THE TRIPLE HELIX KNOWLEDGE TRANSFER PARTNERSHIP ALONG THE INNOVATION SPECTRUM

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Abstract

This paper is based on the triple Helix knowledge transfer partnership along the innovation Spectrum. The triple helix innovation framework has been widely adopted and applied by policy makers has participated in the transformation of each Triple Helix systems provide a fine-grained view of innovation actors and the relationships between them, in a vision of a dynamic, boundary-spanning and diachronic transition of knowledge flows within the system. Triple Helix systems accommodate both institutional and individual roles in innovation and explain variations in innovative performance in relation to the development of and articulation between the knowledge, innovation and consensus spaces. Transcending sectoral or technology boundaries, Triple Helix systems emphasize boundary permeability among the institutional spheres as an important source of organizational creativity, allowing individuals to move within and between the spheres and engage in recombination of elements to create new types of organizations. Empirical guidelines for policy makers, university and business managers can be derived from this analytical framework, in order to strengthen collaboration among Triple Helix actors and enhance regional development.

Key Words: Triple, Helix, Knowledge, Transfer, Partnership, Innovation, Spectrum

Introduction

One of the most important challenges facing modern scientific entities is network cooperation with other organizations and a dialogue facilitating their access to information and knowledge. The essence of this relationship is well illustrated by the Triple Helix Model, which refers to network cooperation in the process of creating knowledge between the academic sector, industry and government. The aim of the study is to analyse and evaluate the relationships in the process of knowledge transfer between the academic sector and other entities working for knowledge-based economy according to the Triple Helix Model.

The early explorations on new perspectives on the role of academia and organised knowledge production in regional innovation, Etzkowitz and Leydesdorfff had consolidated the Triple Helix concept through either collaborative works (e.g. Etzkowitz & Leydesdorff, 1995, 2000) or individual publications (e.g. Etzkowitz, 2008; Leydesdorff, 2000). They developed the Triple Helix model to explain the dynamic interactions between academia, industry, and government that foster entrepreneurship, innovation, and economic growth in a knowledge-based economy (Etzkowitz & Leydesdorff, 2000). In research communities, there are continuous efforts to apply/enhance the Triple Helix model as well as criticisms on its limits or limitations. The 'innovation systems' concept was introduced in the late 1980s to examine the influence of

knowledge and innovation on economic growth in evolutionary systems, in which institutions and learning processes are of central importance (Freeman, 1987; Freeman and Lundvall, 1988). The systems perspective was used to understand better how institutional arrangements could facilitate interactions among economic actors in market as well as non-market transfer of knowledge (Carlsson, 2003). The concept was refined as 'national innovation systems' (NIS), which includes a set of innovation actors (firms, universities, research institutes, financial institutions, government regulatory bodies, and so on), their activities and their inter-linkages at the aggregate level (Freeman, 1988; Dosi et al, 1988; Lundvall, 1988, 1992; Nelson, 1993; Edquist, 1997, 2005).

Sometimes, the Triple Helix model is narrowly understood as a metaphor for the relationship between university, industry, and government. Indeed, this is a good metaphor, but more important is the theoretical rationale underlying the metaphor. For instance, Cai and Etzkowitz (2020) make explicit the five triple helix mechanisms. When reading the classic works of Etzkowitz and Leydesdorff on Triple Helix, one should notice several related concepts, such as spheres, spaces, functions, entrepreneurial universities, and academic revolutions. For instance, a literature review project led by Marcelo Amaral (Co-Editor-in-Chief of the journal) at the Triple Helix Research Group, Fluminense Federal University, consider how explicit these concepts are applied as a critical criterion to identify Triple Helix studies. Lacking a comprehensive understanding of these concepts, which are important parts of the Triple Helix thesis, often leads to misunderstanding and misusing the Triple Helix model in empirical studies (Cai & Lattu, 2021). This paper explores the partnership between triple helix knowledge transfer along the innovation spectrum

REVIEW OF RELATED LITERATURE

Conceptual Frame Work

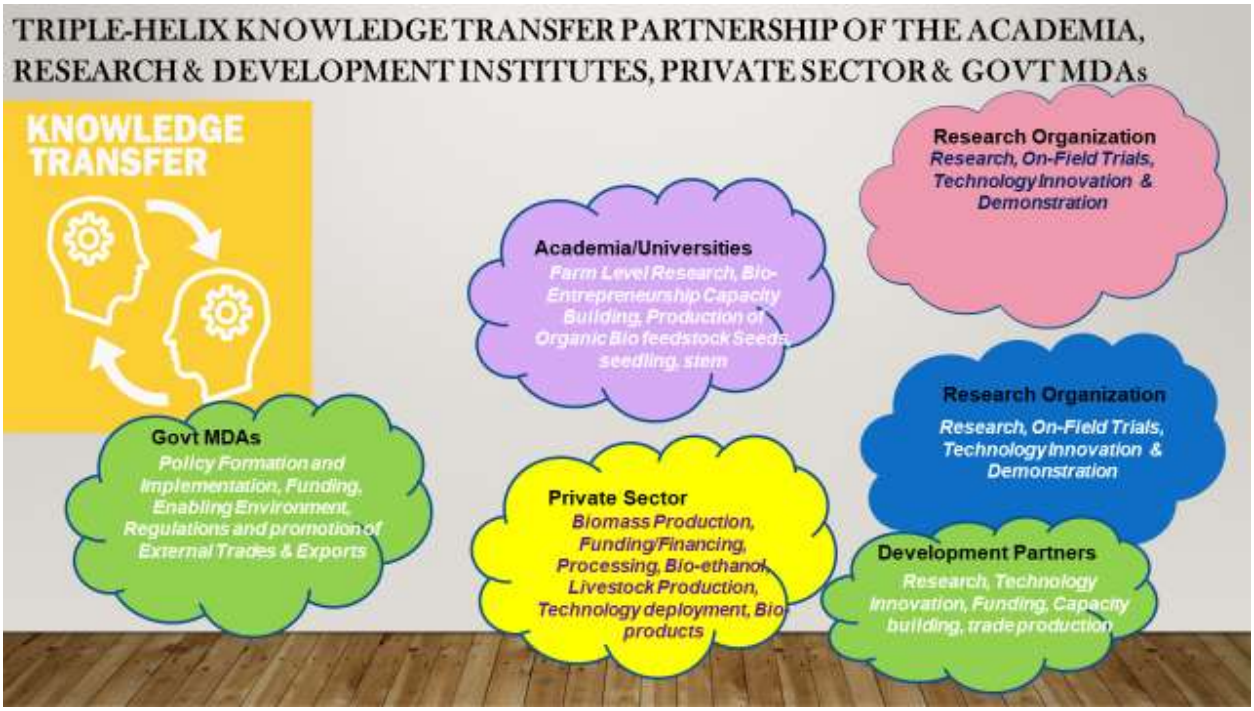
The entrepreneurial university and Triple Helix model are two closely interrelated concepts. One prerequisite of the Triple Helix model is that 'the university's enhanced relevance to technology transfer, firm-formation and regional renewal places it in a primary position in knowledge-based society in contrast to its secondary role in industrial society' (Cai & Etzkowitz, 2020, p. 195). Etzkowitz's thinking related to the Triple Helix model started from his conceptualisation of entrepreneurial university, initially labelled entrepreneurial science (Etzkowitz, 1983). The entrepreneurial university concept was further developed along with Etzkowitz and Leydesdorff's elaboration of the Triple Helix model. Etzkowitz (2004) proposed five principles/propositions of the entrepreneurial university concerning 1) Capitalisation, 2) Interdependency, 3) Independence, 4) Hybridisation, and 5) Reflexivity.

Etzkowitz and Zhou (2017) renewed the propositions in terms of five norms of the entrepreneurial university model, namely 1) Knowledge spilled-over, 2) Hybridisation, 3) Units as quasi-firms, 4) Entrepreneurial culture, and 5) Reflexivity. It should be mentioned that Clark (1998) and Röpke (1998) also proposed the entrepreneurial university concept in the same

period. They shared similar views with Etzkowitz on the major characteristics of an entrepreneurial university (Etzkowitz et al., 2017).

Academic Revolutions

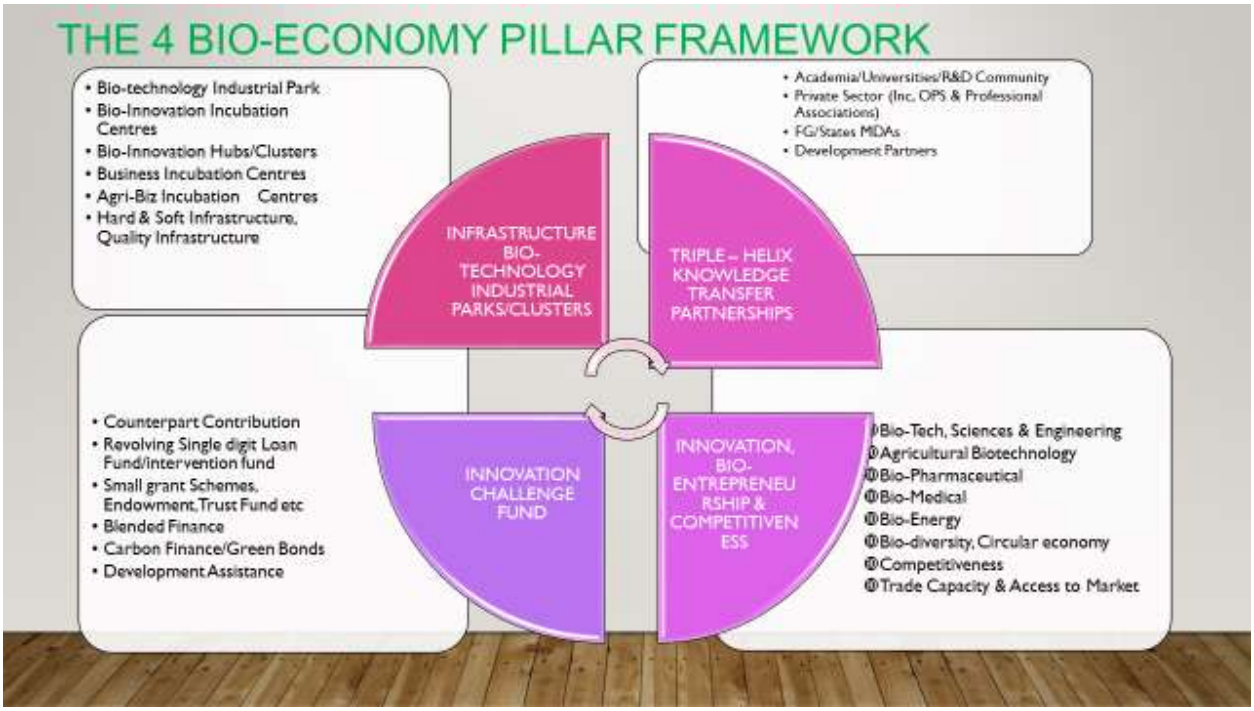
Accompanied with the notion of an entrepreneurial university is the concept of academic revolutions. Before the model of Triple Helix was coined in 1995, Etzkowitz (1990) stressed that the second academic revolution is an essential concept for understanding the changing landscape of higher education in the knowledge-based society. His idea of the second academic revolution is in line with and complementary to the concept of scientific revolutions (Kuhn, 2012) and technical-economic paradigms (Perez, 2010). While the Humboldtian model of integrating research and teaching in universities represents the first academic revolution, the second academic revolution concerns the strengthened economic role of universities. As such, universities are demanded to be entrepreneurial. In such a context, several related concepts emerged, such as the third mission (Etzkowitz, 1994), academic capitalism (Slaughter & Leslie, 1997), and the mode II knowledge production (Gibbons et al., 1994). The third mission disrupts universities' traditional teaching and research trajectories and drives universities to seek reciprocal relationships with stakeholders, e.g., in industry and government. As suggested by Etzkowitz (2008, p. 8), 'a Triple Helix regime typically begins as university, industry, and government enters into a reciprocal relationship with each other in which each attempts to enhance the performance of the other'. Later, Etzkowitz and Viale (2010) drew attention to the third-round academic revolution that emphasises the vital role of universities in social transformation. They argued that both the second and third academic revolutions simultaneously take place in a Triple Helix.



Spheres, Spaces and Functions

Another three concepts are essential for understanding the triple helix interactions, namely spheres, spaces, and functions. Spheres are exchangeable with helices, referring to university, industry and government (Etzkowitz, 2008; Etzkowitz & Leydesdorff, 1995). The notion 'sphere' is borrowed from the ideas of some economists (e.g. Kalecki, 1954; Marshall, 1960), who use the same concept to categorise economic actors from different industrial sectors. What distinguishes Etzkowitz & Leydesdorff's approach from the economists' interests in spheres lies in their emphasis on the interactions/relations between the spheres. While Etzkowitz and Leydesdorff jointly developed the Triple Helix model with a shared understanding of synergy building among the three spheres/helices, they have further elaborated on the mechanisms of Triple Helix interactions from a neo-institutional perspective and a neo-evolutionary perspective, respectively (Leydesdorff, 2012). The former perspective emphasises the relations between the three spheres. To better account for the mechanisms of Triple Helix interactions, the concepts of knowledge, consensus and innovation spaces were developed (Etzkowitz, 2008; Etzkowitz & Zhou, 2017). The latter perspective considers that the three helices also operate 'as selection mechanisms asymmetrically on one another, but mutual selections may shape a trajectory as in a coevolution' (Leydesdorff, 2012, p. 28). In such a lens, the Triple Helix is perceived as three functions, namely, wealth creation, knowledge production, and normative control (Leydesdorff, 2012).

TRIPLE-HELIX KNOWLEDGE TRANSFER PERARTNERSHIP FRAMEWORK



The Triple Helix as a model of innovation primarily conceptualises the dynamics of innovation at the societal level. In this sense, it is similar to other analytical tools, such as the innovation system. The Triple Helix model and the innovation system approach differ due to their separate theoretical roots, namely the general system theory and Simmel's triadic interactions (Cai & Lattu, 2021). Etzkowitz and Zhou (2017) contrasted the two concepts in 10 dimensions. We want to highlight that the Triple Helix is likely to be more effective than the innovation system concept when the analyses focus on 1) How the system-level innovation is organised, and 2) How the dynamic in the system can be measured. The efficacy of Triple Helix analysis on the two aspects is due to some unique insights of the Triple Helix thesis. First, the Triple Helix model requires an organised acceleration process and innovation organisers, which is in contract with the innovation system's assumption that a system of innovation is expected to evolve through self-organisation (Etzkowitz & Zhou, 2017). Second, using the Triple Helix, 'one can measure the extent to which innovation has become systemic instead of assuming the existence of national (or regional) systems of innovations on prior grounds' (Leydesdorff, 2012, p. 25).

The Triple Helix is effective in understanding the dynamics of innovation at the regional, national or international level, as it provides a well-elaborated framework for understanding central inquires in innovation processes, including 1) What are the key actors; 2) What are the mechanisms of interactions between the actors; 3) What are the enabling conditions of the interactions.

Regarding the key actors, the Triple Helix model focuses on university, industry, and government. However, it does not exclude other actors, such as intermediaries, legal firms and non-governmental agencies, but consider them secondary players (Cai & Etzkowitz, 2020). Indeed in each of the spheres of university, industry and government, there are 'a wide array of actors, among whom a distinction is made between: (a) individual and institutional innovators; (b) R&D and non-R&D innovators; and (c) "single-sphere" and "multi-sphere" (hybrid)

institutions' (Ranga & Etzkowitz, 2013, p. 238).The mechanism of Triple Helix interaction is "taking the role of the other" (Etzkowitz, 2008), performing new while maintaining their traditional function.

Organisations taking non-traditional roles are viewed as a major potential source of innovation in innovation. For instance, firms continue to produce goods and services, but also do research and provide training at high levels (e.g., through the corporate university). The government is responsible for resolving market failures, adjusting public policies and establishing market rules, but also makes available venture capital to start new enterprises, particularly for high-risk businesses. Universities keep their traditional roles of teaching and research, but also devote effort to the capitalisation of knowledge, patents, and start-up companies. Cai & Etzkowitz, 2020. The Triple Helix model can only be expected when certain conditions are met. Etzkowitz originally suggested both sufficient and necessary conditions that enable the Triple Helix. The sufficient condition of convening authority concerns the actions of political authorities to convene the representatives of the three helices to address innovation gaps (Etzkowitz, 1993, 2002).

The necessary condition of innovation capacity refers to the ability to create a knowledge base with commercialisation potential (Ranga & Etzkowitz, 2013). Cai (2014, 2015) further identified seven institutional logics as intangible conditions enabling an ideal type of Triple Helix model. It must be stressed that civil society is not absent in the Triple Helix model, as some researchers might misunderstand (Cai & Lattu, 2021). Instead, civil society has been considered 'the launch pad for take-off triple helix interactions' (Etzkowitz, 2014, p. 19) or an institutional ground of the Triple Helix (Cai, 2015). Leydesdorff (2012, p. 30) put it, 'the [triple] helices represent specialisation and codification in function systems which evolve from and within civil society'. (Etzkowitz, 2003) and five rationales (Cai & Etzkowitz, 2020) of Triple Helix, respectively.

Its theoretical foundations have been continuously strengthened by both the founders of the concept and those as a new generation of Triple Helix researchers (Cai & Etzkowitz, 2020). Moreover, the Triple Helix model has also been designed for analysing transformations and dynamics within each of the Helices. The Triple Helix thesis also provides separate concepts/frames to understand the nature of university, industry and government in a Triple Helix.

University-Government Interactions

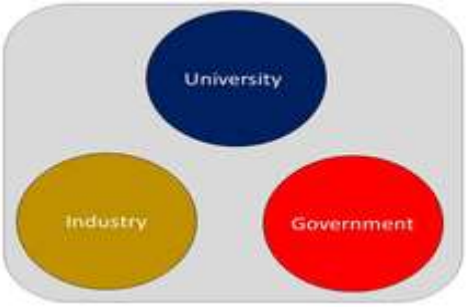
The strength of the interactions between the government and universities depends on the government's general relationship to and policy towards higher education. Etzkowitz and Leydesdorff's model uses a spectrum to define the extent of these interactions. On the one hand, when higher education is largely public, as in continental Western Europe, the government has a higher influence on universities and the research they conduct by being the main source of funding. On the other end of the spectrum, typically associated with the United States, universities still receive some government funding but overall have a higher degree of independence from government influence. However, the two ends of this spectrum are used as ideal-types that are not necessarily reflective of the reality. The changing circumstances can push

the government to create closer ties with academia, for example in wartime, and/or through funding of strategic disciplines, like physics.

Government-Industry interactions

The relationship between governments and industry depends on the government's attitude towards the market. In liberal economies the role of the government will be limited to preventing market failures. On the other hand, where the government is more involved in the economy, the government's role is the regulation of the industry. These are also two ends of a spectrum, leaving room for substantial variation, based on circumstances and disciplines. For example, as pointed out by Bhaven Sampat, in the 1960s, the government created a regulation to prevent patenting by or licensing to industry of university research funded by the National Institutes of Health. One key role of the government in its interaction with industry is the establishment of intellectual property law and its enforcement.

Strength of interaction



Triple Helix Interactions in a Developing Country (Silo Confinement)

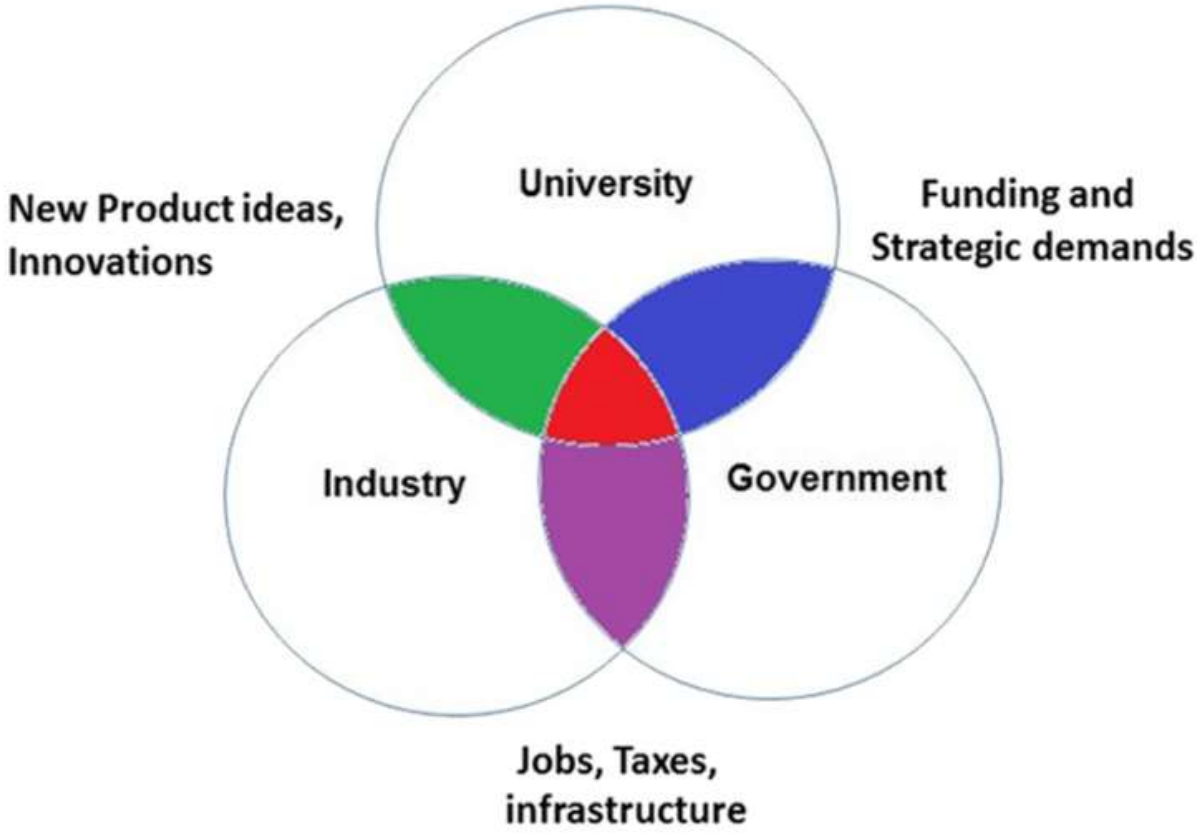
Etzkowitz and Leydesdorff initially argued that the strength of the interactions between governments, industry and university depends on which component is the driving force in the framework. In a statist model, a strong state is driving interactions between the three components in a top-down implementation. It creates stronger ties and a more integrated model. In a laissez-faire model, in which the industry and market forces are the leading forces, the ties are weaker and each institution tends to remain very independent. However, the distinction between the two models is not always clear cut, as the government can choose to adopt a strong or a weak stance depending on the context and the industry. Strength of interactions can also vary according to the development of a country, with a silo model predominating in an underdeveloped country, moderate interactions developing in a middle-income country due to the push for economic growth on the one hand and the pull for a competitive market-driven technological advancement on the other, and strong interactions developing in a developed country, for example in the form of a science park. In a recent paper, Etzkowitz emphasized that the shift towards a knowledge-based society has given a bigger role to universities. Indeed, as innovation is increasingly based on scientific knowledge, the role of universities as creators of knowledge is more valued. As a result, he argues that university, industry and government are more equal, and that no particular element is necessarily the driving force of the triple helix model of innovation.

Evolution and Hybridization

The triple helix model of innovation also blurred the boundaries of the traditional basic roles of university, industry and government. According to Etzkowitz and Leydesdorff, this marks the second step in the triple helix of innovation framework. For example, universities increasingly take part in commercial activity through patenting and licensing, moving beyond the production of basic research. The next step is the emergence of intermediaries between the three elements as well as the hybridization of the three entities. Nevertheless, each entity retains a strong primacy in its original field of expertise: the university remains the main source of knowledge production, industry is the primary vehicle of commercialization and the government retains its regulatory role.

Technology transfer offices have been established by universities to foster the transformation of university basic or applied research with a commercial value into commercial goods. One of the aims of TTOs is to create some revenues for the university, thus enhancing its role as an economic actor. However, the average profitability of TTOs remains very low. For example, the revenues earned through the licensing of patents by TTOs in American universities are, on average, ten times larger than for European TTOs according to the Innovation Policy Platform. Science parks have also emerged as the result of the collaboration of industries and universities with the government. They can stem from the initiative of an industrial region to modernize itself with the impulse of a university. On the other hand, they can be the result of a university initiative to attract industry, as was the case with the development of Stanford's science park around the university or the Research Triangle in North Carolina.

The 'entrepreneurial university' is another hybrid element which Etzkowitz defines around the following elements: the capitalization of knowledge, strong ties with industry and governments, a high degree of independence, and permanent evolution of the relationships between universities, industry and government. Etzkowitz recognizes MIT as a great example of an 'entrepreneurial university'.



Quintuple Helix Model

The quintuple helix model was co-developed by Elias G. Carayannis and David F.J. Campbell in 2010. It is based on the triple and quadruple helix models and adds as fifth helix the natural environment. The quintuple helix views the natural environments of society and the economy as drivers for knowledge production and innovation, thus defining socio-ecological opportunities for the knowledge society and knowledge economy, such as innovation to address sustainable development, including climate change. The quintuple helix can be described in terms of the models of knowledge that it extends, the five subsystems (helices) it incorporates, and the steps involved in the circulation of knowledge. How to define both the quadruple and quintuple helices has been debated, and some researchers see them as additional helices, while others see them as different types of helix which overarch the previous helices.

Empirical Review

The empirical studies have approved the usefulness of Triple Helix in analysing governance and coordination of innovation processes, such as translating knowledge into technology and innovation (Amaral, 2015; Olvera, Piqué, Cortés, & Nemirovsky, 2020). The Triple Helix perspective could be advantageous when there has been increasing consensus regarding the relevance of state intervention in societal and economic development, after the financial and economic crisis in 2008 and especially the recent catastrophe caused by Covid-19.

Cai and Lattu (2021) systematically examined the strengths and weaknesses of the Triple Helix model (as well as the Quadruple Helix model) for understanding innovation dynamics in innovation ecosystems that represent the contemporary or future society. They identified the (changing) features in innovation ecosystems in three dimensions compared to those in innovation systems. First, the model of knowledge production is shifting from mode 2 to mode 3. Second, key players in innovation processes are becoming more diverse and interdependent. The third dimension is about changes in the social context, which are seen from both temporal and spatial perspectives. In the temporal context, innovation must be sustainable, and actors involved in the innovation process are required to be responsible for future generations. In the spatial dimension, innovation processes occur in the context of globalisation, the cornerstone of which has shifted from countries and organisations to individuals.

Cai and Lattu (2021) concluded that although the Triple Helix model was originated in the 1990s when some pioneer nations had just begun their strategies for developing innovation systems, its theoretical core can or have the potential to analyse interactions and synergy building among actors in innovation ecosystems. However, they also reminded that the new features in innovation ecosystems, as mentioned above, have not been explicitly addressed in the theoretical elaboration of the model. For instance, it has been argued that the Triple Helix model was mainly based on Modes 1 and 2 of knowledge production (Carayannis & Campbell, 2009). However, Triple Helix scholars have constantly been developing the theoretical foundations of the Triple Helix model, with attempts to capture the dynamics of sustainable innovation in contemporary society (Cai & Etzkowitz, 2020). For example, Cai and Ahmad (2021) proposed and conceptualised a sustainable entrepreneurial university to respond to the demands arising from the transformation from innovation systems to innovation ecosystems for a renewed understanding of the nature of universities and their roles in society.

In the first article, Rothgang and Lageman (2021) introduce a new concept, 'Kairos constellation', to supplement the theoretical foundations of the Triple Helix model. A Kairos constellation designates a temporary opportunity for a group of actors to take advantage of a coincidence of favourable circumstances to realise a shared target. While Kairos constellations may frequently occur in triple helix interactions, such a phenomenon has not been explicitly theorised by Triple Helix. Thus, the authors try to provide a theoretical account of Kairos constellations and hope this could provide helpful guidance on taking full advantage of a Kairos moment while overcoming potential risks for those actors involved in the Kairos constellations.

In the second article, Virkkala and Mariussen (2021) propose a new method of measuring how various innovation networks can create different types of complex synergies based on first-hand data. It is called connectivity analysis. Such a measurement is different from the existing approaches in two aspects. First, while the current methods mainly measure synergies of cooperation between university, industry, and government at the macro level, the authors look at individual actors, particularly their networks, in their Triple Helix measurement. Second, the authors use first-hand data collected through surveys/interviews for their measurement, which contrasts the existing methods that mainly use patent data, firm data, and other secondary statistical sources. Their approach helps measure more complex synergies because it not only examines the interactions between networks from different helices but also discerns the variation among organisations and networks in the same helix as well as the types of networks (e.g., weak or strong).

In the third article, Malik, Kabiraj, and Huo (2021) quantitatively explore how universities' density in a city moderates foreign/domestic direct investments' contribution to local innovation in the ICT sector in the Chinese context. Their analysis shows that the population of universities in a city positively moderates the relation between these investments and the city's development level. The findings shed light on the Triple Helix thesis in two ways. First, it suggests that the populations of universities are among enabling conditions of Triple Helix. Second, it evidences and conceptualises universities' role in mobilising resources for enlarging innovation effects.

In the last article, Abisuga and Muchie (2021) propose a conceptual model that describes Arts Entrepreneurship Education (AEE). Scholars have highlighted the need for more explicit knowledge, conceptualisation, and theorising on the practicality of integrating arts entrepreneurship education in university programs. This research paper fills the existing gap in the literature on the AEE and argues that if entrepreneurship is to be viewed as a fundamental part of AEE, teachers need to properly know the importance and inclusion in the University's art subject curriculum.

Etzkowitz and Leydesdorff argue that the initial role of universities is to provide education to individuals and basic research. Therefore, interactions between university and industry revolve initially around those two elements. In a linear model of innovation, universities are supposed to provide the research which industry will build upon to produce commercial goods. The other interactions take place through the involvement of industry managers and university faculty in both sectors. According to Etzkowitz, the transfer of people between university and industry constitutes a very important transfer of knowledge. This can be a permanent move in one direction or the other, or in other cases, entire careers spent between the two spheres. He gives the example of Carl Djerassi, a research director for a pharmaceutical company who joined Stanford University while continuing his industrial activity.

However, other scholars have pointed out that consulting activities of faculty members could also have drawbacks, like a reduced focus on educating the students, and potential conflict of interests relating to the use of university resources for the benefit of industry. Additional transfer of knowledge between university and industry happens through informal communication, conferences or industrial interest in university publications. Another type of interaction, for example, is the creation of co-op programs like the MIT-General Electric course which aims at integrating an industry approach into the students' curricula.

METHODOLOGY

This study utilized survey designed to study the triple Helix Knowledge Transfer partnership along the innovation Spectrum. The triple helix innovation framework has been widely adopted and as applied by policy makers has participated in the transformation of each Triple Helix systems provide a fine-grained view of innovation actors and the relationships between them, in a vision of a dynamic, boundary-spanning and diachronic transition of knowledge flows within the system. The research variables are classified in three categories: First, both the notions of an entrepreneurial university and second and third academic revolutions address the transformations in universities. In this regard, the Triple Helix model can serve as a useful tool to analyse the process of capitalisation of knowledge (Etzkowitz, 2011b; Etzkowitz & Goktepe-Hulten, 2010) as well as mechanisms underlying and infrastructures supporting the process (Etzkowitz, 2011a; Etzkowitz & Zhou, 2017; Piqué, Berbegal-Mirabent, & Etzkowitz, 2020). The characteristics of

the entrepreneurial university model can be grasped by the five norms (Etzkowitz & Zhou, 2017), updated from the five propositions of an entrepreneurial university.

Second, concerning the transformation in the industry sector, Etzkowitz and Zhou (2017) use the concept 'triple helix firm' to describe the boundary-spanning nature of firms in a Triple Helix. The firms are hybrid entities, 'combining triple helix elements of the public and private to various degrees, with multiple investors, stakeholders or shareholders' (Etzkowitz & Zhou, 2017, p. 80). Such knowledge-based firms can be formed under ten conditions concerning human capital, material, and organisational factors, respectively.

Third, the Triple Helix provides a unique lens to see government not only as a regulator but as an active agent also. The public venture concept is used to understand the state's role (Etzkowitz & Gulbrandsen, 1999). According to Etzkowitz and Zhou (2017), the optimal role of government can be best performed in an 'innovation state' that attempts to regenerate the sources of productivity in science and technology through new forms of cooperative relations. They further proposed five propositions about the transformation of traditional state functions to promote innovation.

CONCLUSION AND RECOMMENDATION

In conclusion, the triple helix model has been used as a lens through which evolving relationships between university, industry and government can be analyzed.

Based on the findings of this study, the following recommendations are proffered:

Training and skill development should be put in place by diverse actors. The wide range of professional service providers within the Model should be trained to develop the requisite skills and competencies for strengthening the Model such as early identification of research opportunities, collaboration prospects, screening of relevant programmes, baseline assessment of potential activities, and ongoing assessment of progress through structured programme interventions, control, and M&E.

Research and innovation centres should be established. Government should play a fundamental role in making available research and innovation hubs that will ensure translation of concepts into products and services. In so doing, measures should be put in place for continually re-aligning and repositioning the Model strategy to meet the changing needs and patterns of network actors. Improving research commercialization should be high on the Triple Helix policy agenda.

Empirically based policy measures and interventions should be created. This should primarily involve policies designed to strengthen resilience, educate network actors and create awareness among them, and reduce risk factors for commercialization of R&D. Government-led policies and methods should be increased, and follow-ups on R&D and performance of partnership programmes should be undertaken. Simply implementing policies and programmes without follow-ups will not be of any value to the network actors. This recommendation carries the consequence that requires an allocation of extra budget for the human resource needed in this endeavour.

Policies for addressing socioeconomic issues facing the Model actors should be put in place. The policies should aim at addressing, assessing, and alleviating the challenges and weaknesses within the Model.

Protocols for addressing the needs of the actors should be created. Institutional leaders should be equipped with a clear comprehension of the concepts: use, abuse and misuse of, dependence on, and diversion from the Model's unified goals and policies. Protocols for effective functioning of the programme should be created, bearing in mind international/local guidelines in this respect. The contact details of contact persons and other members of the multi-disciplinary team (MDT) that resolves issues within the Model should be made available in each network actor's location, together with information on the processes to be followed in meeting and working together.

The central role of the private sector in South Africa should be recognized. Recognizing the country's socioeconomic realities (includes agriculture, and the formal and informal sectors), wherein the Model operates is crucial in policymaking, strategy and intervention development. Effective participation of the industrial sector in research commercialization and in addressing complex sustainable (economic, environmental and social) development challenges facing the country should be structured through direct/indirect controls within the framework. The resulting increased NSI participation of the private sector should promote learning, support of joint funding, start-up/spin-off joint ventures and mutual collaboration. Private sector NSI participation may further be strengthened through improved tax concessions on company grants, scholarships and bursaries deployed in the HEIs. Therefore, according to critics, the triple helix model is not a relevant policy making tool for developing countries where at least one of these conditions is missing. However, others have argued that the triple helix model is capable of both describing the situation in developing countries and is useful for planning policy.

REFERENCE

Leydesdorff, Loet (2012). "The Knowledge-Based Economy and the Triple Helix Model" (PDF). University of Amsterdam, Amsterdam School of Communications Research. ArXiv: 1201.4553. 201.4553L.

Galvao, Anderson; Mascarenhas, Carla; Marques, Carla; Ferreira, João; Ratten, & Vanessa (2019). "Triple helix and its evolution: a systematic literature review". Journal of Science and Technology Policy Management. 10 (3): 812–833.

Etzkowitz, Henry; Leydesdorff, Loet (1995). "The Triple Helix -University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development". SSRN 2480085.

Etzkowitz, Henry (2008). The triple helix: university-industry-government innovation in action. New York: Routledge. ISBN 978-0-415-96450-0. OCLC 173749026.

Etzkowitz, Henry; Zhou, Chunyan. The triple helix: university-industry-government innovation and entrepreneurship (Second ed.). Abingdon, Oxon. ISBN 978-1-315-62018-3. .

Sampat, Bhaven N. (2006). "Patenting and US academic research in the 20th century: The world before and after Bayh-Dole". Research Policy. **35** (6): 772–789.

Carayannis, Elias G; Barth, Thorsten D; Campbell, David FJ (2012). "The Quintuple Helix innovation model: global warming as a challenge and driver for innovation". Journal of Innovation and Entrepreneurship. **1** (1):

Höglund, Linda; Linton, Gabriel (2017-12-27). "Smart specialization in regional innovation systems: a quadruple helix perspective". R&D Management. **48** (1): 60–

Leydesdorff, Loet (March 2012). "The Triple Helix, Quadruple Helix, and an N-Tuple of Helices: Explanatory Models for Analyzing the Knowledge-Based Economy?" Journal of the Knowledge Economy. **3** (1): 25–35.

Yuzhuo Cai (10 July 2013). "Enhancing context sensitivity of the Triple Helix model: An institutional logics perspective" (PDF). Triple Helix Conference.

Williams, Logan D. A.; Woodson, Thomas S. (2012). "The Future of Innovation Studies in Less Economically Developed Countries". Minerva. 50 (2): 221–237

Abisuga, O. A., & Muchie, M. (2021). Development of Arts Entrepreneurship Education: Excavating and Unravelling the Knowledge Basis. Triple Helix, 1–10.1163/21971927

Cai, Y. (2014). Implementing the Triple Helix model in a non-Western context: an institutional logics perspective. Triple Helix, 1(1), 1–20.

Cai, Y. (2015). What contextual factors shape "innovation in innovation"? —Integration of insights of the Triple Helix and the institutional logics perspective. Social Science Information, 54(3), 299–326.

Cai, Y., & Ahmad, I. (2021). From an Entrepreneurial University to a Sustainable Entrepreneurial University: Conceptualisation and Evidence in the Contexts of European University Reforms. Higher Education Policy. 41307-021-00243-z.

Cai, Y., & Etzkowitz, H. (2020). Theorising the Triple Helix model: Past, present, and future. Triple Helix, 7(2–3), 189–226.

Cai, Y., & Lattu, A. (2021). Triple Helix or Quadruple Helix: Which model of innovation to choose for empirical studies? Minerva. 1024-021-09453-6.

Carayannis, E. G., & Campbell, D. F. J. (2009). "Mode 3" and "Quadruple helix": toward a 21st century fractal innovation ecosystem. International Journal of Technology Management, 46(3/4), 201–234.

Etzkowitz, H. (1983). Entrepreneurial scientists and entrepreneurial universities in American academic science. Minerva, 21(2–3), 198–233.

Etzkowitz, H. (2003). Innovation in innovation: the triple helix of university-industry-government relations. Social Science Information, 42(3), 293–337.

Etzkowitz, H. (2004). The evolution of the entrepreneurial university. International Journal of Technology and Globalisation, 1(1), 64–77. Search Google Scholar

Etzkowitz, H. (2008). The triple helix: university-industry-government innovation in action. New York; London: Routledge.

Etzkowitz, H. (2011a). Special Introduction: Convergence of Science Parks, Centres and Clusters: From Creative Destruction to Creative Reconstruction in a Triple Helix Regime. International Journal of Techno entrepreneurship, 2(3/4).

Etzkowitz, H. (2011b, 11–14, July). Stanford and Silicon Valley: The Co-Evolution of Technology Transfer and Regional Absorptive Capacity, 1930–2005. Paper presented at the Triple Helix IX International Conference: "Silicon Valley:

Etzkowitz, H. (2014). Making a humanities town: knowledge-infused clusters, civic entrepreneurship and civil society in local innovation systems. Triple Helix, 1(1), 10.1186/

Etzkowitz, H. (2017). Innovation Lodestar: The entrepreneurial university in a stellar knowledge firmament. Technological Forecasting and Social Change, 123, 122–129.

Etzkowitz, H., Bikkulov, A., Kovaleinen, A., Leitner, K. H., Poutanen, S., Grey, D. Cai, Y. (2017). Metrics for the Entrepreneurial University. Triple Helix.

Etzkowitz, H., Germain-Alamartine, E., Keel, J., Kumar, C., Smith, K. N., & Albats, E. (2019). Entrepreneurial university dynamics: Structured ambivalence, relative deprivation and institution-formation in the Stanford innovation system. Technological Forecasting and Social Change, 141, 159–1

Etzkowitz, H., & Goktepe-Hulten, D. (2010). Maybe they can? University technology transfer offices as regional growth engines. International Journal of Technology Transfer and Commercialisation, 9(1–2), 166–181.

Etzkowitz, H., & Gulbrandsen, M. (1999). Public entrepreneur: the trajectory of United States science, technology and industrial policy. Science and Public Policy, 26(1), 53–62.

Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix – University-Industry-Government Relations: A Laboratory for Knowledge-Based Economic

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. Research Policy, 29(2), 109–123. doi:doi: DOI:

Etzkowitz, H., & Viale, R. (2010). Polyvalent Knowledge and the Entrepreneurial University: A Third Academic Revolution? Critical Sociology, 36(4), 595.

Ivanova, I., Strand, Ø. Kushnir, D., & Leydesdorff, L. (2015). The Efficiency of Triple-Helix Relations in Innovation Systems: Measuring the Connection between a Countries's Net Income and Its Knowledge Base.

Kuhn, T. (2012). The Structure of Scientific Revolutions: 50th Anniversary Edition. Chicago: University of Chicago Press.

Leydesdorff, L. (2000). The triple helix: an evolutionary model of innovations. Research Policy, 29(2), 243–255.

Leydesdorff, L. (2003). The mutual information of university-industry-government relations: An indicator of the Triple Helix Search Google Scholar

Leydesdorff, L. (2008). Configurational Information as Potentially Negative Entropy: The Triple Helix Model. Entropy, 10(4), 391–410. Search Google Scholar

Leydesdorff, L. (2012). The Triple Helix, Quadruple Helix, and an <i>N -Tuple of Helices: Explanatory Models for Analysing the Knowledge-Based Economy? Journal of the Knowledge Economy, 3(1), 25–35. Search Google Scholar

Leydesdorff, L., & Meyer, M. (2003). The Triple Helix of university-industry-government relations. Scientometrics, 58(2), 191–203. Search Google Scholar

Leydesdorff, L., & Park, H. W. (2014). Can synergy in Triple Helix relations be quantified? A review of the development of the Triple Helix indicator. 1(1), 1.

Malik, T. H., Kabiraj, S., & Huo, C. (2021). Chinese Universities Mobilise FDI and DDI for the City's Innovativeness in the ICT Sector. Triple Helix, 1–35.

Marshall, A. (1960). Principles of Economics: An Introductory Volume (8th Edition ed.): Palgrave MacMillan.

Olvera, C., Piqué, J. M., Cortés, U., & Nemirovsky, M. (2020). Evaluating University-Business Collaboration at Science Parks: a Business Perspective. Triple Helix, 1–41. .1163/21971927-

Perez, C. (2010). Technological revolutions and techno-economic paradigms. Cambridge Journal of Economics, 34(1), 185–202.

Piqué, J. M., Berbegal-Mirabent, J., & Etzkowitz, H. (2020). The Role of Universities in Shaping the Evolution of Silicon Valley's Ecosystem of Innovation. Triple Helix, 7(2), 1–45.

Ranga, M., & Etzkowitz, H. (2013). Triple Helix Systems: An Analytical Framework for Innovation Policy and Practice in the Knowledge Society. , 27(4), Special Issue (August 2013). Industry and Higher Education, 27(4), 237–262.

Röpke, J. (1998). The Entrepreneurial University: Innovation, Academic Knowledge Creation and Regional Development in a Globalised Economy. Retrieved from Marburg, Germany.

Rothgang, M., & Lageman, B. (2021). Kairos in Innovation Policy. Triple Helix, 1–51. 1163/21971927.

Slaughter, S., & Leslie, L. L. (1997). Academic capitalism: politics, policies, and the entrepreneurial university. Baltimore, Md. London: Johns Hopkins University

Virkkala, S., & Mariussen, Å. (2021). Networks of Innovation: Measuring Structure and Dynamics between and within Helices, Regions and Spatial Levels. Empirical Evidence from the Baltic Sea Region. Triple Helix, 1–47.