From Modeling the Interactions among Institutions to Modeling the Evolution of an Ecosystem: A Reflection on the Triple Helix Model and Beyond

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**Abstract**

By decomposing and analyzing the quadruple helix model and *N*-tuple helices into interacting triple helices, Leydesdorff and Lawton Smith’s (2022) research promises to open further the black box inside the higher-order helices, and provides a theoretical basis and guidance for the subsequent governance on the innovation in the higher-order helices model. In this commentary, we have argued that a framework based on agile governance can be applied to the governance of this higher-order helices model with interactions among multiple triple helices. A set of flexible and adaptive actions or methods are necessary to make the governance on the higher-order helices model to be more agile to keep pace with the rapid changes of society.

**Keywords**

Agile governance – Higher-order helices model – Quadruple helix model – Innovation ecosystem
The Evolution from Triple Helix to Higher-Order Helices Model

As a widely adopted innovation model, the triple helix model captures the close interaction and cooperation among universities, industries, and governments in innovative activities at the turn of the century (Etzkowitz and Leydesdorff, 2000). The first author can still remember the excitement felt when reading Etzkowitz and Leydesdorff’s article first time. At the time, China was involved in a set of continued institutional reforms of its innovation system to redesign the linkage among universities, firms, and public research institutes (Xue, 2018) so that China can catch up and take advantage of the promises of the knowledge economy and national innovation system. The model provided an elegant way to understand the complexities underlying the vibrant interactions among the key players of universities, firms, and governments (Cai and Amaral, 2021; Cai and Etzkowitz, 2020; Leydesdorff and Park, 2014). The quadruple helix model (Carayannis and Campbell, 2009), on the other hand, is based on the triple helix model and introduces a fourth helix - civil society or civil participants. Instead of including a few more actors, the fourth helix introduces a mechanism for the participation of all members of society, making innovation a borderless activity (Cai and Lattu, 2021; Carayannis et al., 2021). Therefore, in the quadruple helix, government, industry, academia, and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any single organization or person could do alone (Cai and Lattu, 2021). While this dimension is less salient compared with the other three players, it has increasingly become more important in today’s ecosystem for innovation (Cai and Lattu, 2021). With the advent of the fourth industrial revolution, modeling the reality of the innovation landscape requires more imagination and ingenuity.

It is in this spirit, the paper by Leydesdorff and Lawton Smith (2022) offers a new tool for us to gain deeper insight into today’s global innovation landscape. By decomposing and analyzing the quadruple helix model and N-tuple helices into interacting triple helices, the approach promises to open further the black box inside the higher-order helices, and provides a theoretical basis and guidance for the subsequent governance and related government policy design.

First, with the development of digital technology, the new rounds of scientific and technological revolution and industrial revolution are linking all social actors. Under these transformations, the boundaries of participants in the innovation activities become more blurred, the links among innovation actors are faster and closer, and the interdependence of participants in innovation activities becomes increasingly higher. This new context makes the boundary of innovation activities far beyond the limited relationship of
industry-academia-research cooperation and presents a new feature from “multi-point breakthrough” to “cross-interconnection” (Xue et al., 2019).

Second, innovation activities have become more complex and systematic. It is difficult for a single actor or industry-academia-research cooperation to complete innovation without intimate grasp of complicated and systematic knowledge. The innovation requires closer collaborations among all members of society with co-evolution and symbiosis mechanisms. Furthermore, there is a trend of technology application from “local diffusion” to “comprehensive penetration” (OECD, 2019). The commercialization and diffusion of innovation achievements no longer simply emphasize the development of single technology or industry, but increasingly rely on the development of the external environment around the technology and industry (Liu and Wang, 2021). Therefore, the reality of global innovation has changed dramatically from the competition of national innovation systems to a global innovation ecosystem that demands model changes from triple helix to quadruple helix or even higher-order helices.

Third, the study of Leydesdorff and Lawton Smith (2022) provides insight into how actors within the quadruple helix should connect and interact with others to ensure the acquirement of excess profits from innovation far exceeding the profit created by individual actors, or the “rents” generated by the synergistic interactions among multiple triple helices. In other words, the governance of the quadruple helix and higher-order helices requires an innovation ecosystem mindset. An innovation ecosystem is a social innovation system that is not limited to individuals, individual enterprises, or universities, but becomes a system that spans political, economic, cultural, social, and environmental spheres and connects inventors, investors, producers, and consumers (Carayannis and Campbell, 2009). In the quadruple helix, innovation requires citizens’ participation, which can help to build a symbiotic and co-evolving innovation ecosystem of government, industry, academia, and civil participants to ensure the mutual supply of complementary resources.

An essential issue arising with such an innovation model change is about how the quadruple helix or higher-order helices can be efficiently governed. Leydesdorff and Lawton Smith’s (2022) research provides several implications. First, they argue that the quadruple helix model and higher-order helices can be decomposed into a collection of multiple triple helices, each of which forms an effective synergy. The multiple triple helices are then integrated into one higher-order helix, which in turn forms more innovation and higher innovation efficiency. This means that higher-order helices can integrate independent basic research, applied research, and development research into one, and quickly connect with the market to form an integrated collaborative
innovation. Second, the quadruple helix model also implies value co-creation among various innovation actors. The quadruple helix brings exponential growth of innovation by incorporating more types of innovators, including researchers, producers, investors, and consumers, for interactions (European Commission, 2014). In other words, as the number of communication nodes increases, the integration of ideas and creativity from different industries and fields can activate a large number of innovation demands. The speed and success rate of innovation can increase dramatically as well, far beyond the innovation undertaken by any single innovator. Third, the quadruple helix is transformed from product-centric to user-centric innovation due to the inclusion of civil participants, which also greatly facilitates the rapid adoption of innovation.

2 The Challenges for Higher-Order Helices to Model Transformative Innovation in the 4th Industrial Revolution

The concept and characteristics of higher-order helices coincide with related ideas in transformative innovation. Transformative innovation brings social and ecological dimensions into the innovation process which represents the next stage of the evolution of the innovation process (Schot and Steinmueller, 2018). Transformative innovation is based on the notion that solving the main challenges facing society today requires profound changes to the current socio-technical systems (Schot and Steinmueller, 2018). Such socio-technical transformations confront social and ecological challenges, which involve various innovators (Molas-Gallart et al., 2021). In transformative innovation, there is no single best pathway to achieve sustainability, equity, or any other socially desirable goal (Schot and Steinmueller, 2018). The acceptable pathways are discovered by the negotiations among multiple innovation actors with different motivations and priorities. The innovation process requires closer interaction and more inclusive discussions between different innovators to generate shared commitment and values for effective solutions to social and environmental challenges. The emerging shared values are embedded in the process of systemic change and further shaped and consolidated with these changes (Schot and Steinmueller, 2018). The higher-order helices model reflects the change in such an innovation paradigm.

In the higher-order helices model, enterprises should make full use of data and industry knowledge to strengthen cooperation with universities and governments and fully participate in knowledge production and the formulation of formal regulations (Xue et al., 2019). In addition, enterprises should promote
differentiated competition through socially responsible innovation, and participate in public-interest activities. In particular, many platform enterprises have many public governance functions, which can promote the sustainable development of goals (SDGs) (Jia and Xue, 2021). Research institutions and universities should continue to play an important role as the bridge between government and enterprises while doing basic research, cultivating talents, and shaping values (Xue et al., 2019). In the quadruple helix model, civil participants are very important to introduce the demand for responsible and sustainable development through the expression of claims, while actively participating in governance (Cai and Etzkowitz, 2020). For example, many of the risk regulations for emerging technologies require the active participation of responsible consumers, and social organizations.

For the government and policymakers, transformative innovation policy also moves beyond the primary focus on the regulatory model of science and technology. Alternatively, transformative innovation policy should focus instead on innovation as a search process to address social and environmental challenges through socio-technical system change, guided by social and environmental goals as well as informed by experience and related learning (Schot and Steinmueller, 2018). This change implies that the linkage among ecological, social, and technological domains becomes new focus of innovation. Transformative innovation policy not only stimulates specific technological choices, but also examines the social and environmental drivers and consequences of each choice. Such innovation policy can ultimately foster desired innovation directions while excluding unwanted ones to achieve desired social and environmental goals (Molas-Gallart et al., 2021; Švarc and Dabić, 2021). This is an iterative process without predictable directions and consequences, and such fundamental changes in socio-economic goals require changes in socio-technical regimes embedded in the external institutions. Thus, the socio-technical transformation encompasses a broader systemic change not only in technology but also in social factors, such as consumer practices, demands, culture, and values (Švarc and Dabić, 2021). This requires a more flexible approach to the use of science and technology policy to adapt to the fundamental changes in the innovation model (Schot and Steinmueller, 2018). Thus, under transformative innovation, government governance of quadruple or higher-order helices is not simply adding more helices, which may not be able to reflect underlying changes and complexities.

In the quadruple helix or higher-order helices, the traditional governance model is no longer useful, and a new governance model is needed. With the rapid development of information technology and the participation of civil society, the innovation modes and business models of traditional industrial
organizations have been disrupted (Xue and Zhao, 2019). On the one hand, new technologies and the participation of all members of society are powerful drivers of innovation and stimulate massive social demand. On the other hand, they also bring in issues such as ethics and security, negative externalities. At the same time, with increasing civil participants engaging in innovation, changes occur in the path of industrial development, risk-benefit balancing, and the establishment of market confidence at all times. These changes bring new troubles to the setting of goals and contents of governments’ governance and challenge the applicability of traditional government regulatory policies. The government has difficulties in identifying characteristics of new modes of innovation and social risks in terms of knowledge systems, regulatory policies, and risk evaluations. Second, the traditional system of technology governance is a typical “command-and-control” structure, in which the government, as a regulator, sets standards and norms in advance for identified governance risks, and requires relevant actors to comply with these standards and norms (Jia and Xue, 2021; Xue and Zhao, 2019). For example, in the automobile industry, traditional government policies set standards for the quality of automobile products and the behavior of drivers to avoid related accidents. However, this traditional command-and-control structure is unsustainable in new technological contexts arising from the higher-order helices model. For example, the big data generated by citizen participants often need to be processed by certain algorithms to generate inputs for innovation. These algorithms are adopted as “rules” rather than “products” to influence the innovation activities, resulting in the diversity, dynamicity, and uncertainty on governance risks of innovation. In the case of the ranking algorithm of searching engines, the programmers’ design principle of “maximizing user click-through rate” is not controversial in itself, but when applied to a specific context and reflecting a specific social psychological tendency, the risk of addiction eventually arises. In the face of such a situation, it is difficult for regulators to pre-determine regulatory standards as the risks are difficult to foresee in advance. At the same time, it is also difficult for the regulator to distinguish the specific behavior of a specific actor that directly causes the risk of innovation due to the participation of massive civil participants.

To cope with the aforementioned challenges, the government should actively improve the social governance system from a systematic perspective to include more stakeholders within the quadruple helix or higher-order helices model. The government should encourage and guide the civil society to participate in the decision-making and governance on emerging technologies and collect public opinions widely to establish a systematic “participation-feedback” process of “public participation-decision implementation-decision
feedback-public evaluation” (Xue and Zhao, 2019) within the higher-order helices. Actors in higher-order helices can jointly explore new and effective governance mechanisms to integrate governance resources and exert each advantage. The participants of the higher-order helices model need to express their demands and form governance solutions in the process of joint governance. Along with the extensive inclusion of stakeholders in the new governance model, the government also needs to identify the changing risks at a faster pace. The stakeholders in the higher-order helices model are required to jointly explore risks as well. This requires rapid response, analysis, and processing from multi-stakeholder. Risk sharing and response mechanisms should be established to identify the risks during governance within the higher-order helices model.

3 Agile Governance for the Higher-Order Helices Model

Therefore, in the higher-order helices model, the governance needs to reconsider the three dimensions of law, risk, and benefits, and establish a framework for agile governance, which refers to a set of actions or methods that are flexible, agile, and adaptive, based on an inclusive and sustainable decision-making process. In the process of development and application of emerging technologies, the practices of enterprises and markets usually moves much faster than the government (Jia and Xue, 2021; Xue and Zhao, 2019). Thus, instead of the traditional governance model, governments should adopt agile governance to follow-up and respond timely to potential issues as they arise to ensure the healthy development of emerging innovation fields (Xue and Zhao, 2019). In the new governance model, governments must simultaneously respond to and balance multiple values including security, development efficiency, individual privacy, and social stability (Xue and Zhao, 2019). Compared to the traditional governance model, which can only make zero-sum choices between different values, the pursuit of “multi-win” thinking represented by agile governance is more suitable for the governance of innovation activities based on the quadruple helix or higher-order helices model.

Agile governance is a set of flexible and adaptive actions or methods to create an inclusive and sustainable decision-making process. The agile governance implies that governance can and should be more agile to keep pace with the rapid changes of society (World Economic Forum, 2018). Towards agile governance, the primary consideration of the government is to establish a sustainable governance concept for the continuous establishment of the flexibility and comprehensiveness of the governance framework. The government should always be ready to adapt to changes in the industry, technology, and business
models, and also need to guide related actors to think about options of innovation path. Two-way dynamic interaction between regulation and innovation should be achieved, avoiding path dependency of existing institutions. From a policy process perspective, there are three optimized paths toward agile governance: multiple objectives balance, dynamic process optimization, and flexible transformation of policy tools (Xue and Zhao, 2019).

First of all, agile governance needs to achieve proper balance among multiple objectives. The goal of governance in the higher-order helices model is not simply to maximize benefits but to achieve diversity and a win-win situation. The governance should not emphasize risk control or one-sidedly pursue efficiency but need to balance the relationship between the encouragement of innovation and risk governance by integrating the two goals of timeliness and comprehensiveness. The governments also need to promote the coordination of innovation and regulation, especially by establishing a new system of rules to shape an appropriate environment for innovation.

Second, agile governance for the higher-order helices pursues an interactive way of policy formulation to achieve dynamic optimization. It requires the participation of all members of society to combine multiple interests. The two-way dynamic interaction between the regulator and the regulated entities is an important way to ensure the matching of regulatory thinking with innovation. The government should fully understand the complex interactions and evolutionary behaviors of the higher-order helices actors, strengthen communication with these actors from the beginning of governance modes’ establishment, and provide continuous feedback and adjustment in the process of policy formulation and implementation. The government should become an important communication intermediary as well, and play a role as an institutional platform and bridge to build an ecosystem for the integration of the higher-order helices actors.

Third, the government should clarify the orientation and keep the flexibility of specific regulatory policies when building the governance model for the higher-order helices. In the specific implementation process, the government should avoid the adoption of hard-constraint policy tools, and exploit policy instruments with less intervention to achieve the best policy results. The government should also be ready to transform policy tools to avoid the loss of public welfare.

In addition, the governments should have a global vision to create a better international environment for enterprises’ development and innovation ecosystem. This requires the government to provide high priority to the implementation process of policies involving international markets or international community areas.
In summary, the agile governance model under the higher-order helices model needs to be inclusive and solution-oriented while flexible and experimental in the implementation, but accountable in the formulation.

4 Concluding Remarks

Loet Leydesdorff and Helen Lawton Smith's (2022) research unpacks and analyzes a more complex and systematic model of innovation under the digital age. Their research contributes to the extant quadruple helix and higher-order helices literature, and provide a theoretical basis and guidance for the subsequent governance of the innovation in the higher-order helices model. We have argued that a framework based on agile governance can be applied to the governance of this higher-order helices model with interactions among multiple triple helices. More specifically, a set of flexible and adaptive actions or methods are necessary to make the governance on the higher-order helices model to be more agile to keep pace with the rapid changes of society. Future studies can adopt big data and other empirical tools as a basis for related policy analysis and simulation to formulate the agile governance mode of higher-order helices model, and further, explore the key issue about how the higher-order helices model for innovation can be effectively measured through quantitative research.

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References


