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Understanding the Triple Helix Model and Capitalization of Knowledge

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Abstract

This paper is a preliminary study of the Triple Helix (TH) Model that focuses on understanding the model from different perspectives following secondary research. The methodology used in this study is exploratory and descriptive in nature. Narrative review of previous literatures has been followed to understand the Triple Helix Model. Henry Etzkowitz and Loet Leydesdorff propounded a theory known as Triple Helix in connection with industry, university and government which has become a research hub. The Triple Helix is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization. Therefore, this is going to be popular not only in developed countries but also gradually becoming popular in developing countries. The question comes what is Triple Helix Model? What does the model reflects in the academia? The objective of this study is to understand Triple Helix Model on one side and the evolution of this model including its features on the other. This study examines how the Triple Helix Model has been popularized in the field of academia, industry, and government by focusing on knowledge, innovation, and entrepreneurship through education. This paper includes introduction, methodology, evolution of the Triple Helix Model, routes of the Triple Helix, knowledge production, knowledge and technology transfer, knowledge industries, capitalization of knowledge and innovation, the network society,

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collaboration, Triple Helix and academia, teaching, learning, and future universities. The Triple Helix Model is a neo-evolutionary model of possible synergies between functions such as wealth creation, knowledge production and government regulations, which are the three helixes.

Introduction

In a recent essay in science, Bruno Latour wrote about the transition from the culture of 'science' to the culture of 'research' in the past 150 years:

"Science is certainty; research is uncertainty. Science is supposed to be cold, straight and detached; research is warm, involving, and risky. Science puts an end to the vagaries of human disputes; research creates controversies. Science produces objectivity by escaping as much as possible from the shackles of ideology, passions, and emotions; research feeds on all of those to render objects of inquiry familiar". Latour goes on to argue that science and society cannot be separated; they depend on the same foundation (Latour, 1998, pp. 208-209; in Nowotny, Scott, & Gibbons, 2008, p. 2).

In the 1930s, Massachusetts Institute of Technology (MIT) proposed a strategy of forming new firms and pushing technology, industry, and economy forward by using the university's research under the leadership of Karl Compton. If the firms founded by MIT graduates and faculty were in an independent country, the revenues produced by the companies would make that nation the 24th largest economy in the world (Bank Boston, 1997; in Etzkowitz & Dzisah, 2008). The 4000 MIT-related companies employ about 1.1 million people and have annual world sales of US$ 232 billion. This 1997 output was at the time comparable to a gross domestic product of US$ 116 billion, which was a little less than the GDP of South Africa and more than the GDP of Thailand.

The growth of university-government relations was intertwined with the formation of national identity in Germany in the early 19th century, with the Humboldtian academic model integrating teaching and research. This contribution describes the origins and essential characteristics of the Humboldtian Model of Higher Education (Bongaerts, 2022). The Humboldtian Model requires that universities govern themselves, have academic freedom, and integrate education and research. It shows how this model can be integrated into the European University on Responsible Consumption and Production (EURECA-PRO). Wilhelm von Humboldt and his team developed the innovative Humboldtian Model of Higher Education in Humboldt's native Prussia between 1809 and 1810 to totally reform the education system. After founding the University of Berlin in 1810 and with the support of leading young scientists cum professors, Humboldt intended to implement this new model of tertiary education. With the emergence of the neoliberal university model in the 1990s, key elements of the Humboldtian Model have been complemented by university obligations to meet expectations from government, the business community, and society at large with regard to the usefulness and benefit of university research and educational outputs. This contribution concludes by discussing the potential of implementing the Humboldtian Model of Higher Education within EURECA_PRO (Bongaerts, 2022).

The Triple Helix Model has carried out an old concept of university as an ivory tower. The ivory tower relates to the carriers and lifestyles of academics in university and college systems. They have often garnered reputations as elite by creating and joining associations with other universities. An ivory tower is a metaphorical place—or an atmosphere—where people are happily cut off from the rest of the world in favor of their own pursuits, usually mental and esoteric ones (Steven, 2012).

The word helix comes from the Greek word 'elix' meaning "twisted curved". A filled in helix for example, a spiral (helical) ramp- is a surface called helicoid. The metaphor of Helix or Helixes (Helices, spirals) refers here to interwoven and cross-connected and cross-interconnected sectors (Carayannis & Campbell, 2018). A helix is shaped like a corkscrew or spiral staircase. Nevertheless, since the Triple Helix Model itself was often viewed as an expansion of the "double helix" genetic model. It is understandable that innovation researchers might see room for further expansion. Three actors act, interact and work together for the common goal. Therefore, paying more attention to creating the capacity of university, industry, and government as three primary actors in innovation and entrepreneurship is the key (Zhou & Etzkowitz, 2021).

The term helix in this study according to the scholars, is 'sphere'. Before 1850, much of the technological progress came from practical know-how generated by engineers as there was minute obstruction from empirical mental models in the form of the law of nature; therefore, scientific contribution came mainly from empirical accidental generalizations as there was not much collaboration between scientists and engineers. Most micro-inventions were results of experiments by engineers and through their continuous trial and error processes (Etzkowitz & Viale, 2010, p. 598). Similarly, in the second industrial revolution, some great macro-inventions, such as advances in organic chemistry were based on pivotal breakthroughs in the laws of nature, for example, the discovery of the structure of the benzene molecule by the German chemist August von Kekulé in 1985. Likewise, the first phase of the third industrial revolution is exemplified by such macro-inventions as recombinant DNA (Deoxyribonucleic Acid) and monoclonal antibodies, nuclear power, semiconductors, and antibiotics based on important scientific discoveries.

The need for collaboration between both spheres (academia & industry) is for their sustainability. Hence, the concept of the helix models came into existence in different periods of industrial revolution. According to Viale and Etzkowitz (2010, p. 597), there were different types of knowledge effective in different periods of the three industrial revolutions. According to Schwab (2016) and Sobaih and Jones (2015, p. 163), the First Industrial Revolution (1784) used water and steam power and mechanical production equipment. The Second (1870) used electric power to create mass production and division of labor. The Third (1969) used electronics and information technology to automate production. Now, a Fourth Industrial Revolution (?) is building on the Third, the digital revolution (Cyber-physical systems) that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. It is noteworthy to mention Artificial Intelligence (AI) which has become an integral part of innovation in industrial revolution. Artificial Intelligence is defined as a family of technologies that can recognized, analyzed, act, learn and demonstrate advanced features of human intelligence in the process of problem-solving (McCartney & McCartney, 2020; in Bulchand-Gidumal, William Secin, O'Connor, & Buhalis, 2023). Likewise, each academic revolution is mirrored by an industrial revolution. 1) First academic revolution-19th century -learning and teaching; 2) Second academic revolution-20th century-Economic and Social Development; and 3) Third Academic revolution-21st century- Entrepreneurial University- Triple Helix (Sobaih & Jones, 2015, p. 163)

Mokyr (2002, p. 25; in Viale and Etzkowitz, 2010, p. 597) says that it is agreed by historians of science and economic historians that the component of science properly speaking the classical industrial revolution was quite modest, and that the interaction of scientific knowledge and engineering, applied chemistry, agriculture and so on postdate the middle of the 19th century. Thus, it could relate to the Triple Helix Model. But to know about the Triple Helix Model, first and foremost one should be familiar with how the concept of helix historically existed. In this regard, it is noteworthy to start from the first helix i.e., the Single Helix.

This study includes introduction, review of literature, evolution of the Triple Helix Model, routes of the Triple Helix, knowledge production, knowledge and technology transfer, technology, knowledge industries, capitalization of knowledge and innovation, the network society, collaboration, Triple Helix and academia, teaching, learning, and future universities.

Methodology

Reviews provide a synthesis of published literature on a topic and describe its current state-of-the-art (Ferrari, 2015). As many as 14 types of literature reviews have been described (Grant & Booth, 2009). Each review type has its own goals and protocols that lead to unique strengths and limitations researchers must bear in mind. This article is based on narrative review (unsystematic review) of previous literatures. The purpose of narrative review is to identify a few studies that describe a problem of interest. Narrative reviews have no predetermined research question or specified search strategy, only a topic of interest. They are not systematic and follow no specified protocol. Although the reviewers will learn about the problem, they will not arrive at a comprehensive understanding of the state of the science related to the problem (Demiris, Oliver, & Washington, 2019). There are three types of narrative reviews of the literature: editorials, commentaries, and overview articles (Gray, 1997; Dixon, Munro, & Silcocks, 1998; in Green, Johnson, & Adams, 2006). This study follows the third type of review. Hence, the study is exploratory and descriptive in nature. Therefore, this study followed qualitative research methodology.

This is a preliminary study of the Triple Helix Model that focuses on understanding the model from different perspectives following secondary research. While understanding the model, the research methodology adopted in this study is desktop research that includes reviews, critiques and analysis of literature based on the topic. Desktop research involves research on existing literature to create new knowledge and insight on the relevant study (Toracco, 2016; in Moodley & Naidoo, 2022, p. 1044). Desktop research is the review of previous research findings to gain a broad understanding and gain more in-depth insight (Travis, 2022; in Moodly & Naidoo, 2022).

The objective of studying the Triple Helix Model is to understand it in a better way and to position the dynamics and evolution of university-industry-government relations within the context of challenges facing the global economy—unemployment, low or no growth, spiraling healthcare needs, rapidly emerging digital business models, unsustainable changes to the environment, and both coordinated and uncoordinated regulatory systems. Hence, this study examines how the Triple Helix Model has been popularized in the field of academia, industry, and government. For which question has been raised as what the Triple Helix Model is?

Relatively the Triple Helix Model is unknown to the academia of developing countries. While studying about academia and industry collaboration in the context of tourism and hospitality, the authors studied the article entitled "Determinants of industry–academy linkages and, their impact on firm performance: The case of Korea as a latecomer in knowledge industrialization" written by Eom and Lee (2010) and "Skilling youth through industry linkages: Case of Nepal" studied by Bhattarai (2019). These studies encouraged the authors to understand the Triple Helix Model in a better way. This is not a specific review of aspects of the Triple Helix Model, rather this is an overview of the model. This study delimits only to the Triple Helix Model because it has been already extended to the Quadruple Helix Model and the Quintuple Helix Model. Likewise, Mode 3 has not been included in this study. This is not project funding work. The authors decided to work on their own.

Evolution of the Triple Helix Model

The Single Helix

In the first industrial revolution, knowledge was little formalized, made of practical know-how generated by a series of individual experiments and trial and error. As a result, there is little collaboration inside the university and almost no collaboration between the university and industry. Hence, this model is a single helix (Viale & Etzkowitz, 2010, p. 599). The second industrial revolution is based on important scientific discoveries where knowledge is represented mentally by empirical models and expressed externally in natural and formal language. According to Schiffer (2003, p. 185; in Viale & Etzkowitz, 2010, p. 599), there are also instances of experimental models derived from theory, such as Benjamin Franklin's lightning rod, which arose from the environment of the scientific academy and its informal interaction with community of practitioners; a transitional form between the first and second revolutions. Therefore, in the first case, there is a need for formal collaboration between university and industry.

The Double Helix

According to Viale and Etzkowitz (2010, p. 599), it is difficult to collaborate between two polar- academy and industry as their methodological and epistemological rules and aims are totally different. However, industry is obliged to interact with the university as it does not have skills to tackle many technical problems that arise. In this case, there were not yet the births of a hybrid organization or the phenomena of ‘industrialization’ of the academy, and the ‘scientification’ of the industry. In the second industrial revolution there was weak interaction with the government and this model is the double helix. The first phase of the third industrial revolution (1969) used electronics and information technology to automate production (Schwab, 2016) is characterized by a reinforcement of the center of gravity in formal knowledge and science, mentally represented by mental models. The mental models and the interferences are made explicit externally in formal language and became public through academic publications and patents (Viale & Etzkowitz, 2010, p. 600). The double helix model also failed to connect economic development with social development where government’s cooperation between other two spheres (academia and industry) came into the scene. Academia and government apart from each other are interacting modestly across stronger boundaries than hybrid organization, market economy, linear and nonlinear interactions (Eom & Lee, 2010). Hence, the Triple Helix Model came into existence.

The Triple Helix

The Triple Helix thesis and model emerged as the new outcome of the 1990s, a time when universities and industries were exhorted by policy makers to work together more closely for the benefit of society, generating an upward trend in the commercialization of new knowledge. The thesis became articulated as a confluence between Henry Etzkowitz' long-term interest in the study of university-industry relations and Loet Leydesdorff's focus on an evolutionary model in which there is an overlay of communications between different and independent spheres of activity (Smith & Leydesdorff, 2012). The framework was first theorized by Henry Etzkowitz and Loet Leydesdorff in the 1990s, with the publication of “The Triple Helix, University-Industry-Government Relations: A laboratory for Knowledge-Based Economic Development”. Therefore, it is very important to know the different helices as developed by different scholars in different periods. For the first time, they are Henry Etzkowitz and Loet Leydesdorff (1995, 1997, 1998, 2000, pp. 11-112) who propounded a theory known as Triple Helix in connection with university-industry-government that explain the dynamics of their relationships which has become research hub (Hattangadi, 2022). It states that the relationships between these three actors and they must be mutually beneficial for a successful innovation system. In their studies, Vlados and Chatzinikolaou (2019) developed the concept of Triple Helix Model based on its publications into three consecutive phases: a. phase of theoretical foundation (1995-2000), b. phase of conceptual expansion (2001-2010), and c. phase of recent developments and systematic implementation attempts (2011-2018).

The Triple Helix (TH) model can be considered as an empirical heuristic which uses as explanate not only economic forces (Schumpeter, 1939; Nelson & Winter, 1982; in Smith & Leydesdorff, 2012), and legislation and regulation by regional or national governments (Freeman, 1987; Freeman & Perez, 1988; in Smith & Leydesdorff, 2012), but also the endogenized dynamics of transformations by science-based inventions and innovations (Noble, 1977; Whitley, 1984; in Smith & Leydesdorff, 2012). The Triple Helix is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization (Etzkowitz, 2003; in Bouraoui et al., 2011). The first dimension of the Triple Helix 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; Bouraoui et al., 2011).

The rise of the Triple Helix Model has coincided with the rise of the knowledge-based economy and innovation system, in which economic growth is based on continuous innovation and advances in science and technology. The Triple Helix Model referred in this article follows the definition provided by the Helix Conference official website: The Triple Helix relationship of university-industry-government is, to a large extent, about competition and cooperation for resources, redistribution of power and network building. From the institutional-logics perspective, the meanings of power, resources and networks vary by institutional logic (Thornton et al., 2012; in Cai, 2015).

The Triple Helix concept comprises three basic elements: (1) a more prominent role for the university in innovation, on a par with industry and government in a knowledge-based society; (2) a movement toward collaborative relationships among the three major institutional spheres, in which innovation policy is increasingly an outcome of interaction rather than a prescription from government; (3) in addition to fulfilling their traditional functions, each institutional sphere also 'takes the role of the other' performing new roles as well as their traditional function. Institutions taking non-traditional roles are viewed as a major potential source of innovation in innovation. (Triple Helix Conference website, 2011; in Cai, 2015, p. 9).

In developing the Triple Helix Model, Etzkowitz & Leydesdorff draw insights from multiple disciplines, such as "evolutionary economics, the sociology science and technology, and the sociology of higher education, as well as policy analysis with an evaluative perspective" (Zhou, 2014, p. 4; in Cai and Etzkowitz, 2020, pp. 21-22). Since 1996, the concept Triple Helix further developed and created a community of scholars' practitioners and the policy makers. The theoretical foundation of the model has been strengthened via multiple disciplinary perspectives, such as the "new evolutionary theory" (Leydesdorff & Meyer 2006; in Cai & Lattu, 2022), "neo-institutionalism" (Ranga & Etzkowitz, 2012; Galvao et al., 2019) or "institutional logics" (Cai, 2015; in Cai & Lattu, 2022) and "social network theory" (Villanueva et al., 2006; in Cai & Lattu, 2022. p. 272).

Etzkowitz and De Mello (2004; in Razak & White, 2015) trace the origins of the Triple Helix Model of innovation back to 1967, when H.W. Julius, Director of the Netherlands Central Organization for Applied Scientific Research, introduced the concept of a 'triangle'. He stated: "all those responsible, in one way or another, for the all-important economic development of their countries rack their brains to find the balance within the many complicated relationships in the modern eternal triangle of government, industry and science" (Etzkowitz & De Mello, 2004, p. 163; in Razak & White, 2015). As a universal model (Zhou & Etzkowitz, 2021, p. 3), the Triple Helix can be used to address issues in micro, meso and macro levels. It is a significant scientific discovery and distinct contribution to innovation and entrepreneurship studies, as well as environmental philosophy (Beckman, 2021; in Zhou & Etzkowitz, 2021) The Triple Helix was identified in the early 1980s, through the analysis of an "entrepreneurial university" (MIT) and its role in resolving the dilemma of creative destruction in the renewal of the New England region in 1920–1940s (Etzkowitz, 1983; Zhou & Etzkowitz, 2021). The validity of the model was confirmed through observation of the co-evolution of Stanford University and Silicon Valley. Almost as soon as it was proposed, observers were tempted to add additional helices to address issues beyond innovation, vitiating the original purpose without providing a logical methodology other than simple additionality.

Hattangadi (2022) defines the Triple Helix Model of innovation as it refers to constant interactions between academia, industry, and governments to foster economic and social development. The model emphasizes boosting innovation for development. The Triple Helix Model includes economic development, teaching, and research (Etzkowitz & Viale, 2010, p. 2; Sobaih & Jones, 2015, p. 162). Carayol (2003; in Viale & Etzkowitz, 2010, p. 600) argued that the need for epistemological and cognitive integration between science and technology brought about deep change in academy-industry relations. It is through the leadership and cooperation of individuals from universities, industry, and government that all three institutional spheres participate in the birth of hybrid institutions and this model is the Triple Helix. Viale & Etzkowitz (2010, p. 601) also highlights that future scientists should be able to manage different and distant conceptual frames and see both the theoretical and practical implications of their research.

It describes the role of universities in joining hands with industry and government. It explains social formats for the production, transfer, and application of knowledge. Triple Helix covers the creative destruction – a concept coined by Joseph Schumpeter in 1942 which describes that new innovations kill the older ones. Innovation arises within each of the three spheres – university, industry, and government. The best example of Triple Helix is Silicon Valley. The government provided land, flexible financing, stretched tax holidays and fitting guidelines to the IT cluster in California, US. The small and big IT businesses thrived in this cluster. The world has seen success stories of Dell, HP, Oracle, Intel, Microsoft etc. The very needs of the industry, powered by the created market, generate the need for academia which in this case comprises ICT professionals who are given all facilities to do Research and Development (R&D) and new product development to boost new products. Government, industry, and academia all profit as taxes is collected on sales of goods, revenue is generated, and knowledge is developed inside a suitable research environment (Hattangadi, 2022).

Generally, new technical and scientific knowledge is often regarded as the prime source of innovation, Von Hippel (1988; in Hjalager, 2015) emphasized R&D as a principal driver of innovation. R&D includes not only enterprises' own R&D but also R&D mediated and stimulated through universities and public research units, military spending, etc., which leads to significant discoveries that may eventually result in successful commercialization. Over the years, innovation studies have increasingly included other sources of ideas and inspiration for innovation, thus recognizing that many firms are innovative in spite of the fact that they do not invest in formalized R&D. A point raised by Leonard-Barton (1995; in Hjalager, 2015) is that some categories of core knowledge capabilities are essential to have inside the companies, while less critical resources can be insourced when needed. In her view, sustaining the sources of innovation is a strategic process of great importance, and creative knowledge is not confines to specified departments and dedicated employees but rather is widespread.

Some studies on triadic factor dynamics in different fields have well supported this model. For example, this "triadic reciprocal causation" in psychology, introduced by Albert Bandura (Eysenk, 2004; in Zhou & Etzkowitz, 2021, p. 3) refers to the mutual influence between three sets of factors: (1) personal factors (e.g., cognitive, affective, and biological events): (2) the environment; and (3) behavior. These three factors play roles as three interrelated actors. Moreover, triadic is in line with the reasonableness parsimony criteria of Occam's razor. The best example is Chinese philosopher Lao Tzu's (570 BC) discovery, stating in Tao Te Ching as that Tao begat one, One begat two, Two begat three, Three begat all things (Lao Tzu, 2021; in Zhou & Etzkowitz, 2021).

The elements of evolutionary theory in the development of the Triple Helix Model were first described by Etzkowitz (2003). According to Dosi (1982; in Razak & White, 2015), in a co-evolutionary model, two sub-dynamics (technologies and institutions) are assumed to operate upon each other, and this co-evolution could be further reinforced over time. From an evolutionary view, it is possible that a double helix will produce a fairly stable trajectory when the two sub dynamics mutually shape each other in a co-evolution. Academic patenting and licensing activities have massively increased since the 1980s in the United States and the 1990s in Europe. As this trend is clearly impacting the dissemination of and access to academic knowledge, the question arises whether the current encouragement of academic patenting and licensing is indeed generating the main benefit that policy makers at both the university and the government level claim it is achieving. Namely, the commercial development of academic knowledge.

Knowledge production and diffusion are widely viewed as the engines of economic and social progress in Western societies (European Commission, 1997; in Hladchenko & Pinheiro, 2018). The advent of the ‘‘knowledge economy” has put a premium on the interplay between science and society/economy in the context of technology transfer and other collaborative arrangements to foster global competitiveness. As a result, conceptualizations such as the Triple Helix Model (Etzkowitz & Leydesdorff, 2000; Hladchenko & Pinheiro, 2018) have become rather prevalent across policy and academic circles alike. Heuristically, the Triple Helix prescribes corresponding institutional logics both at the societal field level and at the level of the organizational fields of higher education and science, on the one hand, and industry/business, on the other (Cai, 2014; Hladchenko & Pinheiro, 2018). The core trigger for the implementation of the Triple Helix lies in the institutional logic of the state, which involves ‘‘shared beliefs on knowledge as a key to economic growth’’ (Cai 2014, p. 4; Hladchenko & Pinheiro, 2018). Cai (2014; Hladchenko & Pinheiro, 2018) argues that the dominant institutional logics in non-Western societies, which tend to be contrary to the ‘‘ideal’’ institutional logics of Western societies, can hinder the implementation of the Triple Helix Model. The four-stage development model differs from Etzkowitz's three-step model, but the focus of the four-stage model is how the concept of Triple Helix has been institutionalized (see table 1)

Table 1

The Evolution of the Ideal Triple Helix Model

Stages of development	Major Triple Helix activities	Favorable institutional logics
Stage I. Realization of the needs	Realizing the importance of entering a reciprocal relationship between university, industry, and government	Shared beliefs on knowledge as a key to economic growth.
Stage II. Intra-organizational transformation	Taking the role of the other	Market orientation Process management
Stage III. Interactions between organizations	Growing and innovating through cooperation with others. Generating hybrid organizations	Effective IP protection system Civil society
Stage IV. Institutionalization of the Triple Helix Model	Feedback loops between policymakers and participants Institutionalized norms of ‘entrepreneurial university’, ‘knowledge-based formation and growth’, and ‘innovation state’ (Etzkowitz, 2008)	Competitive market Democratic policymaking

Note. Adapted from Cai (2015, p. 17) which describes the evolution of the ideal Triple Helix Model.

While highlighting the importance of the Triple Helix Model as a global model, scholars of different disciplines have published many different leading books. As quoted by Cai and Etzkowitz (2020), the Triple Helix Model has been elucidated by Etzkowitz in his book *Triple Helix: University-Industry-Government Innovation in Action* (Etzkowitz, 2008) and especially its second edition (Etzkowitz & Zhou, 2017), e.g., on the concepts of field theory, the role of Civil Society in Triple Helix, and the knowledge, consensus, and innovation spaces. In addition, other scholars have contributed to developing theoretical foundations of Triple Helix, drawing from various theoretical insights, such as institutional theory (Cai, 2014, 2015), social network theory (Deakin, 2014; Cai, 2014, 2015), and game theory (Megnigbeto, 2018; Cai, 2014, 2015). The above-mentioned model and theories are the foundation of many different theories-oriented books on knowledge production, technology, innovation, entrepreneurship, and university. The books are *Theory and Practice of the Triple Helix System in Developing*

Countries: Issues and Challenges by Saad and Zawdie (2011), *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societie*s by Gibbons, Limoges, Nowotny, Schwartzman, Scon, and Trow (2010), *The Commodification of Academic Research: Science and the Modern University* by Radder (2010), *The Capitalization of Knowledge: A Triple Helix of University–Industry Government* by Viale and Etzkowitz (2010), *The New Invisible College: Science for Development* by Wagner (2008), *Re-thinking Science: Knowledge and the Public in an Age of Uncertainty* by Nowotny et al. (2008), *The Constitution of Knowledge: A Defense of Truth* by Rauch (2021), *Knowledge Democracy: Consequences for Science, Politics, and Media* by In't Veld (2010), and *The Age of Knowledge: The Dynamics of Universities, Knowledge & Society* by Dzisah and Etzkowitz (2012). Other improvements include identification of enabling conditions (Ranga & Etzkowitz, 2013; Cai & Etzkowitz, 2020) the distinction between institutional spheres and functions (Zhou, 2014; Cai & Etzkowitz, 2020), and circulation around the Triple Helix (Etzkowitz & Dzisah, 2012; in Cai & Etzkowitz, 2020). There are many articles related to the Triple Helix Model that are published in policy research journals. Latterly, the first issue of the Triple Helix Journal entitled *Triple Helix: A Journal of University-Industry-Government Innovation and Entrepreneurship* edited by Yuzhuo Cai and Marcelo Amaral as its own discipline came out in 2014 which became the landmark of producing knowledge on the Triple Helix Model.

The disciplinary norm view posits that there are large differences in publication productivity and commercialization opportunities across disciplines. These are determined primarily by the traditions, methodologies, and reward structures of each discipline (Teodorescu, 2000; in Halilem, 2010). A typology was used to differentiate disciplines: Physical sciences and Engineering (Chemical Engineering, Chemistry, Computer Science, Earth and Planetary Sciences, Energy, Engineering Materials Science, Mathematics, Physics, and Astronomy); Life sciences (Agricultural and Biological Sciences; Biochemistry, Genetics, and Molecular Biology; Environmental Science; Immunology and Microbiology; Neuroscience); Health sciences (Medicine and Dentistry, Nursing and Health Professions, Pharmacology, Toxicology and Pharmaceutical Science, Veterinary Science, and Veterinary Medicine); and Social Sciences and Humanities (Arts and Humanities, Business, Management and Accounting, Decision Sciences, Economics, Econometrics and Finance. Psychology, and Social Sciences). These four sets of disciplines were equally studied in literature. However, when considering the differences between the focus, Social Sciences and Humanities were studied more in the case of Research (35%), but less in the case of Entrepreneurialism (13%). Physical Sciences and Engineering were studied more in the case of Entrepreneurialism (35%). One explanation is that researchers in Physical Sciences and Engineering are significantly more involved in knowledge transfer than their colleagues in other research fields (Landry et al., 2006; in Halilem, 2010); they obtain substantially more industry funding and thus commercialize more than the other disciplines (Harman, 2001; in Halilem, 2010).

The Triple Helix of innovation has attracted considerable attention in both developed and developing economies as an integral policy making tool to enhance innovation and promote economic development (Etzkowitz & Leydesdorff, 1997; in Razak & White, 2015). Specifically, it advocates the strengthening of collaborative relationships between (1) academia (university; novelty production), (2) industry (business; wealth generation), and (3) government (state; public control) and networks, putting a particular emphasis on “trilateral networks and hybrid organizations”, where those helices overlap in a hybrid fashion to improve innovation (Etzkowitz & Leydesdorff, 2000, pp. 111-112; Leydesdorff & Meyer, 2006).

Clearly some senses of the changes were heralded earlier in the 20th century in the first real steps then taken towards building academic industrial links, notably those originated at MIT, by Vannevar Bush and his colleagues at MIT. Similarly, the research corporation, founded by Frederick Cottrell, a professor of chemistry at the University of California Berkeley, introduced the principle of utilizing income generated by patents to seed-fund new research. A potentially self-generating system of research funding was initiated that was subsequently expanded by the government. This contrasted with many European, Asian and Latin American countries where basic and even applied research was pursued in government institutes (Etzkowitz, Webster, Gebhardt, & Terra, 2000, p. 317). When the Helix Model became popular, some case studies revealed that countries like Korea, Mexico, Brazil, Ghana, Indonesia, Malaysia, and India (Saad & Zawdie, 2011) adapted this model. This reveals how the Triple Helix Model is becoming a global phenomenon that is formulated as a model for helping with the explanation of a phenomena (Smith & Leydesdorff, 2012).

Routes of the Triple Helix Model

The evolution of the Triple Helix Model may have different trajectories in different institutional contexts. Etzkowitz and Leydesdorff (2000) distinguish three types of Triple Helix Models, namely the ‘statist model’, the ‘laissez-faire model’, and the 'balanced model' (Ranga & Etzkowitz, 2013). The path to the Triple Helix begins from two opposing standpoints: a statist model of government controlling academia and industry, and a laissez-faire model with industry, academia, and government separate and apart from each other, interacting only modestly across strong boundaries.

Statist Society

In his book Etzkowitz (2008, p. 13) has described dominant institutional spheres in some countries. Industry and the university are subordinate parts of the state. When relationships are organized among the institutional spheres, the government plays the coordinating role. In this model, the government is expected to take the lead in developing projects and providing the resources for new initiatives. Industry and academia are seen to be relatively weak institutional spheres that require strong guidance, if not control. The statist model relies on specialized organizations linked hierarchically by the central government. Translated into science and technology policy, the statist model is characterized by specialized basic and applied research institutes, including sectoral units for industries. Universities are largely teaching institutions, distinct from industry.

The statist model often carries with it the objective that the country should develop its technological industry separately from what is happening in the rest of the world. In Europe this model can be seen in terms of companies that are expected to be the dominant national leader in a particular field, with the government supporting those companies, such as the Bull computer company in France.

Laissez-Faire Society

In this model, the university is a provider of basic research and trained persons. Its role in connection with industry is to supply knowledge, mainly in the form of publications and graduates who bring tacit knowledge with them to their new jobs. It is up to industry to find useful knowledge from the universities without expectations of much assistance. Industry is also expected to operate on its own, with firms linked to each other by the market relationships of buying and selling. There is expected to be intense competition among firms, with collaboration forbidden.

In the Laissez-faire model the role of government is expected to be limited to clear cases of “market failure” when economic impetuses by themselves do not call an activity into existence. There is expected to be only limited interactions between university, industry, and government in a Laissez-faire regime. When there are inter-actions and interrelationships among the spheres, they are expected to take place across strongly defended boundaries preferably through an intermediary. For example, many years before US universities became directly involved in patenting and research there was an organization called the research cooperation, an independent not-for-profit organization.

Balanced Model

The above-mentioned two different routes (statist and laissez-faire society) gave birth to the third route i.e., known as The Triple Helix Model (Etzkowitz, 2003; in Hladchenko & Pinheiro, 2018) to which scholars addressed it as an ideal or balanced or hybrid model that includes the relationship between the three spheres (academia, industry, and government) (Viale & Etzkowitz, 2010). According to Etzkowitz and Klofsten (2005; in Razak & White, 2015), the hybrid Triple Helix Model can be described as characterized by the following elements:

a. a prominent role for the university in innovation, on

b. a par with industry and government in a knowledge-based society

c. a movement towards collaborative relationships among the three major institutional spheres in which innovation policy is an outcome of their interactions rather than a prescription from the government.

d. In addition to fulfilling their traditional functions, each institutional sphere also "takes the role of the other" (Etzkowitz & Klofsten, 2005, p. 245; Cai, 2015, p. 12; Razak & White, 2015).

The emerging demands for cooperation (partnership) with others address challenges that gradually lead to the second stage of Triple Helix development, where internal transformation is characterized by 'taking the role of the other', (Etzkowitz, 2008, p. 9) and ‘take the view of the other’ (Etzkowitz & Viale, 2010, p. 602). This means that, in addition to performing its traditional (as primary activities), each takes the role of the other (as secondary activities), but meanwhile university, university or government retain their respective primary roles and distinct identities (Cai, 2015, p. 12). Thus, taking the role of the other can also be perceived as organizations learning from each other and as a way of organizational innovation (Cai, 2015).

Knowledge Production

Knowledge production has become the part and parcel of the Triple Helix studies which has been applied by most of the scholars who studied on the Triple Helix Model. The author team of Gibbons et al., (2010) distinguish between two different modes of knowledge production, and they are “Mode 1” and “Mode 2” which has been critically analyzed by Carayannis and Campbell (2010, 2018).

Mode 1 refers to a form of knowledge production- a complex of ideas, methods, values, norms-that has grown up to control the diffusion of the Newtonian model to more and more fields of inquiry and ensure its compliance with what is considered sound scientific practice. Mode 1 is meant to summarize in a single phrase the cognitive and social norms which must be followed in the production, legitimation, and the diffusion of knowledge of this kind. For many, Mode 1 is identical with what is meant by science (Gibbons et al., 1994/2010, p. 3). Mode 1 focuses on the traditional role of university research in an elderly "linear model of innovation” understanding. This reflects basic university research which converts into applied research and finally transforms into applied research to experimental development (Carayannis & Campbell, 2009, p. 210). The basic university research is interested in “first/basic principles” and "discoveries”, with a disciplinary research structure, where quality is controlled primarily by disciplinary peers or a disciplinary peer review process. This disciplinary peer exercises a strong quality gatekeeper function and represents a university (higher education) system with powerful hierarchies, built into the institutions (Gibbons et al., 2010).

Success in Mode 1 (of Mode 1 university research) is defined as a quality or excellence that is approved by hierarchically established peers: “Success in Mode 1 might perhaps be summarily described as excellence by disciplinary peers” (Gibbons et al., 2010). Mode 1 is not concerned with the application, diffusion and use of knowledge and Mode 1 does not focus on features in relation to problem-solving for the society or the economy. Non-linear innovation models are of no major concern for Mode 1.

“Non-linear models of innovation”, on the contrary, underscores a more parallel coupling of basic research, applied research and experimental development. Thus, Higher Education Institutions (HEIs) in general, university-related institutions and firms join together in variable networks and platforms for creating innovation networks and knowledge clusters (Carayannis & Campbell, 2009, p. 210). Mode 2 knowledge production, on the contrary, can be characterized by the following five principles: (1) "knowledge produced in the context of application"; (2) "trans-disciplinarily”; (3) “heterogeneity and organizational diversity"; (4) "social accountability and reflexivity”;

(5) and "quality control" (Carayannis & Campbell, 2010, p. 9). Mode 2 represents a "problem solving which is organized around a particular application" and where "Knowledge production becomes diffused throughout society. This is why we also speak of a socially distributed knowledge" (Gibbons et al., 2010). In Mode 2 the terms "discovery", "application" and "fabrication" (also fabrication of knowledge) overlap. Continuous communication and negotiation between knowledge producers are crucial. Manifold network arrangements are a necessary feature for linking together knowledge producing sites "through functioning networks of communication" (Gibbons et al., 1994, p. 6; in Carayannis & Campbell, 2010, p. 9).

Analytically the set of attributes is used to allow the differences between Mode 1 and Mode 2 to be specified with some clarity. To summarize using terms which will be explored more fully below; in Mode 1 problems are set and solved in a context governed by the, largely academic, interest of a specific community. By contrast, Mode 2 knowledge is carried out in the context of application. Mode 1 is disciplinary while Mode 2 is transdisciplinary. [T]ransdisciplinarity refers to knowledge or research that frees itself of its specialized or disciplinary boundaries, that defines and solves its problems independently of disciplines, relating these problems to extra-scientific developments (Mittelstraß 1992, p. 250, translated; in Bunders, Broerse, Keil, Pohl, Scholz, & Zweekhorst, 2010). Mode1 is characterized by homogeneity, Mode 2 by heterogeneity. Organizationally, Mode1 is hierarchical and tends to preserve its form, while Mode 2 is more heterarchical and transient. Each employs a different type of quality control. In comparison with Mode 1, Mode 2 is more socially accountable and reflexive. It includes a wider, more temporary, and heterogeneous set of practitioners, collaborating on a problem defined in a specific and localized context (Gibbons et al., 2010, p. 3). Carayannis and Campbell (2018) defined Mode 1 as "academic excellence" and Mode 2 as "problem-solving."

Knowledge and Technology Transfer

Knowledge transfer (KT) has been identified as an essential element of innovation which drives competitive advantage in increasingly knowledge-driven economies and in which small firms have an important part to play (Lockett, Cave, Kerr, & Robinson, 2009, p. 265). Knowledge transfer means the two-way transfer of ideas, research results, expertise, or skills between one party and another that enables the creation of new knowledge and its use in:

a. The development of innovative new products, processes and/or services
b. The development and implementation of public policy.

Knowledge transfer will encourage the dissemination and assimilation of knowledge and stimulate engagement between wider society (including business, government and public) and the research community (RCUK, 2006b; in Lockett et al., 2009). It should note that the term knowledge transfer has become synonymous with a range of related terms, including dialogue (Ruddle 2000; in Lockett et al., 2009), exchange (Schartinger et al., 2002; Swart & Henneberg 2007; in Lockett et al., 2009) and translation

(Czarniawska & Sevon, 1996; in Savory, 2006; Lockett et al., 2009). The term knowledge transfer is used widely within government (HM Treasury, 2006; in Lockett et al., 2009), research councils (RCUK, 2006b; in Lockett et al., 2009), HEIs (Lambert, 2003; in Lockett et al., 2009) and agencies, such as Association for University Research and Industry Links (AURIL), as an overarching term which encompasses interaction between universities and industry.

Technology transfer and knowledge transfer are often used interchangeably as technology transfer involves the creation and uptake of new knowledge, while the creation and uptake of new knowledge usually imply the use of technology (Amesse & Cohendet, 2001; Gopalakrishnan & Santoro, 2004; Oliver & Liebeskind, 1998; in Landry, Amara, & Quimet, 2007, p. 563). Following Gopalakrishnan and Santoro (2004; in Landry et al., 2007, p. 563), technology transfer refers to a much more limited set of activities than knowledge transfer. In fact, technology and knowledge differ significantly in four aspects: purpose, degree of codification, type of storage and degree of observability. Technology refers to tools for changing the environment, while knowledge embodies theories and principles helping us to understand the relationships between causes and effects. Technology refers to codified information stored in publications, software, and blueprints, whereas knowledge tends to have a tacit component and is stored in people's heads. Technology is tangible and the impact of its use is precise while knowledge can be less tangible and the impact of its use is more amorphous (Landry et al., 2007).

Scholarly studies on research transfer have primarily concentrated on the commercialization of research and protected intellectual property. Knowledge transfer between universities and industry or government agencies has been tracked through patent data (Henderson, Jaffe, & Trajtenberg, 1998; Mowery, Sampat, & Ziedonis, 2002; in Landry et al., 2007, p. 563), citation analyses (Spencer, 2001; in Landry et al., 2007, p. 563), licensing (Thursby & Thursby, 2002; in Landry et al., 2007, p. 563), spin-off creations (Link & Scott, 2005; Lockett & Wright, 2005; O'Shea, Allen, Chevalier, & Roche, 2005; Powers & McDougall, 2005; Shane & Stuart, 2002; Zucker, Darby, & Armstrong, 2002; in Landry et al., 2007, p. 563), collaboration between universities and industry and/or government agencies (Cohen, Nelson, & Walsh, 2002; Irwin, More, & McGrath, 1998; Lee, 1996; Owen- Smith, 2002; Patel & Pablo d'Este, 2005; in Landry et al., 2007, p. 563), and assessment of university technology transfer offices (Rogers, Yin, & Hoffmann, 2000; Siegel et al., 2003; Trune & Goslin, 1998; in Landry et al., 2007, p. 563).

Thus, technology transfer is a two-way flow from university to industry and vice versa, with different degrees and the forms of academic involvement: (1) the product originates in the university but its development is undertaken by an existing form, (2) the commercial products originates outside of the university, with academic knowledge utilize to improve the product, or (3) the university is the source of the commercial product and the academic inventor becomes directly involved in its commercialization through establishment of a new company (Etzkowitz, 1998, p. 827).

Technology

A `Triple Helix' of academic-industry-government relations is likely to be a key component of any national or multinational innovation strategy in the late twentieth century. The focus on interactions between institutions of fundamental research `on the supply side' and corporations has not only been reflected in technology policies, but also in technology studies. Linear models of `demand pull' or `technology push' have been superseded by evolutionary models that analyze the developments in terms of networks (Nelson & Winter, 1982; Dosi et al., 1988; Leydesdorff & Van den Besselaar, 1994; in Etzkowitz & Leydesdorff, 1997). Nonlinear dynamics has provided us with co-evolutionary models: How do technologies and institutions co-evolve (Nelson, 1994; in Etzkowitz & Leydesdorff, 1997).

The Triple Helix (TH) model was emerged from workshop on Evolutionary Economics and Chaos Theory: New Directions in Technology Studies (Leydesdorff & Van den Besselaar, 1994; in Etzkowitz & Ledesdorff, 1997; Leydesdorff & Meyer, 2006) organized with the intention of crossing the boundaries between institutional analysis of the knowledge infrastructure, on the one hand (Etzkowitz, 1994; in Leydesdorff & Meyer, 2006), and evolutionary analysis of the knowledge base of an economy, on the other (David & Foray, 1994; Nelson, 1994; in Leydesdorff & Meyer, 2006). The evolutionary analysis focuses on the functions of selection environments in terms of outputs, whereas the historical analysis informs us about how institutions and institutional arrangements carry these functions (Andersen, 1994; in Leydesdorff & Meyer, 2006). In the call for papers for the first time the Triple Helix conference, Etzkowitz and Leydesdorff (1995) formulated this tension between the historical and evolutionary perspectives as follows: “Three sources of variation have been acknowledged in technology studies: (1) industrial sectors differ with respect to their relations to the technologies that are relevant for the developments in those sectors (Pavitt, 1984; in Leydesdorff & Meyer, 2006); (2) different technologies induce different patterns of innovation and diffusion (Freeman & Perez, 1988; Faulkner & Senker, 1994; Leydesdorff & Meyer, 2006); and (3) systems of innovation (national systems of innovation) integrate and differentiate the various functions differently (Lundvall, 1998; in Eom & Lee, 2010; Nelson, 1993; in Leydesdorff & Meyer, 2006). The variations, however, are both functional and institutional. The functional communications can sometimes be codified in new institutional settings; the institutional sectors (public, private and academic) that formerly operated at arm’s length are increasingly working together, with a spiral pattern of linkages emerging at various stages of the innovation process” (Etzkowitz & Leydesdorff, 1995, p. 15).

Knowledge Industries

Knowledge industries are those industries which are based on their intensive use of technology and/or human capital. While most industries are dependent in some way on knowledge as inputs, knowledge industries are particularly dependent on knowledge and technology to generate revenue. Some industries that are included in this category include education, consulting, science, finance, insurance, information technology, health service, and communications. The term "knowledge industry" was suggested by Austrian-American economist Fritz Machlup to describe these industries in the context of his new idea of the knowledge economy. He first proposed and popularized the ideas of knowledge industries and the knowledge economy in his 1962 book, The Production and Distribution of Knowledge in the United States (Nyiri, 2002).

Capitalization of Knowledge and Innovation

Capitalization of knowledge happens when knowledge generates an economic added value. The generation of economic value can be said to be 'direct' when one sells the knowledge for some financial, material, or behavioral good. The Triple Helix is a model for capitalizing knowledge in order to pursue innovation (Viale, 2010, p. 31).

According to Etzkowitz and Viale (2010) and Viale (2010, p. 32), the emergence of the new academic role of the Janus scientist who have followed two faces of Greek God, one who is able to interface both with the academic and industrial dimensions of research, reveals itself through the introduction of new institutional rules and incentives quite different from traditional academic ones. The need for stronger and more extensive face to face interaction is manifested through the phenomenon of the proximity between universities and companies and through the creation of hybrid organizations of R & D. Similarly, Viale and Etzkowitz (2010, p. 599) also coined a term 'Kali Scientist' for the new scientist who are focused on the generation of knowledge for innovation as a metaphor, like the many arms of the Hindu Goddess Kali, she uses different disciplinary approaches in problem solving.

Knowledge can be subdivided into the categories ontic and deontic (Viale, 2010). Ontic knowledge analyses how the world is, whereas deontic knowledge is focused on how it can be changed. These two forms of knowledge can be represented according to two main modes: the analytical mode deals with the linguistic forms that we used to express knowledge; the cognitive mode deals with the psychological ways of representing and processing knowledge (Viale, 2010, p. 33).

The term or concept of innovation can have several meanings. Innovation may mean "change" only or can also refer to an "improvement" or "betterment." As stated by Phan (2004; in Batala, Regmi, Sharma, & Ullah, 2019, p. 411) innovation did not equate to invention. Schumpter (2006; in Batala et al., 2019) redefined that inventions were were connected with basic scientific or technological research, while innovations were further developments of these, or the application of bright ideas. According to the Thompson's (1965; in Batala et al., 2019), definition "innovation is the generation, acceptance and implementation of new ideas, processes products or services".

In a modern sense, innovation is being understood mostly as knowledge-based or knowledge-driven. So how can there be a change, improvement, betterment, or reform, which is leveraging, using, and applying knowledge? The history of science and technology relates to the invention of methods, tools, and techniques, and it investigates how emerging knowledge has enabled people to create new things and systems (McNeil 1990; Bijker, Hughes, & Pinch 2012; in Hjalager, 2015). Further, the history of science and technology examines how humanity's understanding of the natural world (science) and ability to manipulate it (technology) have changed over time. As an academic discipline, it also addresses the cultural, economic, and political impacts of scientific inventions and innovations. While knowledge production (or knowledge creation) is often associated closer to research (R&D innovation expresses a focus of utilizing knowledge for economic (economy), social (society), and political (democracy) purposes. In that sense, mature innovation and innovation systems require a knowledge base or knowledge production (Carayannis & Campbell, 2018).

Innovation can be traced back to innovative individuals, the 'entrepreneurs', in Schumpeter's major piece of work entitled 'The theory of economic development' published in German in 1912 and first translated into English in 1934 (Schumpeter, 1983; in Nguyen, 2022). The field of innovation studies was established later in the late 1950s (Martin, 2012; in Nguyen, 2022). These days, the definition of innovation often aligns with what Schumpeter underlined about novelty, yet the types of innovation are varied, and the importance of innovation goes beyond its conventional economic value (Cajaiba-Santana, 2014; De Vries et al., 2016; in Nguyen, 2022).

Innovation is a complex process involving a significant number of actors and sources of learning, knowledge, and skills (EU, A Background Paper, 2008; in Bouraoui et al., 2011). A Triple Helix Model of university-industry-government as relatively equal, interdependent, and inter-acting institutional spheres is increasingly becoming the requisite basis for innovation and development in a knowledge-based society (Etzkowitz & Dzisah, 2008). Innovation takes on a new meaning as the spirals of the triple helix intertwine. Innovation is one of the main engines of long-term economic growth and is closely linked with knowledge which is the major value creating factor in modern society. The word knowledge refers to the theoretical or practical understanding of a subject. Knowledge is also associated with expertise and skills gained by a person through experience or education. Knowledge is produced through research. There are two different types of research: curiosity- driven research and technology- driven research.

There are clear indications that the conceptualization and contextualization of knowledge have become increasingly broader. Knowledge creation and production was and still is being extended to knowledge application, diffusion, and use, incorporating ideas of innovation. Knowledge users out in the practical fields are just as important as knowledge producers (knowledge creators), and, depending on the specific constellation or network configuration (for example, in a non-linear innovation arrangement), the same person or institution can act as a knowledge producer and/or knowledge user (Carayannis & Campbell, 2010).

In fact, innovation which refers to the reconfiguration of elements into a more productive combination (Etzkowitz, 2008), has taken on a broader meaning within the context of an economic structure predicated on knowledge. The implicit understanding inherent in this new transformation is that we are dealing with a new logic of 'innovation in innovation' based upon the restructuring and enhancement of the organizational arrangements and incentives that foster creativity. Based on these calculations, the university is increasingly being viewed as the institution capable of taking up, in addition to its traditional roles of knowledge production, preservation, and transmission, the task of socio-economic development and regional innovation. This ambitious mandate is derived from the growing awareness that productivity and global competitiveness are based on the constant production, mobilization, and generation of both new and reformulated knowledge (Castells 1996; in Dzisah, & Etzkowitz, 2012).

The Network Society

The new society is made up of networks. Networks are, however, a very old form of social organization. But throughout history, networks have had major advantages and a major problem. Social network theory is an umbrella term for theories that focus on individuals, teams and organizations, and the web of interpersonal relationships that both constrain and enable human action in these social systems. The problem was the embedded inability of networks to manage complexity beyond a critical size. Networks were historically useful for personal interaction, for solidarity, and for reciprocal support. But they were bad performers in mobilizing resources and focusing these resources on the execution of a given task. Large, centralized apparatuses usually outperformed networks in the conduct of war, in the exercise of power, in symbolic domination, and in the organization of standardized, mass production. Yet this substantial limitation of networks & competitive capacity was overcome with the development of new information/communication technologies, epitomized by the Internet. Electronic communication systems give networks the capacity to decentralize and adapt the execution of tasks, while coordinating purpose and decision making. Therefore, flexibility can be achieved without sacrificing performance. Because of their superior performing capacity, networks, through competition, are gradually eliminating centered, hierarchical forms of organization in their specific realm of activity (Castells, 2000, p. 695).

A network is a set of interconnected nodes. Networks are flexible, adaptive structures that, powered by information technology, can perform any task that has been programmed in the network. They can expand indefinitely, incorporating any new node by simply reconfiguring themselves, on the condition that these new nodes do not represent an obstacle to fulfilling key instructions in their program. For instance, all regions in the world may be linked into the global economy, but only to the point where they add value to the value-making function of this economy, by their contribution in human resources, markets, raw materials, or other components of production and distribution. If a region is not valuable to such a network, it will not be linked up; or if it ceases to be valuable, it will be switched off, without the network as a whole suffering major inconvenience. Naturally, networks based on alternative values also exist, and their social morphology is like that of dominant networks, so that social conflicts take the shape of network-based struggles to reprogram opposite networks from the outside. How? By scripting new codes (new values, for instance) in the goals organizing the performance of the network. This is why the main social struggles of the information age lie in the redefinition of cultural codes in the human mind. The network enterprise, as a new form of business organization, is made of networks of firms or subunits of firms organized around the performance of a business project. Governance relies on the articulation among different levels of institutional decision making linked by information networks. And the most dynamic social movements are connected via the Internet across the city, the country, and the world (Castells, 2000, p. 695).

The prevalence of networks in organizing social practice redefines social structure in our societies. According to Castells (2000), "social structure means the organizational arrangements of humans in relationships of production/consumption, experience, and power, as expressed in meaningful interaction framed by culture". In the Information Age, these specific organizational arrangements are based on information networks powered by microelectronics-based information technologies (and in the near future by biologically based information technologies) (Castells, 2000, p. 695). Under the conditions of this new, emerging social structure, sociology must address several conceptual and methodological issues in order to be equipped to analyze core processes of social organization and social practice (Castells, 2000, pp. 695-696).

Collaboration

The collaboration between science and technology became intense at its origin as university came into the scene as an engine when industry started to support the process, and government also functioned as an acceleration that had encouraged, structured, and funded these discoveries. Therefore, academy-industry relations as well as government support, directly and indirectly had resulted in the micro-inventions in the sectors of biotechnologies and information & communication technologies (Viale & Etzkowitz, 2010, p. 598). Research collaboration takes formal (personal or research exchange; joint research, contract research, consulting, patent and publications or industry- funded laboratories) informal (meetings/conferences) mechanisms (Abbasnejad et al., 2011; in Sobaih & Jones, 2015, p. 162).The Council on Government Relations (1995; in Sobaih & Jones, 2015) in the US has listed six mechanisms for university-industry research collaboration : sponsored research, collaborative research, consortia, technology licensing, star-up companies and exchange of research materials.

Viale & Etzkowitz (2010, p. 598) argued that integration means more than collaboration. Therefore, integration between research in different fields and between academia and industry can reinforce the global role of the universities-from basic science to innovation and production-the development of less specialized universities with a wider disciplinary scope and the birth of a new scientist who integrates knowledge and innovation as in the entrepreneurial model. Moreover, such scientists also synthesize different kinds of disciplinary knowledge, for example life sciences and informatics or life sciences and nanotechnology or cognitive science and informatics or cognitive sciences and biotechnology, and like Leroy Hood, formerly of the California Institute of technology and the University of Washington, are involved in the creation of new disciplines from synthesis of elements of previous ones, as in bioinformatics (Viale & Etzkowitz, 2010, p. 598).

Triple Helix and Academia

According to Bhattrai (2019), Technical and Vocational Education and Training (TVET) is an integral part of the national education system in all societies. It involves the study of technologies and related sciences, and acquisition of practical skills, attitudes, understanding, and knowledge relating to occupations in various sectors of economic and social life and prepares people for the world of work. Bhattarai (2019, p. 8) follows four pillars of education on the basis of Delor's (1996; in Bhattarai, 2019, p. 8) report. The report provides the concept of four pillars of education: learning to know, learning to do, learning to be, and learning to live together. The first pillar: learning to know focuses on the development of skills and knowledge needed to take benefits and function in this world. Acquisition of literacy, numeracy, critical thinking, and general knowledge are some of the examples. The second pillar: learning to do highlights the learning of skills that would enable individuals to effectively participate in the global economy and society. It is the acquisition of applied competencies linked to professional success. The third pillar 'learning to be' emphasizes the learning that contributes to a person's mind, body, and spirit. The fourth pillar 'learning to live together' places emphasis on the development of social skills and values such as respect and concern for others, and the appreciation of cultural diversity (Delor’s, 1996; in Bhattarai, 2019, p. 8). UNESCO's Education for Sustainable Development Initiative (2012; in Bhattarai, 2019, p. 8) added one more pillar: learning to transform oneself and society. When individuals and groups gain knowledge, develop skills, and acquire new values as a result of learning, they are equipped with tools and mindsets for creating lasting change in organizations, communities, and societies (Bhattarai, 2019, p. 8). Bhattarai (2019, p. 9) in his study has proposed that if Nepal incorporates the Triple Helix Model with five pillars of education in TVET curricula then it would support in stopping forceful migration abroad in search for job opportunities.

Teaching

In this case, the decision process can be described as a problem-solving or invention process. As is to be shown later, the problem-solving process is the place where creativity comes into play. But beforehand, the concept of creativity must be defined. Creativity is normally discussed in the context of the characterizations of creative products, creative processes, and creative persons (Funke, 2000; in Leydesdorff, 2013). Creative products are developed by creative persons in a creative process and are normally (Linneweh, 1978; Schlicksupp, 1999; Sternberg & Lubart, 2002; in Leydesdorff, 2013) characterized as new, i.e., different from already existing products and as useful and practical at the same time.

In order to describe how a creative disposition may influence teaching, it is important to have a look at the process which takes place before a teacher acts, independent whether it is an act of designing lessons or an act of interacting in class. In both cases, this process preceding action is a decision process that results in the decision on how to act. To describe this process in more detail, it can be divided into three sub-processes (Hanke, 2011; Leydesdorff, 2013): (1) the subprocess of perceiving the environment,

(2) the subprocess of activating possibilities of how to act, and (3) the subprocess of choosing one of these possibilities (Leydesdorff, 2013). Each of these three sub processes is influenced by internal and external conditions. External conditions are those aspects of the environment that teachers perceive, e.g., location, media available, number of pupils, etc. Internal conditions are the teachers' knowledge (Neuweg, 2011; in Leydesdorff, 2013), their beliefs (Pajares, 1992; in Leydesdorff, 2013), their experiences, their emotions (Hascher & Krapp, 2009; in Leydesdorff, 2013) and motivation (Krapp & Hascher, 2009; in Leydesdorff, 2013), their skills, etc., and perhaps their creative disposition as well (Hanke et al., 2011; in Leydesdorff, 2013).

According to Leydesdorff (2013), concerning teaching, a creative disposition may influence the way that teachers act because creativity influences the decision process that precedes action. As mentioned above, it can be assumed that creative people are able to perceive (subprocess 1) their environment differently because they do not rely only on their schemata. Additionally, they will also be able to create new but nevertheless useful possibilities of how to act and do not only activate their existing schemata (subprocess 2). Concerning the third subprocess of the decision process, it is assumed that a creative disposition may lead to a different evaluation of the possibilities and therefore to a different choice of how to act.

The knowledge as well as the beliefs of a teacher influence the way teaching takes place and the results of the teaching process (Pajares 1992; Neuweg 2011; in Leydesdorff, 2013). But knowledge and beliefs are not the only factors influencing the teaching process. Since under certain conditions teaching can be described as a problem-solving process, i.e., as an invention process, it seems probable that the creative disposition of the teacher may be another factor that influences the teaching process (Hanke et al. 2011; in Leydesdorff, 2013).

Learning

Learning and capability/competence can be seen as linked ideas. Competence is an ability to single-loop learn with respect to use and development of technology. Capability is the ability to double-loop learn with respect to use and development of technology while dynamic capability is an example of triple-loop learning (Savory, 2006).

As per Savory (2006), applying three levels of learning to the RBVF (resource-based view of firm) suggests three parallels:

a. Single loop learning relates to the concept of competence. Competence is based on the development of the ability to operate with set conditions, making adjustments accordingly. Thus, competence in an area such as stress analysis can be seen as based on single loop learning to apply the methods of analysis in new situations.

b. Double-loop learning relates to the concept of capability as it is concerned with re-organizing following a reassessment of the underlying assumptions of a situation. Thus, the capability to reconfigure what and how competences are used within specific settings requires the application of double-loop learning.

c. Triple-loop learning relates directly to dynamic capability. It requires the understanding of not just how to configure sets of competences, but also the way new competences can be acquired. There is a significant requirement for dynamic capability to encapsulate effective and critically operated knowledge management practices.

Future Universities

In the last two centuries, there have been several revolutions in university missions globally. The first academic revolution in the 19th century in the US made research an explicit academic mission-learning and teaching (Jenks & Riesman, 1968; in Sobaih & Jones, 2015) and is by no means finished in many universities worldwide (Etzkowitz, 1998). Despite continuing industrial growth, universities in some developing countries remained resolutely focused on the first university mission and have not embraced the second mission (research) in the same way as universities in developed countries, e.g., US (Etzkowitz & Leydesdorff, 2000). In the late 20th century, a second revolution took place, notably in the US and some parts of Europe and Asia, to include issues relating to economic and social development as a part of a university ‘third mission' (Etzkowitz, 1998; in Sobaih & Jones, 2015). In the early 21st century, a third academic revolution took place-again in the US and Europe-based upon the entrepreneurial university concept embedded in the Triple Helix Model of university-industry-government reciprocal relations (Etzkowitz & Viale, 2010). Schofield (2012) explained that entrepreneurial universities have become the centers of gravity for economic and social development and knowledge creation. The rise of an entrepreneurial university model that incorporates classic ivory tower and Humboldtian elements with a culture of entrepreneurship, innovation, and technology transfer. The emergence of polyvalent knowledge, in such areas as biotechnology, computer science and nanotechnology, that is at one and the same time theoretical and practical; patentable and publishable (Viale & Etzkowitz, 2010, p. 4).

Alexander and Manolchev (2020) placed the Classic Humboldtian model of the world’s research intensive (RI) or research-led universities (Classic: RI) close to the origin point, as the most structurally constrained and, as noted by Alexander & Miller (2017; in Alexander & Manolchev, 2020) the least responsive to demand pressures. Also scoring low on structural flexibility, the above-mentioned scholars place former technical or polytechnic institutions (in the UK named the ‘new’ or ‘92 group of universities’) slightly further along the structural flexibility and demand responsiveness axes. This is due to the commercial, competitive and efficiency pressures that they have faced in the past 15 years (Cranfield and Taylor, 2008; in Alexander & Manolchev, 2020), brought about by their wider range of programs (such as foundation degrees or professional-body recognized qualifications) and greater onus on employment-readiness and the transition into work (Alexander & Manolchev, 2020).

Universities, or HEIs in more general, have three main functions: teaching and education, research (research and experimental development, R&D), and the third mission activities, for example, innovation (Campbell & Carayannis, 2013b, p. 5; in Carayannis

& Campbell, 2014; Carayannis & Campbell, 2018). In reference to "arts universities," now the question and challenge arises, whether, to which extent and in which way the arts universities differ from the (more traditional) universities in the sciences. Arts universities obviously place an emphasis on the arts, and the arts are not identical with the sciences. However, arts universities frequently make references to the sciences, thus also arts universities can express competences in teaching and in carrying out research in the sciences. The other major challenge of arts universities is to engage in "artistic research" and "arts-based innovation." By this, arts universities (and other higher education institutions in the arts) are also being linked to and are being interlinked with national innovation systems and multilevel innovation systems. This widens the whole interdisciplinary and transdisciplinary spectrum of higher education systems. Hybrid and innovative combinations of universities of arts and universities of the sciences are possible and indicate organizational opportunities for promoting creativity (Campbell & Carayannis, 2013b, p. 5; in Carayannis & Campbell, 2014; Carayannis & Campbell, 2018).

Placed higher on the structural flexibility axis than the Classic model but not significantly higher on the demand axis, the need for employment-readiness is even greater for Entrepreneurial universities. This model represents an extension of the current model of Further Education Colleges which, in certain instances, are delivering university-level teaching. Also in this category are non-full-service institutions (such as some specialist Management Colleges/Academies), or others who lack Research-degree Awarding Powers. Thus, we envisage Entrepreneurial universities to be working directly with employers, perhaps delivering apprenticeships, T-Level qualifications and aligned with the nations' skills policy (Gallagher and Reeve (eds.), 2018; in Alexander & Manolchev, 2020). At the opposite-corner of the framework, combining high-levels of responsiveness (e.g., a digitally enabled model) but lower levels of structural flexibility, is the Interactive university. This model is built around speaker/knowledge-replicators and applied knowledge disseminators, relying on knowledge creating (Classic) institutions to sense demand signals from the market and to create new knowledge to fill these demands. This reliance on 'classic' sources of knowledge-creation renders platform universities relatively structurally tied, as diffusers of knowledge and 'observatories', rather than research houses.

Figure 1

University of the Future

2nd Order Categories	University of the Future
Wicked problem focused	
Cross-disciplinary, systems-thinking	Platform
Embracing technology and virtual business models	
Enterprise/ Employability-focused	
Real-life skills for 'studentpreneurs'	Entrepreneurial
Community impact	

Technology and AI focused	
Knowledge co-created by students, employees, technology	Interactive
Fields and subjects change with rise of AI	
Knowledge-creation focused	
Connecting research and education	Classic (Poly and RI)
Knowledge originates in academia and disseminated outside	

Note. Alexander and Manolchev (2020).

Conclusion

The Triple Helix as a model refers to the interaction between three institutional spheres i.e., academia, industry, and government is an internationally recognized model for understanding entrepreneurship, the changing dynamics of universities, innovation, and socio-economic development which is the new outcome of the 1990s. Henry Etzkowitz and Loet Leydesdorff (1995, 1997, 1998, 2000, pp. 11-112) propounded a theory known as Triple Helix which has become a research hub (Hattangadi, 2022). The term 'helix' is 'sphere' and the need for their collaboration for sustainability gave birth to the concept of helix models that came into existence in different periods of industrial revolution. The First Industrial Revolution (1784), the Second (1870) and the Third (1969). Likewise, each academic revolution is mirrored by an industrial revolution. 1) First academic revolution-19th century -learning and teaching; 2) Second academic revolution-20th century-Economic and Social Development; and 3) Third Academic revolution-21st century- Entrepreneurial University- Triple Helix (Sobaih & jones, 2015, p. 163). In the first industrial revolution, knowledge was little formalized, made of practical know-how generated by a series of individual experiments and trial and error. As a result, there is little collaboration inside the university and almost no collaboration between the university and industry. Hence, this model is a single helix (Viale & Etzkowitz, 2010, p. 599). In the second industrial revolution there was weak interaction with the government and this model is the double helix. Hence, the Triple Helix Model came into existence.

Etzkowitz and Leydesdorff (2000) distinguish three types of Triple Helix Models, namely the 'statist model", the 'laissez-faire model', and the 'balanced model'. The path to the Triple Helix begins from two opposing standpoints: a statist model of government controlling academia and industry, and a laissez-faire model with industry, academia, and government separate and apart from each other, interacting only modestly across strong boundaries. After that, knowledge production has become the part and parcel of the Triple Helix studies which are based on different modes of knowledge production, and they are "Mode 1" and "Mode 2".

Gibbons et al. (1994/2010) defined Mode 1 as "academic excellence" and Mode 2 as "problem-solving." Similarly, technology transfer and knowledge transfer are often used interchangeably as technology transfer involves the creation and uptake of new knowledge, while the creation and uptake of new knowledge usually imply the use of technology (Amesse & Cohendet, 2001; Gopalakrishnan & Santoro, 2004; Oliver &

Liebeskind, 1998; in Landry, Amara, & Quimet, 2007, p. 563).

The capitalization of knowledge happens when knowledge generates an economic added value. Knowledge can be subdivided into the categories ontic and deontic (Viale, 2010). Ontic knowledge analyses how the world is, whereas deontic knowledge is focused on how it can be changed. Therefore, the term "knowledge industry" to describe in the context of his new idea of the knowledge economy was suggested. Knowledge industries are those industries which are based on their intensive use of technology and/or human capital. Some industries that are included in this category include education, consulting, science, finance, insurance, information technology, health service, and communications (Nyiri, 2002). Similarly, there is a concept of innovation used extensively in this study which may mean "change" only or can also refer to an "improvement" or "betterment." Innovation is a complex process involving a significant number of actors and sources of learning, knowledge, and skills (EU, A Background Paper, 2008; in Bouraoui et al., 2011). This study of the Triple Helix Model strongly emphasizes collaboration between science and technology. Likewise, social network theory is an umbrella term for theories that focus on individuals, teams and organizations, and the web of interpersonal relationships that both constrain and enable human action in these social systems.

Finally, in the last two centuries, there have been several revolutions in university missions globally. Schofield (2012) explained that entrepreneurial universities have become the centers of gravity for economic and social development and knowledge creation. Universities, or HEIs in more general, have three main functions: teaching and education, research (research and experimental development, R&D), and the third mission activities, for example, innovation (Campbell & Carayannis, 2013b, p. 5; in Carayannis & Campbell, 2014; Carayannis & Campbell, 2018).

If the disjuncture between theory and invention is accepted, the appearance of entrepreneurial scientists is an anomaly (Aitken 1976; in Etzkowitz, 2012). The phenomenon of academic scientists commercializing must be one that goes beyond the availability of investment funds since earlier generations of scientists, such as Pasteur and the Curies, seldom took advantage of commercial opportunities (Etzkowitz 1983). The first phase of entrepreneurial science is the internal development of academic research groups as “quasi-firms.” The second phase refers to academic participation in the externalization and capitalization of knowledge in tangible products and distance learning courseware. As universities spin-off for-profit entities from their research and educational activities, and fund some of their own research, they shift their institutional focus from eleemosynary to self-generation. The ability to balance among multiple sources of support, including industry, state and local government and self-funding can be expected to increase the independence of the university.

The Triple Helix Model provides an incentive to seek unevenness between the institutional dimensions in the arrangements and social functions performed by such arrangements. The friction between the two layers (based on knowledge of expectations and institutional interests) and between the three domains (economics, science, and politics) provides a wealth of opportunities for solving puzzles and innovation. It is noteworthy to understand that the Triple Helix Model is the focus of the operational strategy to promote regional development and knowledge-based economies. Likewise, markets and sciences operate at a global level, not in line with stimuli confined to institutions and inter-institutional agreements. Therefore, the Triple Helix Model is a neo-evolutionary model of possible synergies between functions such as wealth creation, knowledge production and government regulations, which are the three helixes (Leydesdorff, 2012). This is formulated as a model for helping with the explanation of a phenomena (Smith & Leydesdorff, 2012).

The Triple Helix Model was tested and successfully implemented in developed countries and the model is seen to be adapted gradually in developing countries too. This shows the popularity of the Triple Helix Model throughout the world. The countries where this model has not been studied and implemented yet, are advised to develop this model in any form of Triple Helix Model as indicated by Bhattarai (2019). This study will be helpful to those who are involved in academia, industry, and policy makers. Research on the Triple Helix Model should be continued in academia.

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