

Editorial



Triple Helix Model of Innovation: From Boundaries to Frontiers

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In one of our recent editorials, we discussed the boundaries and limitations of applying the Triple Helix model (Cai & Amaral, 2021). We had then defined the Triple Helix model's boundaries as the delineations between the situations where the model is more effective in analyzing phenomena related to innovation and those not related to. We had described the boundaries in terms of scope analysis and explanatory power. This elaboration on the boundaries helps to understand the model's strengths and weaknesses. Here, we encourage researchers to explore the frontiers of Triple Helix research, leading to the expansion of the model's application. One can only explore the frontiers when knowing the boundaries. While the boundaries are associated with limitations, the frontiers are unlimited. Although the frontiers of Triple Helix research are beyond our imagination, we try to provide some examples of efforts in such a direction concerning theoretical, methodological and empirical aspects, which are all interrelated.

Theoretical foundations of Triple Helix

In its essence, Triple Helix is an analogy or metaphor that allows to understand the non-linear interaction between actors from the spheres that generate knowledge (university), that use or consume knowledge (company) and that regulate and promote economic activity (government), aiming at the generation and transmission of scientific and technological knowledge that will allow companies to innovate and, based on that, society to build economic and social development (Cai & Amaral, 2021).

Etzkowitz and Leydesdorff (1995) developed the Triple Helix model mainly based on inductive reasoning of best practices of regional innovation in the US and Europe. Their theoretical elucidation of the model was inspired by Georg Simmel's sociological concept of triads: while a triad significantly differs from a dyad, 'the further expansion to four or more persons by no means correspondingly modifies the group any further' (Simmel, 1950, p. 138). Specifically, Etzkowitz and Leydesdorff extended Simmel's micro-level triads analysis to the meso level of organizational interactions (Cai and Etzkowitz, 2020) for conceptualizing the dynamics of innovation at the societal level (Cai & Amaral, 2021). As such, Cai and Etzkowitz (2020) summarized five rationales of the Triple Helix model as follows: 1) the complex relations among various players in innovation processes can be both reduced and preserved by applying Simmel's social geometry of triadic interactions; 2) the dynamic of Triple Helix interactions for innovation is generated through 'taking the role of the other'; 3) The evolution of the Triple Helix model is not spontaneous, being on the contrary pre-structured or coordinated; 4) the integration of both top-down coordination and bottom-up initiatives underlines Triple Helix interactions; 5) specific conditions enable the Triple Helix model.

To further enhance the Triple Helix model's explanatory power in analyzing innovation dynamics, as suggested by Cai and Etzkowitz (2020), we need to develop theoretical accounts of micro-level mechanisms of the Triple Helix rationales. As such, frontier research in this direction concerns the efforts to equip more powerful theoretical engines with the Triple Helix model for elucidating the micro-foundations of Triple Helix and connecting the macro and micro levels of analysis. Some typical examples of such efforts resort to institutional theory in order to explain the mechanism of taking on the role of the other (Cai & Liu 2020) and applying social network theory to analyze Triple Helix interactions (Virkkala & Mariussen, 2021).

New horizons in theorizing the Triple Helix model also include strengthening the conceptualization of the model. For instance, Etzkowitz and Leydesdorff have different views on conceptualizing Triple Helix interactions, leading to the neo-institutional and neo-evolutionary perspectives of Triple Helix,

respectively (Leydesdorff, 2012). The neo-institutional perspective emphasizes the relations between three institutional spheres: university, industry and government. Related to the spheres, there are knowledge, consensus and innovation spaces. From a neo-evolutionary standpoint, the three helices, namely wealth creation, knowledge production and normative control, are 'selection mechanisms' that asymmetrically influence one another. Such 'mutual selections may shape a trajectory as in a coevolution' (Leydesdorff, 2012, p. 28). Based on the understanding that both Etzkowitz's concept of triple spaces and Leydesdorff's concept of triple functions are complementary for understanding the roles of university, industry and government in innovation processes, Cai (2022a) integrates the two perspectives to develop a critical construct in his conceptualization of a neo-Triple Helix model of innovation ecosystems.

At the microeconomic level, from the viewpoint of the university, the sociological idea of academic revolutions and the emergence of the entrepreneurial university explain the behavior change in the process of generating, appropriating and disseminating knowledge in the last forty years. From the companies' side, Open Innovation explains the openness to knowledge and technology 'not invented here' as well as how the knowledge flows have been reorganized in the last twenty years (Chesbrough, 2003). The Lean Startup movement, among others, has reinforced and reinvented university-industry-government linkages accelerating the innovation process (Ries, 2011). Triple Helix as a theory in its original form provides an explanation, but no metric to measure it nor tools to manage these relations. A vast plain remains open to the explorers.

Relations between the Triple Helix model and other approaches to innovation

Another frontier area in the Triple Helix model's theoretical development concerns the relations between the Triple Helix model and other approaches in innovation studies. For instance, the recent special issue on Triple, Quadruple and Quintuple Helix models of innovation (Amaral & Cai, 2022) collects six articles that advance the state-of-the-art research on relations between these models. While generally acknowledging that the helical models can supplement one another, these studies highlighted some questions for future research.

First, how can the efficacy of the Triple Helix model be retained and justified while our society is becoming more complex than it was in the 1990s when the model originated? For instance, Leydesdorff and Lawton Smith (2022) defended the legitimacy of the Triple Helix approach by arguing that Quadruple, Quintuple, and N-tuple helices can be decomposed into

different combinations of interacting triple helices. Deakin (2022) supported Leydesdorff and Lawton Smith's argument by demonstrating the Triple Helix model's explanatory power when applied to the analysis of the EU's policy practices, particularly the Research and Innovation Strategies related to Smart Specialization and the Entrepreneurial Discovery Process.

Second, how do the Triple Helix and other helical models differ? For instance, Xue and Gao (2022) and Park and Stek (2022) stated that the choice of the helix model to be applied in empirical analysis or measurement depends on the empirical context. Their views are somehow similar to Cai and Lattu (2022), who tried to help researchers to choose a suitable helix model in particular empirical studies by providing a systematic comparison of both the advantages and weaknesses of Triple Helix and Quadruple Helix. However, Cai and Lattu (2022) also suggested the potential for synergy building between the two helix models since they are supplementary to each other.

Third, how can different helical models be integrated or united to form consistent frameworks for better understanding contemporary societal transformations? In this regard, Cai (2022a) proposed the neo-Triple Helix model of innovation ecosystems, which distinguishes two layers of triple helices: 1) university – industry – government interactions (i.e., 'innovation genes') and 2) interactions between innovation genes, social structures and the natural environment. The former generates innovation dynamics that drive innovation systems, and the latter generates sustainable development dynamics, which, together with innovation dynamics, underline innovation ecosystems. Similarly, Carayannis and Campbell (2022) called for scholars of different Helix models to jointly develop an emerging unified theory of helical architectures, particularly as a response to the current situation in Europe with conflicts and struggles between democracies and autocracies.

Operationalization of Triple Helix

One particular interest in Triple Helix studies is quantitatively capturing bilateral and trilateral interactions and synergies. Among various efforts to develop Triple Helix indicators, the best established method was developed by Loet Leydesdorff based on Shannon's entropy formula that can evaluate the strength of synergy within a system (Leydesdorff, 2021). In their study on developing a Triple Helix-based efficiency index of innovation, Jovanović et al. (2022) provided a review of existing Triple Helix measures by highlighting the pros and cons of each measurement. Their analysis implied that current

approaches mainly measure the synergies and outcomes of Triple Helix interactions while lacking attention to measure Triple Helix efficiency in terms of transforming inputs of an innovation system into innovation outputs fostered by Triple Helix actors.

Besides measuring Triple Helix efficiency, the frontiers of operationalizing Triple Helix interactions also consist of quantitative analysis of the intersection of the helices from the social network perspective (Virkkala & Mariussen, 2021) and measuring synergies of Triple Helix interactions using game theory (Mègnigbèto, 2018). Since the relations between different actors in innovation processes are becoming increasingly complex, the measurement of Triple interactions might be limited by traditional social science methods, and new technics, such as machine learning, are expected to be applied (Cai & Etzkowitz, 2020; Cai et al., 2019).

Sustainable development and social innovation from the Triple Helix perspective

One critique of the Triple Helix model is that the nearly 30 years old model cannot fully take into account new and complex factors that emerged in recent societal transformations (Brundin et al., 2008; Drori et al., 2013; Reich-Graefe, 2016; Tuunainen, 2002). While the Triple Helix was developed in the context, in which nations and regions were striving to build innovation systems, we are now in the era of innovation ecosystems (Zheng & Cai, 2022). According to Smorodinskaya et al. (2017, p. 5248), “Eco” stands to emphasize the non-linear nature of innovation and the crucial role of collaboration in producing innovations to achieve sustainable development in non-linear environments’ (p. 5248). Cai et al. (2020) defined innovation ecosystems as

co-innovation networks, in which actors from organizations concerned with the functions of knowledge production, wealth creation and norm control interact with each other in forming co-evolution and interdependent relations (both direct or indirect) in cross-geographical contexts, and, through which new ideas and approaches from various internal and external sources are integrated into a platform to generate shared values for the sustainable transformation of the society (p. 2).

How to analyze innovation ecosystems, in particular sustainable development, from the Triple Helix perspective is at the frontier of Triple Helix research. For

instance, Zhou and Etzkowitz (2021) proposed 'Triple Helix twins', adding the university – public – government Triple Helix to supplement the university – industry – government Triple Helix, which represent the sustainability and innovation dimensions, respectively. Cai (2022a) proposes the neo-Triple Helix model to conceptualize innovation ecosystems by integrating the insights from Triple, Quadruple and Quintuple Helix models. These models can shed particular light on analyzing social innovation, which underpins the sustainable development (Eichler & Schwarz, 2019).

In some respects, the Triple Helix theory when proposed in the nineties was beyond its time in assuming the interaction between different actors as the key element. The central element is not the number of actors or spheres, but the knowledge flow between them, i.e. the way they interact. With this perspective, a good theory can cover and explain almost all aspects of the phenomena studied and incorporate new topics and findings. In this case, sustainability, social innovation, responsible innovation, bioethics and other topics can be analyzed through the prism of Triple Helix.

Triple Helix model in a global context

The Triple Helix Model has been primarily applied to understand and analyze innovation processes in national or regional contexts. Since, in innovation ecosystems, innovation processes are becoming increasingly interconnected on a global scale, novel analytical tools are urgently needed to address the complex interactions between various innovation actors (Cai et al., 2019). This also reflects a paradox in innovation studies: while more and more innovations occur through international interactions, most approaches to innovation are mainly for analysis at the regional or national level. To resolve the research challenge, scholars tried to adapt these approaches to analyze innovation in a global context. For instance, the concept of global innovation networks (e.g. Cano-Kollmann et al., 2018; Liu et al., 2013; Necochea-Mondragón et al., 2017) has been commonly used for studying various innovation phenomena beyond national borders. As has been too the concept of global clusters of innovation (Engel, 2014).

In Triple Helix research, Cai et al. (2019) called for a Triple Helix Model of the transnational innovation ecosystem, in which overlapping spheres of transnational cooperation are evolving in the respective sectors of university, industry and government. They also suggested extending the knowledge,

innovation and consensus space, as core concepts of the neo-institutional version of Triple Helix (Etzkowitz, 2008), to transnational contexts. The three transnational spaces are respectively associated with three functions, namely knowledge production, wealth creation and normative control, as core concepts of the neo-evolutionary version of Triple Helix (Leydesdorff, 2012). Cai (2022a) went on to elaborate on a global Triple Helix interaction by proposing the neo-Triple Helix model of innovation ecosystems based on integrating Triple, Quadruple and Quintuple models, as mentioned earlier.

The neo-Triple Helix model is merely a conceptual tool. It needs to be evolved into a more robust analytical framework and verified by empirical studies. In this regard, Cai (2022b) provided evidence of the role of international university research collaboration in creating transnational university-industry co-innovation networks based on analyzing the interviews with 18 actors engaged in EU – China innovation cooperation. In so doing, they constructed a theoretical framework to elucidate the mechanism of interactions between international university collaboration and international industry collaboration by synthesizing insights from social network theory and institutional theory. Zheng and Cai (2022) applied the neo-Triple Helix model to identify unique features of innovation ecosystems, which cross regional and national borders, and draw implications on the role of policy in transforming innovation systems into innovation ecosystems.

The articles in the issue

Among the five articles included in this issue, while Marule's (2022) article can be regarded as a typical empirical study applying the Triple Helix model within its boundaries, the other four demonstrate efforts to explore the frontiers. Runiewicz-Wardyn (2022) tried to enhance the theoretical foundations of Triple Helix by integrating the concept of proximity in geographical, cognitive, institutional, organizational, social and cultural dimensions with the Triple Helix model. Lawton Smith and Leydesdorff (2022) continued the debate on triple and higher-order helices by reflecting on the points made by several articles responding to their paper *Triple, Quadruple, and Higher-Order Helices: Historical Phenomena and (Neo-) Evolutionary Models* (Leydesdorff & Lawton Smith, 2022). Gebhardt et al. (2022) and Izdebska et al. (2022) represent pioneering research in analyzing sustainable development by applying and adjusting the Triple Helix model.

Invitation for contributions

We invite contributions to opening new horizons of Triple Helix research. When engaging in the research frontiers, researchers are expected to build on and advance existing studies within the boundaries of Triple Helix or those already on the frontiers. Our journal intends to organize a series of special issues in order to promote frontier research on Triple Helix. We also welcome proposals for special issues dealing with topics within or beyond the boundaries of Triple Helix.

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