge society, knowledge democracy, and knowledge economy (Campbell & Carayannis, 2009, p.224; Liyanage & Netswera, 2021). There is a need to develop a purposeful design called Green University System for greening a university as this is a proposed model for Botswana (Liyanage & Netswera, 2021). The universities’ stakeholders in Botswana view that the production of green knowledge and innovation is vital. Therefore, the universities’ conventional structure should be reconfigured so that the universities enable producing green knowledge and innovation up to the broadest superior level of the knowledge system, Mode 3, and QuinHMI (Liyanage & Netswera, 2021).

There are eight knowledge clusters/eight requisites/eight elements of green university, green corporate governance, green corporate culture, three pillars of sustainability, green education, green research, green community outreach, green internal operations, and green reporting. The authors argue that this green university model is not only applicable to Botswana, but also can be adopted this model by any other conventional universities around the world. The model has been designed empirically. The other researcher can test the model to confirm, vary, contradict, or repudiate the model based on empirical evidence (Liyanage & Netswera, 2021).

As Liyanage and Netswera (2021) expressed that a change in universities is also inevitable in the fast-paced world. Likewise, Torraco (2005) argues that there

are two distinct theoretical frameworks to change universities i.e. “O” theory (Organization Development) and “E” theory (Beer & Nohria, 2000; in Torraco, 2005). Top management-driven change, E, is entirely different from the O theory’s participatory nature. With expert consultants’ help, the top management creates new strategies and structures to have systemic change for increasing the organization’s economic value. Beer and Noria (2000; in Torraco, 2005) argue that both theories, O theory and E theory, can achieve a planned change of the organization and mix both systems to reduce costs and increase the benefits. Hence, the transformation of traditional universities to sustainable university in a knowledge-based economy is an innovation which requires an institutional change which can be achieved by theory O or theory E.

## **Conclusion**

“The empires of the future are the empires of the mind” (Winston Churchill, 1945; in Carayannis & Campbell, 2009, p.222; 2012, p.47)

The Triple Helix Model emphasizes the symbiotic relationship between academia, industry and government in knowledge production has become integral to driving innovation and significant progress globally. Academia serves as the foundation for knowledge creation and industry applies this knowledge to innovate new products and technologies. Likewise, government provides support, funding and regulations that help to facilitate these interactions and ensure sustainability. Understanding the importance of this model which is based on partnership and knowledge exchange, it enables stakeholders to overcome the challenges and to ensure economic and social development (Hattangadi, 2022).

The helix model, as cited by Spadaro et al.(2023), has understandably been applied to various scientific topics: circular economy (Arsova et al., 2021), smart cities (Dameri, Negre, & Sabraux,2016), urban resilience (Pirlone, Spadaro, & Candia, 2020), the food sector (Dudin, Lyasnikov, & 2014), bioeconomy (Grundel & Dahlstrom, 2016), transportation (Verlinde & Macharis, 2016), and mobility (Bressers, 2012).

All helices have emphasized on the importance of capitalization of knowledge which is considered as economic driver for overall development. The literatures

show that the evolution of helix models within innovation theory has advanced from the Triple Helix to more intricate frameworks such as the Quadruple and Quintuple Helix Models developed by Carayannis and Campbell (2006; 2009; 2010; & 2012) each adding layers of complexity and interdisciplinary focus. To use metaphoric terms, the Quadruple Helix embeds and contextualizes the Triple Helix, while the Quintuple Helix embeds and contextualizes the Quadruple Helix (and Triple Helix). The Triple Helix represents a core model for knowledge production and implication. The Quadruple Helix as a fourth helix in which the “media-based and culture-based public” and “civil society” is conceptualized (Carayannis & Campbell, 2013, p.1296). The Quintuple Helix innovation model adds as a fifth helix (and perspective) of the “natural environments of society” as a pivotal actor in decision-making processes. The Quintuple Helix refers to the socio-ecological transition of society, economy, and democracy; therefore, this helix innovation system is ecologically sensitive.

One of the major outcomes of the Quintuple Helix Model is green knowledge that incorporates green economy; green growth; and social ecology which are the major foundations for sustainability. While understanding the knowledge production related to academia in terms of universities that brought a great transformation of traditional university (Mode 1); entrepreneurial university (Mode 2); and higher education institutions including their sub-units (Mode 3) (Carayannis & Campbell, 2012, pp. 24-25).

This study has shed light on the importance of green university as a model proposed in Botswana. This is completely a new model ever came out in the academic world. Both Quadruple and Quintuple Helix focuses on Mode 3 Knowledge production. Mode 3 knowledge production as developed by Carayannis and Campbell (2006) focuses on advancement and massification of research and education. Though this study is based on two helices including N-tuple Helix through the lens of Mode 3 knowledge production, some scholars have applied this model in the field of responsible tourism as well (e.g., Kunneman, 2005; in Platenkamp, 2007; Portegies et al., 2009, p.527; Issac & Platenkamp, 2013, p.178; Isaac, 2014). Further research should be continued in this global theory of helix studies.

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