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LOET LEYDESDORFF ON THE TRIPLE HELIX: HOW SYNERGIES IN UNIVERSITY-INDUSTRY-GOVERNMENT RELATIONS CAN SHAPE INNOVATION SYSTEMS

Theory Talks

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LOET LEYDESDORFF ON THE TRIPLE HELIX: HOW SYNERGIES IN UNIVERSITY-INDUSTRY-GOVERNMENT RELATIONS CAN SHAPE INNOVATION SYSTEMS

This is the sixth and last in a series of Talks *dedicated to the technopolitics of International Relations, linked to the forthcoming double volume 'The Global Politics of Science and Technology' edited by Maximilian Mayer, Mariana Carpes, and Ruth Knoblich*

The relationship between technological innovation processes and the nation state remains a challenge for the discipline of International Relations. Non-linear and multi-directional characteristics of knowledge production, and the diffusive nature of knowledge itself, limit the general ability of governments to influence and steer innovation processes. Loet Leydesdorff advances the framework of the "Triple Helix" that disaggregates national innovation systems into evolving university-industry-government eco-systems. In this *Talk*, amongst others, he shows that these eco-systems can be expected to generate niches with synergy at all scales, and emphasizes that, though politics are always involved, synergies develop unintentionally.

What is the most relevant aspect of the dynamics of innovation for the discipline of International Relations?

The main challenge is to endogenize the notions of technological progress and technological development into theorizing about political economies and nation states. The endogenization of technological innovation and technological development was first placed on the research agenda of economics by evolutionary economists like Nelson and Winter in the late 1970s and early 1980s. In this context, the question was how to endogenize the dynamics of knowledge, organized knowledge, science and technology into economic theorizing. However, one can equally well formulate the problem of how to reflect on the global (sub)dynamics of organized knowledge production in political theory and International Relations.

From a longer-term perspective, one can consider that the nation states – the national or political economies in Europe – were shaped in the 19th century, somewhat later for Germany (after 1871), but for most countries it was during the first half of the 19th century. This was after the French and American Revolutions and in relation to industrialization. These nation states were able to develop an institutional framework for organizing the market as a wealth-generating mechanism, while the institutional framework permitted them to retain wealth, to regulate market

forces, and also to steer them to a certain extent. However, the market is not only a local dynamics; it is also a global phenomenon.

Nowadays, another global dynamics is involved: science and technology add a dynamics different from that of the market. The market is an equilibrium-seeking mechanism at each moment of time. The evolutionary dynamics of science and technology nowadays adds a non-equilibrium-seeking dynamics over time on top of that, and this puts the nation state in a very different position. Combining an equilibrium-seeking dynamics at each moment of time with a non-equilibrium seeking one over time results in a complex adaptive dynamics, or an eco-dynamics, or however you want to call it – these are different words for approximately the same thing.

For the nation state, the question arises of how it relates to the global market dynamics on the one side, and the global dynamics of knowledge and innovation on the other. Thus, the nation state has to combine two tasks. I illustrated this model of three subdynamics with a figure in my 2006 book entitled*The Knowledge-Based Economy: Modeled, measured, simulated* (see image). The figure shows that first-order interactions generate a knowledge-based economy as a next-order or global regime on top of the localized trajectories of nation states and innovative firms. These complex dynamics have first to be specified and then to be analyzed empirically.

For example, the knowledge-based dynamics change the relation between government and the economy; and they consequently change the position of the state in relation to wealth-retaining mechanisms. How can the nation state be organized in such a way as to retain wealth from knowledge locally, while knowledge (like capital) tends to travel beyond boundaries? One can envisage the complex system dynamics as a kind of *cloud* – a cloud that touches the ground at certain places, as Harald Bathelt, for example, formulated.

How can national governments shape conditions for the cloud to touch and to remain on the ground? The Triple Helix of University-Industry-Government Relations can be considered as an eco-system of bi- and tri-lateral relations. The three institutions and their interrelations can be expected to form a system carrying the three functions of (i) novelty production, (ii) wealth generation, and (iii) normative control. One tends to think of university-industry-government relations first as neo-corporatist arrangements between these institutional partners. However, I am interested in the ecosystem shaped through the tri- and bilateral relationships.

This ecosystem can be shaped at different levels. It can be a regional ecosystem or a national ecosystem, for instance. One can ask whether there is a surplus of synergy between the three (sub-)dynamics of university-industry-government relations and where that synergy can generate wealth, knowledge, and control; in which places, and along trajectories for which periods of time – that is, the same synergy as meant by "a cloud touching the ground".

For example, when studying Piedmont as a region in Northern Italy, it is questionable whether the synergy in university-industry-government relations is optimal at this regional level or should better be examined from a larger perspective that includes Lombardy. On the one hand, the administrative borders of nations and regions result from the construction of political economies in the 19th century; but on the other hand, the niches of synergy that can be expected in a knowledge-based economy are bordered also; for example, in terms of metropolitan regions (e.g., Milan–Turin–Genoa).

Since political dynamics are always involved, this has implications for International Relations as a field of study. But the dynamic analysis is different from comparative statics (that is, measurement at different moments of time). The knowledge dynamics can travel and be "footloose" to use the words of Raymond Vernon, although it leaves footprints behind.

Grasping "wealth from knowledge" (locally or regionally) requires taking a systems perspective. However, the system is not "given"; the system remains under reconstruction and can thus be articulated only as a theoretically informed hypothesis.

In the social sciences, one can use the concept of a hypothesized system heuristically. For example, when analyzing the knowledge-based economy in Germany, one can ask whether more synergy can be explained when looking at the level of the whole country (e.g., in terms of the East-West or North-South divide) or at the level of Germany's Federal States? What is the surplus of the nation or at the European level? How can one provide political decision-making with the required variety to operate as a control mechanism on the complex dynamics of these eco-systems?

A complex system can be expected to generate niches with synergy at all scales, but as unintended consequences. To what extent and for which time span can these effects be anticipated and then perhaps be facilitated? At this point, Luhmann's theory comes in because he has this notion of different codifications of communication, which then, at a next-order level, begin to self-organize when symbolically generalized.

Codes are constructed bottom-up, but what is constructed bottom-up may thereafter begin to control top-down. Thus, one should articulate reflexively the selection mechanisms that are constructed from the bottom-up variation by specifying the *why* as an hypothesis. What are the selection mechanisms? Observable relations (such as university-industry relations) are not neutral, but mean different things for the economy and for the state; and this meaning of the observable relations can be evaluated in terms of the codes of communication.

Against Niklas Luhmann's model, I would argue that codes of communication can be translated into one another since interhuman communications are not operationally closed, as in the biological model of *autopoiesis*. One also needs a social-scientific perspective on the fluidities ("overflows") and translations among functions, as emphasized, for example, by French scholars such as Michel Callon and Bruno Latour. In evolutionary economics, one distinguishes between market and non-market selection environments, but not among selection environments that are differently codified. Here, Luhmann's theory offers us a heuristic: The complex system of communications tends to differentiate in terms of the symbolic generalizations of codes of communication because this differentiation is functional in allowing the system to process more complexity and thus to be more innovative. The more orthogonal the codes, the more options for translations among them. The synergy indicator measures these options as redundancy. The selection environments, however, have to be specified historically because these redundancies—other possibilities—are not given but rather constructed over long periods of time.

How did you arrive where you currently work on?

I became interested in the relations between science, technology, and society as an undergraduate (in biochemistry) which coincided with the time of the student movement of the late 1960s. We began to study Jürgen Habermas in the framework of the "critical university," and I decided to continue with a second degree in philosophy. After the discussions between Luhmann and Habermas (1971), I recognized the advantages of Luhmann's more empirically oriented systems approach and I pursued my Ph.D. in the sociology of organization and labour.

In the meantime, we got the opportunity to organize an interfaculty department for Science and Technology Dynamics at the University of Amsterdam after a competition for a large

government grant. In the context of this department, I became interested in methodology: how can one compare across case studies and make inferences? Actually, my 1995 book *The Challenge of Scientometrics* had a kind of Triple-Helix model on the cover: How do cognitions, texts, and authors exhibit different dynamics that influence one another?

For example, when an author publishes a paper in a scholarly journal, this may add to his reputation as an author, but the knowledge claimed in the text enters a process of validation which can be much more global and anonymous. These processes are mediated since they are based on communication. Thus, one can add to the context of discovery (of authors) and the context of justification (of knowledge contents) a context of mediation (in texts). The status of a journal, for example, matters for the communication of the knowledge content in the article. The contexts operate as selection environments upon one another.

In evolutionary economics, one is used to distinguishing between market and non-market selection environments, but not among more selection environments that are differently codified. At this point, Luhmann's theory offers a new perspective: The complex system of communications tends to differentiate in terms of the symbolic generalization of codes of communication because this differentiation among the codes of communication allows the system to process more complexity and to be more innovative in terms of possible translations. The different selection environments for communications, however, are not given but constructed historically over long periods of time. The modern (standardized) format of the citation, for example, was constructed at the end of the 19thcentury, but it took until the 1950s before the idea of a citation index was formulated (by Eugene Garfield). The use of citations in evaluative bibliometrics is even more recent.

In evolutionary economics, one distinguishes furthermore between (technological) trajectories and regimes. Trajectories can result from "mutual shaping" between two selection environments, for example, markets and technologies. Nations and firms follow trajectories in a landscape. Regimes are global and require the specification of three (or more) selection environments. When three (or more) dynamics interact, symmetry can be broken and one can expect feed-forward and feedback loops. Such a system can begin to flourish auto-catalytically when the configuration is optimal.

From such considerations, that is, a confluence of the neo-institutional program of Henry Etzkowitz and my neo-evolutionary view, our Triple Helix model emerged in 1994: how do institutions and functions interrelate and change one another or, in other words, provide options for innovation? Under what conditions can university-industry-government relations lead to wealth generation and organized knowledge production? The starting point was a workshop about *Evolutionary Economics and Chaos Theory: New directions for technology studies* held in Amsterdam in 1993. Henry suggested thereafter that we could collaborate further on university-industry relations. I answered that I needed at least three (sub)dynamics from the perspective of my research program, and then we agreed about "A Triple Helix of University-Industry-Government Relations". Years later, however, we took our two lines of research apart again, and in 2002 I began developing a Triple-Helix indicator of synergy in a series of studies of national systems of innovation.

What would you give as advice to students who would like to get into the field of innovation and global politics?

In general, I would advise them to be both a specialist and broader than that. Innovation involves crossing established borders. Learn at least two languages. If your background is political science,

then take a minor in science & technology studies or in economics. One needs both the specialist profile and the potential to reach out to other audiences by being aware of the need to make translations between different frameworks. Learn to be reflexive about the status of what one can say in one or the other framework.

For example, I learned to avoid the formulation of grandiose statements such as "modern economies are knowledge-based economies," and to say instead: "modern economies can increasingly be considered as knowledge-based economies." The latter formulation provides room for asking "to what extent," and thus one can ask for further information, indicators, and results of the measurement.

In the sociology of science, specialisms and paradigms are sometimes considered as belief systems. It seems to me that by considering scholarly discourses as systems of rationalized expectations one can make the distinction between normative and cognitive learning. Normative learning (that is, in belief systems) is slower than cognitive learning (in terms of theorized expectations) because the cognitive mode provides us with more room for experimentation: One can afford to make mistakes, since one's communication and knowledge claims remain under discussion, and not one's status as a communicator. The cognitive mode has advantages; it can be considered as the surplus that is further developed during higher education. Normative learning is slower; it dominates in the political sphere.

What does the "Triple Helix" reveal about the fragmentation of "national innovation systems"?

In 2003, colleagues from the Department of Economics and Management Studies at the Erasmus University in Rotterdam offered me firm data from the Netherlands containing these three dimensions: the economic, the geographical, and the technological dimensions in data of more than a million Dutch firms. I presented the results at the Schumpeter Society in Turin in 2004, and asked whether someone in the audience had similar data for other countries. I expected Swedish or Israeli colleagues to have this type of statistics, but someone from Germany stepped in, Michael Fritsch, and so we did the analysis for Germany. These studies were first published in *Research Policy*. Thereafter, we did studies on Hungary, Norway, Sweden, and recently also China and Russia.

Several conclusions arise from these studies. Using entropy statistics, the data can be decomposed along the three different dimensions. One can decompose national systems geographically into regions, but one can also decompose them in terms of the technologies involved (e.g., high-tech versus medium-tech). We were mainly relying on national data. And of course, there are limitations to the data collections. Actually, we now have international data, but this is commercial data and therefore more difficult to use reliably than governmental statistics.

For the Netherlands, we obtained the picture that would more or less be expected: Amsterdam, Rotterdam, and Eindhoven are the most knowledge-intensive and knowledge-based regions. This is not surprising, although there was one surprise: We know that in terms of knowledge bases, Amsterdam is connected to Utrecht and then the geography goes a bit to the east in the direction of Wageningen. What we did not know was that the niche also spreads to the north in the direction of Zwolle. The highways to Amsterdam Airport (Schiphol) are probably the most important.

In the case of Germany, when we first analyzed the data at the level of the "Laender" (Federal States), we could see the East-West divide still prevailing, but when we repeated the analysis at the lower level of the "Regierungsbezirke" we no longer found the East-West divide as dominant (using 2004 data). So, the environment of Dresden for example was more synergetic in Triple-Helix terms than that of Saarbruecken. And this was nice to see considering my idea that the knowledge-based economy increasingly prevails since the fall of the Berlin Wall and the demise of the Soviet Union. The discussion about two different models for organizing the political economy—communism or liberal democracy—had become obsolete after 1990.

After studying Germany, I worked with Balázs Lengyel on Hungarian data. Originally, we could not find any regularity in the Hungarian data, but then the idea arose to analyze the Hungarian data as three different innovation systems: one around Budapest, which is a metropolitan innovation system; one in the west of the country, which has been incorporated into Western Europe; and one in the east of the country, which has remained the old innovation system that is state-led and dependent on subsidies. For the western part, one could say that Hungary has been "europeanized" by Austria and Germany; it has become part of a European system.

When Hungary came into the position to create a *national* innovation system, free from Russia and the Comecon, it was too late, as Europeanization had already stepped in and national boundaries were no longer as dominant. Accordingly, and this was a very nice result, assessing this synergy indicator on Hungary as a nation, we did not find additional synergy at the national (that is, above-regional) level. While we clearly found synergy at the national level for the Netherlands and also found it in Germany, but at the level of the Federal States, we could not find synergy at a national level for Hungary. Hungary has probably developed too late to develop a nationally controlled system of innovations.

A similar phenomenon appeared when we studied Norway: my Norwegian colleague (Øivind Strand) did most of our analysis there. To our surprise, the knowledge-based economy was not generated where the universities are located (Oslo and Trondheim), but on the West Coast, where the off-shore, marine and maritime industries are most dominant. FDI (foreign direct investment) in the marine and maritime industries leads to knowledge-based synergy in the regions on the West Shore of Norway. Norway is still a national system, but the Norwegian universities like Trondheim or Oslo are not so much involved in entrepreneurial networks. These are traditional universities, which tend to keep their hands off the economy.

Actually, when we had discussions about these two cases, Norway and Hungary, which both show that internationalization had become a major factor, either in the form of Europeanization in the Hungarian case, or in the form of foreign-driven investments (off-shore industry and oil companies) in the Norwegian case, I became uncertain and asked myself whether we did not believe too much in our indicators? Therefore, I proposed to Øivind to study Sweden, given the availability of well-organized data of this national system.

We expected to find synergy concentrated in the three regional systems of Stockholm, Gothenburg, and Malmö/Lund. Indeed, 48.5 percent of the Swedish synergy is created in these three regions. This is more than one would expect on the basis of the literature. Some colleagues were upset, because they had already started trying to work on new developments of the Triple Helix, for example, in Linköping. But the Swedish economy is organized and centralized in this geographical dimension. Perhaps that is why one talks so much about "regionalization" in policy documents. Sweden is very much a national innovation system, with additional synergy between the regions.

Can governments alter historical trajectories of national, regional or local innovation systems?

Let me mention the empirical results for China in order to illustrate the implications of empirical conclusions for policy options. We had no Chinese data set, but we obtained access to the database Orbis of the Bureau van Dijk (an international company, which is Wall Street oriented, assembling data about companies) that contains industry indicators such as names, addresses, NACE-codes, types of technology, the sizes of each enterprise, etc. However, this data can be very incomplete. Using this incomplete data for China, we said that we were just going to show how one could do the analysis if one had full data. We guess that the National Bureau of Statistics of China has complete data. I did the analysis with Ping Zhou, Professor at Zhejiang University.

We analyzed China first at the provincial level, and as expected, the East Coast emerged as much more knowledge intense than the rest of the country. After that, we also looked at the next-lower level of the 339 prefectures of China. From this analysis, four of them popped up as far more synergetic than the others. These four municipalities were: Beijing, Shanghai, Tianjin, and Chongqing.

These four municipalities became clearly visible as an order of magnitude more synergetic than other regions. The special characteristic about them is that –as against the others – these four municipalities are administered by the central government. Actually, it came out of my data and I did not understand it; but my Chinese colleague said that this result was very nice and specified this relationship.

The Chinese case thus illustrates that government control can make a difference. It shows – and that is not surprising, as China runs on a different model – that the government is able to organize the four municipalities in such a way as to increase synergy. Of course, I do not know what is happening on the ground. We know that the Chinese system is more complex than these three dimensions suggest. I guess the government agencies may wish to consider the option of extending the success of this development model, to Guangdong for example or to other parts of China. Isn't it worrisome that all the other and less controlled districts have not been as successful in generating synergy?

Referring more generally to innovation policies, I would advise as a heuristics that political discourse is able to signal a problem, but policy questions do not enable us to analyze the issues. Regional development, for example, is an issue in Sweden because the system is very centralized, more than in Norway, for example. But there is nothing in our data that supports the claim that the Swedish government is successful in decentralizing the knowledge-based economy beyond the three metropolitan regions. We may be able to reach conclusions like these serving as policy advice. One develops policies on the basis of intuitive assumptions which a researcher is sometimes able to test.

As noted, one can expect a complex system continuously to produce unintended consequences, and thus it needs monitoring. The dynamics of the system are different from the sum of the sub-dynamics because of the interaction effects and feedback loops. Metaphors such as a Triple Helix, Mode-2, or the Risk Society can be stimulating for the discourse, but these metaphors tend to develop their own dynamics of proliferating discourses.

The Triple Helix, for example, can first be considered as a call for collaboration in networks of institutions. However, in an ecosystem of bi-lateral and tri-lateral relations, one has a trade-off between local integration (collaboration) and global differentiation (competition). The markets

and the sciences develop at the global level, above the level of specific relations. A principal agent such as government may be locked into a suboptimum. Institutional reform that frees the other two dynamics (markets and sciences) requires translation of political legitimation into other codes of communication. Translations among codes of communication provide the innovation engine.

Is there a connection between infrastructures and the success of innovation processes?

One of the conclusions, which pervades throughout all advanced economies, is that knowledge intensive services (KIS) are not synergetic locally because they can be disconnected – uncoupled – from the location. For example, if one offers a knowledge-intensive service in Munich and receives a phone call from Hamburg, the next step is to take a plane to Hamburg, or to catch a train inside Germany perhaps. Thus, it does not matter whether one is located in Munich or Hamburg as knowledge-intensive services uncouple from the local economy. The main point is proximity to an airport or train station.

This is also the case for high-tech knowledge-based manufacturing. But it is different for medium-tech manufacturing, because in this case the dynamics are more embedded in the other parts of the economy. If one looks at Russia, the knowledge-intensive services operate differently from the Western European model, where the phenomenon of uncoupling takes place. In Russia, KIS contribute to coupling, as knowledge-intensive services are related to state apparatuses.

In the Russian case, the knowledge-based economy is heavily concentrated in Moscow and St. Petersburg. So, if one aims –as the Russian government proclaims – to create not "wealth from knowledge" but "knowledge from wealth" – that is, oil revenues –it might be wise to uncouple the knowledge-intensive services from the state apparatuses. Of course, this is not easy to do in the Russian model because traditionally, the center (Moscow) has never done this. Uncoupling knowledge-intensive services, however, might give them a degree of freedom to move around, from Tomsk to Minsk or *vice versa*, steered by economic forces more than they currently are (via institutions in Moscow).

Final question. What does *path-dependency* mean in the context of innovation dynamics?

In *The Challenge of Scientometrics. The development, measurement, and self-organization of scientific communications* (1995), I used Shannon-type information theory to study scientometric problems, as this methodology combines both static and dynamic analyses. Connected to this theory I developed a measurement method for path-dependency and critical transitions.

In the case of a radio transmission, for example, you have a sender and a receiver, and in between you may have an auxiliary station. For instance, the sender is in New York and the receiver is in Bonn and the auxiliary station is in Iceland. The signal emerges in New York and travels to Bonn, but it may be possible to improve the reception by assuming the signal is from Iceland instead of listening to New York. When Iceland provides a better signal, it is possible to forget the history of the signal before it arrived in Island. It no longer matters whether Iceland obtained the signal originally from New York or Boston. One takes the signal from Iceland and the pre-history of the signal does not matter anymore for a receiver.

Such a configuration provides a path-dependency (on Iceland) in information-theoretical terms, measurable in terms of bits of information. In a certain sense you get negative bits of information, since the shortest path in the normal triangle would be from New York to Bonn,

and in this case the shortest path is from New York via Iceland to Bonn. I called this at the time a critical transition. In a scientific text for instance, a new terminology can come up and if it overwrites the old terminology to the extent that one does not have to listen to the old terminology anymore, one has a critical transition that frees one from the path-dependencies at a previous moment of time.

Thus, my example is about radical and knowledge-based changes. As long as one has to listen to the past, one does not make a critical transition. The knowledge-based approach is always about creative destruction and about moving ahead, incorporating possible new options in the future. The hypothesized future states become more important than the past. The challenge, in my opinion, is to make the notion of options operational and to bring these ideas into measurement. The Triple-Helix indicator measures the number of possible options as additional redundancy. This measurement has the additional advantage that one becomes sensitive to uncertainty in the prediction.

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