Measuring Helix Interactions in the Context of Economic Development and Public Policies: From Triple to Quadruple and N-Tuple Helix vs. N-Tuple and Quadruple Helix to Triads

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Abstract

Quadruple collaboration has risen rapidly in place of the traditional triple helix model of institutional collaboration between universities, governments, and companies. Loet Leydesdorff and Helen Lawton Smith (2022) approach this challenge by aiming to resolve the issue of evaluating and analyzing various quadruple and n-tuple helices. This article seeks to recognize the increasing complexity of new and developing issues in quadruple and n-tuple helices as a response to their research. Higher order helices raise a number of important scientific difficulties, including conceptual and practical issues. The goal of this contribution is to highlight some of the major challenges involved with researching multiple helices in terms of knowledge innovation, as well as to offer some alternative areas for future research on n-tuple helices measurement.

Keywords

triple helix – quadruple helix – n-tuple helix – multiple helices – knowledge-based innovation
1 Introduction

New challenges are arising that were not previously present, such as the COVID-19 epidemic, carbon neutrality, and fake news, amongst other things. In order to deal with these new challenges, a new networked governance operation that includes more actors than the three institutional actors of academics, business, and government needs to be established.

Instead of the old triple helix model of collaboration between universities, governments, and companies, quadruple cooperation has developed as a new policy trend. Given the policy impacts of the quadruple model, the European Commission and other countries, notably South Korea, are proposing and developing the prospect of a new innovation paradigm in response to these changes (Yoon et al., 2017; Cai and Amaral, 2021; Zhu and Park, 2022).

When compared to the long-lasting triple helix literature, despite steadily increasing discussions on the quadruple, quintuple, and n-tuple helix models, it remains difficult to provide clear answers to the new models’ definition and scope, agenda to focus on, related systems, and methodological measurements (Park 2014a; Park 2014b; Leydesdorff and Park, 2014; Cai and Lattu, 2021; Caryannis et al., 2021). In response, the writers of the article, Loet Leydesdorff and Helen Lawton Smith (2022), propose answers to the question of how to evaluate and assess diverse quadruple-helix difficulties. In addition, their empirical research (as well as software tools) provides a thorough understanding of the similarities and differences between established triple helix models and emerging quadruple helix models, as well as the implications of these models for theoretical, policy, and industrial possibilities and consequences.

We feel that public response has always been a key factor in a quadruple framework composed of knowledge, innovation, consensus and government spheres (Ranga and Etzkowitz, 2013; Park, 2020). We set out to achieve the following in order to contribute to an open discussion about the economic development and knowledge production of helix interactions. The goal of this paper is to call attention to a number of key issues associated with the study of the proliferation of n-tuple helices. We examine the tension that occurs between arranging research topics and analytical procedures under a “helix” framework and, in particular, the measuring operations available for evaluating the quadruple and n-tuple helix.

2 Is There a One-Size-Fits-All Solution?

It was the collaboration of Leydesdorff and Etzkowitz (1996) that ushered in the transition from the double to triple helix in the late 1990s, and the
development of a dynamic model that can measure the degree of independent, competitive, and interactive information exchange in the knowledge production process, which is a significant achievement in the field. While Leydesdorff and Smith's (2022) dynamic triple helix model was developed primarily for academic objectives, the most notable distinction between it and the present quadruple helix is the incorporation of a wide range of policy viewpoints. For example, the European Commission's smart specialization strategy expanded its key sectors to include media- and culture-based civil societies, including non-governmental organizations (NGOs) (Yoon et al., 2017). Therefore, doing academic analysis driven by a politically established agenda appears to be highly problematic and insufficient.

Rather than being passively handed down from the outside under the leadership of a certain institutional actor, Leydesdorff and Lawton Smith (2022) highlight that the knowledge-based society is formed from an internal network dynamic that has developed over time through interaction of university, industry, and government sectors. Leydesdorff and Lawton Smith (2022) asserted that through the trajectory and regime concepts of knowledge formation and evolution, the knowledge structure generated at a specific point in the process evolves by restricting or activating the innovation system. Leydesdorff and Lawton Smith’s (2022) idea has been empirically validated to a large extent through the use of bibliographic data and scientometric network indicators. Further, Leydesdorff and Lawton Smith (2022) assert that the quadruple helix’s unit of analysis is an interacting triad relationship.

Several European and Asian countries, including South Korea, are discussing quadruple and quintuple helices in the context of open innovation to address a variety of societal concerns and to bring together sometimes opposing perspectives. To effectively utilize the knowledge resources held by various institutional sectors within a country, networks must be expanded beyond universities, industries, and governments. Furthermore, new tools and indicators are required to track and visualize the dynamics of mutual cooperation on a scientific level (Sharif et al., 2018; Pardo Martinez and Cotte Poveda, 2021; Qureshi et al., 2021; Virkkala and Mariussen, 2021). When applying scientific concepts and indicators for developing policy recommendations, we must take construct validity into consideration. Is it necessary to develop a new unit of analysis in place of Leydesdorff and Lawton Smith’s (2022) suggesting triad relationships in this regard? There are arguments to be made in favor and against, because in normative science, a policy-oriented model can view interacting triad relations as output rather than input of a quadruple helix.

The quadruple helix, in contrast to the Leydesdorff and Lawton Smith's (2022) existing triple helix, may not be a novel model because it also deals with the established processes of scientific knowledge and research and development.
Besides universities, for example, non-profit organizations and civic advocacy groups have emerged as important players in the process of development, thereby demonstrating their ability to generate novelty in the field of knowledge production. Living Labs are a good example because they have recently been hailed as a useful model of knowledge production and diffusion opportunities for problem-solving both within and outside of a country’s university, industry, and government sectors (Van Geenhuizen, 2016). Those in the business world who pursue social entrepreneurship are not only pursuing financial prosperity, but they are also willing to take risks in order to respond to various government-mandated programs and address societal concerns such as economic inequality, environmental degradation and crime (Choi, et al., 2021).

When it comes to quadruple, quintuple, and/or n-tuple helix interactions, one can wonder, Leydesdorff and Lawton Smith’s (2022) formulating question, that is, “Does the decrease of uncertainty in the division of labors still matter in the ideal configuration of higher order helices?” In a world where the boundaries between universities, corporations, and governments are becoming increasingly blurred, and their functions are becoming increasingly ambiguous, it is challenging to find empirical data that can be used to quantify the knowledge dynamics of reciprocal trade. The concept of social networks, which is defined as three interconnected entities (university-industry-government) with humans (or organizations) as the unit of analysis, must be revised in order to more accurately measure a number of new institutional actors involved in multilateral helix innovation across countries and regions.

3 Why Do We Need Quadruple and Multiple Helices?

Before considering the quadruple helix, it is useful to consider the step from a double helix to a triple helix innovation model. The double helix involves a process of interaction between two types of actors involved in knowledge production, for example industry and universities. The adding of strands to a double helix is seen as fundamentally changing the innovation system from a “dynamic” innovation system to a triple helix innovation regime (Leydesdorff and Etzkowitz, 1996). However, Leydesdorff and Lawton Smith (2022) question whether a fourth or n-th strand adds further analytical value. Leydesdorff and Etzkowitz (1996) had initially noted that moving from interaction between two actor-types (double helix) to three actor-types (triple helix) creates an important additional dynamic: the opportunity for two parties to cooperate against a third party, changing the dynamics from a trajectory (stable, moving around an equilibrium) to a regime (complex, non-linear and unstable). However
adding a fourth, fifth or $n$-th Helix, according to Leydesdorff and Lawton Smith (2022: 28), “add to the sum of the three helices but create no new dynamics, beyond that of their sub-triple helices.”

This comment provides an interesting perspective because the third dimension is a provocative variation on the second dimension, but the third to fourth, fifth, and $n$-th structure is still, in essence, a simple sum of the third dimensions. However, Carayannis and Campbell’s (2010) quadruple helix concepts, as well as the more recently emerging literature on multi-level perspectives on socio-technical transitions (see Geels et al., 2017), provide a slightly different argument. Socio-technical transitions within a knowledge-based society involve a wide range of actor-types, including politicians and activists (and not just policy makers), emergent and incumbent firms which have opposing interests, cultural influences which can change consumer preferences, media, regulatory bodies, different levels of government, etc. Geels et al. (2017) write “transitions are not only about the market diffusion of new technologies but also about changes in user practices, cultural discourses, and broader political struggles. Transitions are therefore not tame, but disruptive, contested, and non-linear processes.” (2017: 464) As a result “transitions require complex negotiations and trade-offs between multiple objectives and constraints, including cost-effectiveness, equity, social acceptance (legitimacy), political feasibility, resilience, and flexibility.” (2017: 464)

While Leydesdorff and Lawton Smith (2022) recognize that more than three distinct innovation actor types can be involved in innovation processes, they claim that this does not create new types of dynamics beyond the summation of triple helix dynamics. So when following this perspective, shifts in (socio)-technical (triple helix) regimes can be explained by changes in different triple helix relationships rather than any over-arching quadruple or n-tuple helix relationship. Within the context of low-carbon energy transitions, this could mean (for example) the decline of the oil and gas exploration and production triple helix, and the rise of a photovoltaics or offshore wind turbines triple helix. This shift could, for example, be brought about by a third consumer-politics-venture capital triple helix-type relationship, which influences the other innovation actors (Geels et al., 2017; Meijer et al., 2019; Steen et al., 2019).

Essentially Leydesdorff and Lawton Smith (2022) appear to be breaking down these complex innovation systems with multiple actors into its “building blocks”: sets of inter-acting triple helix systems which can be analyzed separately. This “broken down” triple helix view of looking at complex systems and the quadruple or $n$-tuple helix provides a novel analytical paradigm for approaching complex innovation systems. Because of Leydesdorff and
colleagues’ empirical approach (see also Ivanova and Leydesdorff, 2014), which focuses on information redundancy generation (synergy in knowledge production), the influence of one triple helix system on another triple helix system can also be validated by future research. For example, does the decline of the domestic university-industry-government triple helix in South Korea (Park and Leydesdorff, 2010) lead to the creation of a stronger university-industry-government triple helix as the country’s innovation system internationalizes? (Kwon et al., 2012)

At the same time the approach of reducing complex systems to a collection of triple helices risks overlooking certain overarching dynamics that the literature on socio-technical transitions and higher-order helices aims to capture. Reducing complex systems to triple helices may be a useful descriptive analytical approach, but it does not explain the transition from one technological regime to another. At best, a triple helix-centered approach enables the observation of the strengthening of one triple helix (e.g. renewable energy or with international innovation actors) and the weakening of another triple helix system (e.g. hydrocarbon energy or with domestic innovation actors). From this viewpoint, socio-technical transitions are seen as being external to a triple helix regime, and therefore an otherwise successful triple helix, with high levels of synergy, could conceivably decline relatively quickly due to technological lock-in when a transition occurs. From a policy perspective, a failure to incorporate socio-technical transitions limits the value of the classical university-industry-government triple helix model.

The limitations of a purely triple helix approach suggest a need for a quadruple helix or n-tuple helix to understand the functioning of socio-technical transitions, which have far broader societal implications. While many policy-makers and academics have already arrived at this conclusion, and have suggested a range of novel innovation actors, Leydesdorff and Lawton Smith (2022) also note the measurement challenges of quadruple and higher-order helices.

4 Measuring the Quadruple Helix

While there is policy interest in quadruple and higher-order helices, Leydesdorff and Lawton Smith (2022) caution against focusing on higher-order helices from a very practical perspective: “Instead of specifying new and more helices – for example, for political reasons – we suggest keeping the models simple so that they can be used for the precise (and where possible numerical and visualized) evaluations” (2022: 27) From this perspective, reducing the quadruple
while the advice of Leydesdorff and Lawton Smith (2022) makes sense, the visualization of a quadruple helix is relatively simple in practice, with four overlapping sets, see Figure 1. Gathering bibliometric data on a fourth helix is also feasible. In addition to industry, government and universities, foreign institutions often play a notable role in national innovation systems and can be identified from bibliometric data (see for example Kwon et al., 2012). Depending on the data set, it is also possible to make a distinction between large conglomerates and smaller firms, or between firms active in different sectors (see for example Stek and Van Geenhuizen, 2015). Empirical methods for identifying green technologies and analysis at the level of individual research departments have also been proposed (Gautam, 2019; Akbari et al., 2022). In this sense quadruple helix policy ideas can be visualized, and in certain cases they may also be measurable.

While we take seriously the observation by Leydesdorff and Lawton Smith (2022) that higher-order helices "create no new dynamics, beyond that of their subtriple helices" (2022: 27), it is compelling and appears feasible to explore the possibility of additional fourth-helix dynamics nonetheless. If we follow the mathematical notation of Leydesdorff and Lawton Smith (2022) and observe the quadruple helix in Figure 1, in addition to studying the constituent Triple Helices and their overlap \( H_{ABC}, H_{ACD}, H_{BCD} \) and \( H_{ABD} \), the overlap of a quadruple helix at \( H_{ABCD} \) may provide an opportunity to measure further synergies, which in turn help better understand shifts in technological regimes and their constituent triple helices. For instance, a period of heightened quadruple helix formation could signal that a shift is underway from one triple helix regime to another triple helix regime. Such an observation would also greatly

![Figure 1](https://example.com/figure1.png)

**Figure 1**
Graphical arrangement for four overlapping sets (quadruple helix), adapted from Jones, McKinnes and Staveney (1999)
enhance the socio-technical transition literature of Geels et al. (2017) and others, and provide a clear understanding of when quadruple helix dynamics are really relevant, and when they are not.

An empirical exploration of the quadruple helix, in the same manner that Ivanova and Leydesdorff (2014) have empirically explored the triple helix, would keep the quadruple helix literature scientifically grounded, and would greatly enhance its scientific credibility.

5 Conclusion

We hope that current discussions have managed to highlight both the great contribution by Leydesdorff and Lawton Smith’s (2022) with regards to the triple and quadruple helix literature, and shown some areas where scientific debate continues and further conceptualization and empirical research are needed. We share Leydesdorff and Lawton Smith’s (2022) concern that the quadruple helix concept lacks a strong scientific foundation and that there is a risk of incorporating additional helices into an innovation model to satisfy policy demands and without sufficient empirical evidence. At the same time, we also believe that the existence of quadruple-helix dynamics should not be dismissed out of hand, especially when considering higher-order dynamics, such as the transition between socio-technological regimes.

While it is important to recognize the growing complexity of new and emerging problems and the networked governance that is emerging to address them, the power of such ideas is greatly enhanced by solid scientific research that provides empirical evidence. In terms of the quadruple helix as it stands today, we have a basic concept, but we are still seeking “proof of concept”.

In addition to these fundamental scientific concerns, many other conceptual and practical questions remain about higher order helices, such as the quadruple helix model. There appears to be no consensus on what they are, how they differ from traditional models, where the n-tuple helix is, how to implement it at the policy level, how to develop and support it, or what factors should be taken into consideration in order for all of these discussions to be fruitful. While policy interest in higher-order helices is welcome, caution is needed in their implementation. At the very least a simple visual understanding of these relationships is needed before using these concepts in policy-making processes.

None of the above remarks are intended to deny or discredit the Leydesdorff and Lawton Smith’s (2022) arguments or research findings; rather, we are seeking to determine whether they are appropriate or sufficient for answering a
number of new goals and concerns pertaining to the quadruple helix. We humbly conclude that many questions about the quadruple or n-tuple helix remain.

References


