The Triple Helix in the context of global change: dynamics and challenges

Helen Lawton Smith[a]* & Loet Leydesdorff [b]

Abstract

Understanding how economies change through the interactions with science and governance as different spheres of activity, requires either new conceptual tools or advances in existing ones. In this paper the evolution of the metaphor of a Triple Helix of university-industry-government relations is positioned within the context of global economic change, highlighting how these relations are both continuing and mutating or changing, and the conditions under which a Triple Helix might be seen to be unraveling in the face of pressures on each of the three helices – university-industry-government. The reciprocal dynamics of innovation both in the Triple Helix thesis and in the global economy are systemically explored.

Keywords: Triple Helix, globalization, innovation, systems, dynamics, evolution

[a] Department of Management, Birkbeck, University of London, London WC1E 7HX, UK; h.lawton-smith@bbk.ac.uk ; * corresponding author

[b] University of Amsterdam, Amsterdam School of Communication Research (ASCoR), Kloveniersburgwal 48, 1012 CX Amsterdam, The Netherlands; loet@leydesdorff.net ; http://www.leydesdorff.net

Introduction

The Triple Helix thesis emerged in the mid-1990s, a time when universities and industry were exhorted by policy makers to work together more closely for the benefit of society resulting from the commercialisation of new knowledge (see for example Branscomb 1993 on the US). The thesis became articulated as a confluence between Henry Etzkowitz' long-term interest in the study of university-industry relations and Loet Leydesdorff's interest in an evolutionary model in which there is an overlay of communications between different and independent spheres of activity. The first paper, Etzkowitz & Leydesdorff, (1995), *The Triple Helix---University-Industry-Government Relations: A Laboratory for Knowledge-Based Economic Development* came about after Etzkowitz' (1994) participation in a workshop in Amsterdam and an ensuing volume, entitled *Evolutionary Economics and Chaos Theory: New Directions in Technology Studies* (Leydesdorff & Van den Besselaar 1994).

The metaphor of a Triple Helix emerged thereafter in discussions about organizing a follow-up conference under this title in Amsterdam in January 1996.[1] Since then, Etzkowitz & Leydesdorff (2000) further elaborated the Triple Helix of University-Industry-Government Relations into a model for studying both knowledge-based and developing economies. Over time the model has evolved, been re-interpreted and critiqued (e.g., Carayannis & Campbell, 2009; Cooke & Leydesdorff, 2006; Lawton Smith & Ho, 2006; Shinn, 2002). In this paper, the objective is to position the dynamics and evolution of university-industry-government relations (TH) within the context of challenges facing the global economy – unemployment, low or no growth, spiraling healthcare needs, rapidly emerging digital business models, unsustainable changes to the environment, and both coordinated and uncoordinated regulatory systems.

In this context, the analysis is concerned with where the model's basic elements continue in practice and as a policy agenda. We further consider the conditions under which the original elements of the model have become distorted through political and competitive pressures. Have the pressures on the individual components forced them apart? Underpinning all of these is the key question: How can the Triple Helix approach contribute to the understanding of what exists in terms of institutional relations and what is known in terms of mechanisms in order to provide the specification of 'an enterprising state' in which universities, businesses, and governments would co-innovate to solve the global economic challenges?

Following from this, the crucial issues are those of: under which conditions can the three functions—wealth generation, organized knowledge production, and normative control—operate synergetically, to what extent or at which level, and at what price? In order to answer the question by exploring these issues, we first turn to the model to examine its evolution and

[1] Precursors of using this metaphor can be found in Lowe (1982) and Sabato (1975). Lewontin (2000) uses the same metaphor in a biological context.

consider how it might continue to mutate and/or to unravel as the three spheres are under increasing pressures from global changes. We consider these three functional dynamics as further heuristics in the application of a Triple Helix model in theory and in practice.

The model, its different versions, and its evolution

The Triple Helix model of university-industry-government relations is depicted in Figure 1 as alternating between bilateral and trilateral coordination spheres of activity. The relationships between them remain in transition because each of the partners develops also its own (differentiating) mission. Thus, a trade-off can be generated between integration and differentiation as possible synergies can be explored and potentially shaped. The form these relationships take, their drivers and outcomes are a reflection of context-dependent forces and agendas.

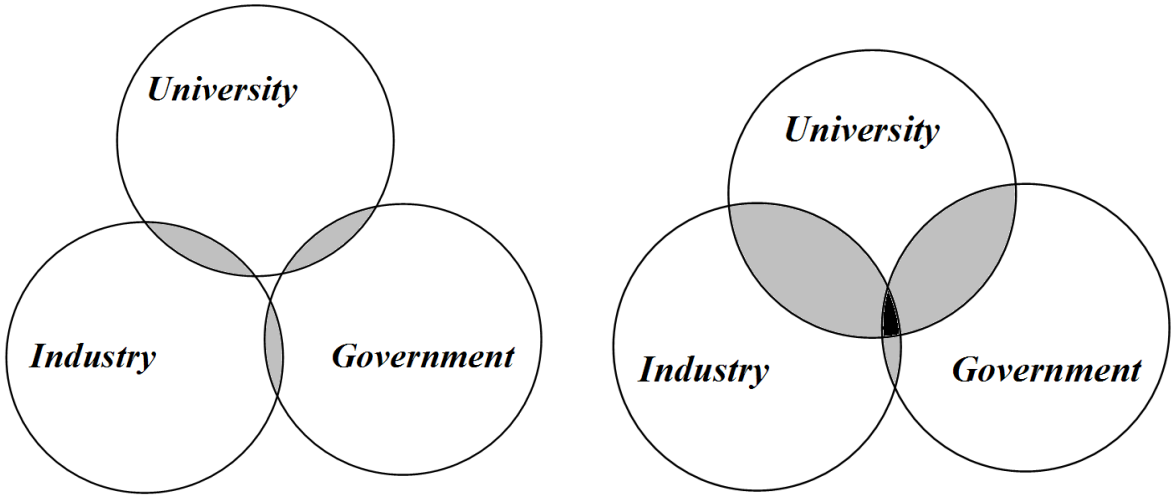

Figure 1: A Triple Helix configuration with negative and positive overlap among the three subsystems.

The Triple Helix (TH) can be considered as an empirical heuristics which uses as *explanantes* not only economic forces (e.g., Schumpeter, 1939; Nelson & Winter, 1982), and legislation and regulation by (regional or national) governments (e.g., Freeman, 1987; Freeman & Perez, 1988), but also the endogenised dynamics of transformations by science-based inventions and innovations (Noble, 1977; Whitley, 1984). The TH model does not exclude focusing on two of the three dynamics—for example, in studies of university-industry relations (Clarke, 1998; Etzkowitz, 2002) or as in the "variety of capitalism" tradition (Hall & Soskice, 2001)—but the third dynamics should at least be declared as another source of variation.

TH models can be elaborated in various directions. Firstly, the networks of university-industry-government relations can be considered as neo-institutional arrangements which can be made the

subject of social network analysis (e.g., Owen-Smith *et al.*, 2002). This model can also be used for policy advice about network development, for example in the case of transfer of knowledge and the incubation of new industry. The new and potentially salient role of universities in knowledge-based configurations can then be explored in terms of different sectors, regions, countries, etc. (Godin & Gingras, 2000; Shinn, 2002). Over the past ten years, this neo-institutional model has also been developed into a discourse about "entrepreneurial universities" (Clark, 1998; Etzkowitz, 2002, 2008; Mirowski & Sent, 2007). Regions ("regional triple helix spaces," Etkowitz 2002) are then considered as endowed with universities that can be optimised for a third mission, as an incentive additional to higher education and internationally oriented research.

Secondly, the networks span an architecture in which each relation occupies a position. One can thus obtain a systems perspective on knowledge-based innovations in a hypothesised space; this theoretical construct—the knowledge-based economy—can be informed by systematic data analysis (e.g., Leydesdorff & Fritsch, 2006; Strand & Leydesdorff, in press).

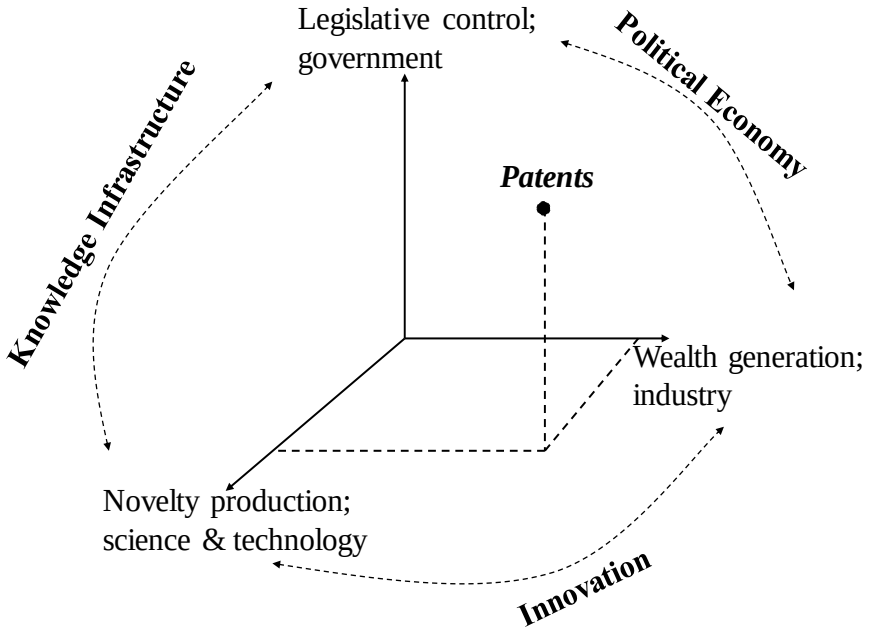

Figure 2: Patents as events in the three-dimensional space of Triple Helix interactions. (Source: Leydesdorff, 2010, at p. 370.)

In Figure 2, patents as events, for example, are considered as positioned in terms of the three social coordination mechanisms of (1) wealth generation on the market by industry, (2) legislative control by government, and (3) novelty production in academia. Whereas patents are output indicators for science and technology, they function as inputs into the economy. Their main function, however, is to provide legal protection for intellectual property. In other words,

relevant events in a knowledge-based economy can be positioned in this three-dimensional space of industry, government, and academia. When events (e.g., patents) can also circulate, a three-way interaction effect can be expected. This knowledge-based economy contributes to the political economy by ensuring that the social organization of knowledge as R&D is endogenised into the system's dynamics.

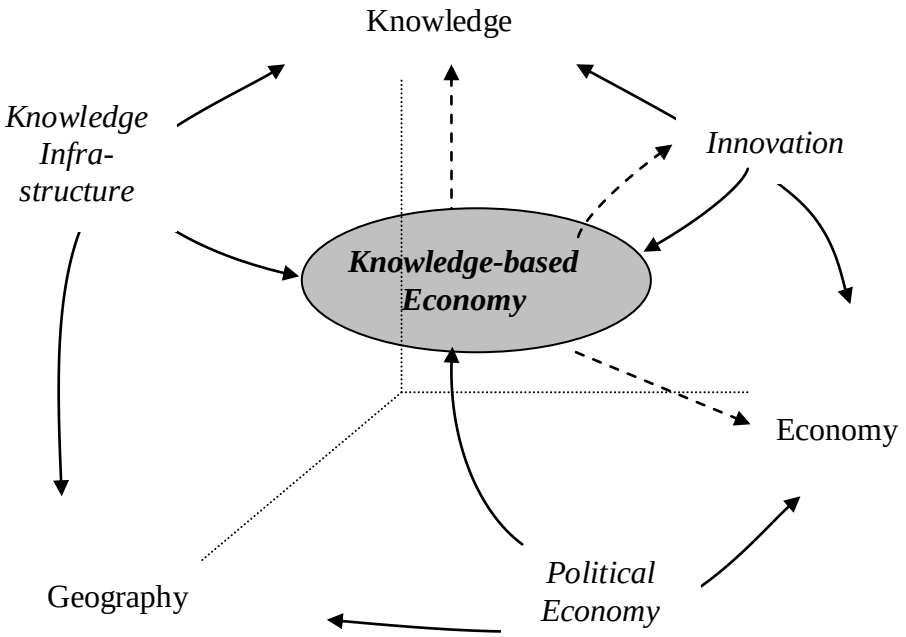

Figure 3: The first-order interactions generate a knowledge-based economy as a next-order system. (Source: Leydesdorff, 2010, at p. 379.)

The three functions in Figure 3 can also be considered as interaction terms among relational exchange processes (e.g., in an economy), political positions in a bordered unit of analysis (e.g., a nation), and the reflexive and transformative dynamics of knowledge. When these interaction terms exhibit second-order interaction, a knowledge-based economy can increasingly be shaped (Foray, 2004; Leydesdorff, 2006).

Whereas innovation agencies may be in favour of university-industry-government relations for institutional reasons (Mirowski & Sent, 2007; cf. Etzkowitz, 2008), the crucial research issues remain related to questions such as: under which conditions can the three functions operate synergetically, to what extent or at which level, and at what price? Is a country or region able to retain "wealth from knowledge" and/or "knowledge from wealth" (as in the case of oil revenues). Such a synergy can be expected to perform a life-cycle. In the initial stage of emergence, "creative destruction" of the relevant parts of the old arrangements is the driving

force. New entrants (scientists, entrepreneurs) can be expected to attach themselves preferentially to the originators—the innovation organisers—of the new developments. How should networks be constructed in terms of participating institutions, and in which order? Can one locally construct a path-dependency and therewith a competitive advantage? (Cooke & Leydesdorff, 2006; Ivanova & Leydesdorff, in preparation.)

In addition to "creative destruction" as typical for Schumpeter Mark I, Soete & Ter Weel (1999) proposed considering "creative agglomeration" as typical of the competition among corporations. This changes the dynamics of development in the later stage of development, and is sometimes called "Schumpeter Mark II" (Freeman & Soete, 1997; Gay, 2010). In a bibliometric study of the diffusion of the new technology of RNA interference (Fire *et al.*, 1998; Sung & Hopkins, 2006), Leydesdorff & Rafols (2011) found a change of preferential attachments from the inventors in the initial stage to emerging "centers of excellence" at a later stage. In the patent market, however, a quasi-monopolist was found in the market (Leydesdorff & Bornmann, 2012) located in Colorado, whereas the research centres of excellence were concentrated in major cities such as London, Boston, and Seoul. Drug development requires a time horizon different from that required by the application of the technique in adjacent industries, such as the production of reagents for laboratories (Lundin, 2011).

In other words, the new technologies can move along trajectories in all three relevant directions and with potentially different dynamics. The globalization of the research front requires an uncoupling from the originators and a transition from Mode-1 to Mode-2 research in order to make the technique mutable (Gibbons *et al.*, 1994; Latour, 1987). From this perspective, "Mode-1" and "Mode-2" are no longer considered as general systems characteristics of society and policy making, but as stages in the life-cycles of technological transformations. An analogy to Schumpeter Mark I and Mark II within the domain of organised knowledge production and control can thus be specified. Universities, however, are poorly equipped for patenting (Leydesdorff & Meyer, 2010). Some of the original patents may profitably be held by academia. In the case of RNA interference, for example, two original US-patents ("Tuschl-I" and "Tuschl-II") were co-patented by MIT and the Max Planck Society in Germany (MIT Technology Licensing Office, 2006), but a company was founded as a spin-off to further develop the technology. As noted, the competition thereafter shifted along a commercial trajectory.

In summary, whereas one can expect synergies to be constructed, the consequent system "self-organises" in terms of relevant selection environments, while leaving behind institutional footprints. Three dimensions are important: the economic, political, and socio-cognitive potentials for change. Both local integrations and global pressures for differentiation can continuously be expected—which have implications for the partial unraveling and reconstruction of the triple helix model.

Geography and dynamics of the model

These complexities are further shaped by geography—place and space. Different from discussions about national (Lundvall, 1988; Nelson, 1993) or regional systems of innovation (Cooke 1992, Braczyk *et al.*, 1998), the Triple Helix model enables an analyst to consider empirically whether specific dynamics (e.g., synergies) among the three composing media emerge at national and/or regional levels. With respect to the latter, in various countries the Triple Helix concept has been used as an operational strategy for regional development and to further the knowledge-based economy; for example, in Sweden (Jacob, 2006) and Ethiopia (Saad *et al.*, 2008). In Brazil, the Triple Helix became a "movement" for generating incubators designed to promote enterprise-formation in the university context (Almeida, 2005). In other cases, however, sectors and/or technologies (e.g., biotechnology) may be more relevant systems of reference for innovations than geographical units of analysis (Carlsson, 2006).

Globalisation has brought about a transformation in the configuration of the Triple Helix model in varying degrees depending on the openness of countries, which amounts to mutation. In the case of Japan, for example, and using a specific operationalisation, Leydesdorff & Sun (2009) found that since the opening of China and the demise of the Soviet Union (1991)—both major changes in international competition—the national science system of Japan has increasingly become a retention mechanism for international relations. Thus, a further differentiation between the national and the global level was needed in this explanation. In principle, the Triple Helix indicator—that is, the mutual information among three dimensions—can be extended to more than three dimensions (Kwon *et al.*, 2012). In this example the original components have generated a regulator that contextualizes and distorts the interplay among universities, industry, and government agencies at the national level.

Unravelling can also be seen in practice. In a study of Hungary, Lengyel & Leydesdorff (2011) found that its national system of innovations fell into three regional systems of innovation following the transition of the 1990s and the accession to the EU in 2004. The authors distinguish: (*i*) a metropolitan area around Budapest, (*ii*) a knowledge-based innovation system in the western part of the country which is integrated into other EU countries, and (*iii*) an eastern part of the country where the old (state-led) dynamics still prevail. The national level no longer adds synergy to these three regional systems.

The roles of the academic, industrial, and governmental contributions are also not given. The central role of universities in many TH studies is based on the assumption that this system is more adaptive than the others because of the continuous flux of students (Shinn, 2002). In a recent study of Norway, however, Strand & Leydesdorff (in press) found foreign direct investment via the offshore (marine and maritime) industries in the Western part of the country

to be a greater source of synergy in the knowledge-based developments of regions than the university environments of the major centers in Trondheim and Oslo.

Two conclusions can be drawn from these nation-based studies: (*i*) medium-tech industry is more important for synergy than high-tech, and (*ii*) the service sector tends to uncouple from geographical location because a knowledge-intensive service is versatile and not geographically constrained. These conclusions accord with the emphasis in the literature on embeddedness (Cohen & Levinthal, 1989) versus the footlooseness of high-tech industries (Vernon, 1979). Certain Italian industrial districts, for example, while very innovative, are under the continuous threat of deindustrialization because incumbent multinational corporations may buy and relocate new product lines (Beccatini, 2003; dei Ottati, 2003). In institutional analyses that focus on local and regional development using the Triple-Helix model, the structural effects of globalisation are sometimes not given the significance that is needed in understanding new configurations.

Conclusions and future directions

What is the contribution of these models and possible variations in terms of providing heuristics to empirical research and policy practices? How do we understand the Triple Helix model in the context of global change? We considered new theoretical advances matched by new empirical evidence. First, the neo-institutional model of arrangements among different stakeholders can be investigated in case study analysis. Case studies can be enriched by addressing the relevance of the *three* major dimensions of the model on an equal footing *ex ante*, with insights into possible mutations or unravellings. Research can then inform about specifics, such as path-dependencies (e.g., Etzkowitz *et al.*, 2000; Viale & Campodall'Orto, 2002). Thus, the Triple Helix perspective does not disclaim the legitimacy of studying, for example, bi-lateral academic-industry relations or government-university policies. However, one can expect more interesting results by studying the interactions among the three sub-dynamics in the context of global change.

Secondly, the model can be informed by the increasing understanding of complex dynamics and simulation studies from evolutionary economics (e.g., Malerba *et al.*, 1999; Windrum, 1999). Thirdly, the Triple Helix model adds to the meta-biological models of evolutionary economics the sociological notion of meaning being exchanged among the institutional agents (Luhmann, 1995). Finally, on the normative side of developing options for innovation policies, the Triple Helix model provides an incentive to search for *mismatches* (mutations, unravellings) between the institutional dimensions in the arrangements and the social functions performed by these arrangements.

The frictions between the two layers (knowledge-based expectations and institutional interests), and among the three domains (economy, science, and policy) provide a wealth of opportunities for puzzle solving and innovation. We plead for a shift of focus from "best practices" to

systematic learning about the dynamics from also failures. The evolutionary regimes are expected to remain in transition as they are shaped along historical trajectories. A knowledge-based regime continuously upsets the political economy and the market equilibria as different sub-dynamics. Conflicts of interest can be deconstructed and reconstructed, first analytically and then perhaps also in practice in the search for informed solutions to problems of economic productivity, wealth retention, and knowledge growth.

The rich semantics of partially conflicting models reinforces a focus on solving puzzles among differently codified communications reflexively. The lock-ins and bifurcations are systemic, that is, largely beyond control; further developments are based on the variation and the self-organising dynamics of interactions among the three selection environments. These sub-dynamics can also be considered as different sources of variance which disturb and select from one another. Resonances among selections shape trajectories in co-evolutions, and the latter may recursively—that is, selectively—drive the system into new regimes. This neo-evolutionary framework assumes that the processes of both integration and differentiation in university-industry-government relations remain under reconstruction. How reconstruction is observed as processes of continuance, mutation, and unraveling in theory and in practice sets a research agenda with both industrial and political relevance.

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