# The Bi-Evolution of the University in the Triple Helix Era[1]

Henry Etzkowitz
Science Policy Institute
State University of New York
Henryetzkowitz@earthlink.net

## Introduction

The university is a flexible and capacious organization. Like the Church, its medieval counterpart, it is capable of reconciling apparent contradictions while pursuing multiple goals in tandem. As the university takes up a new role in promoting innovation, its educational and research missions are also transformed. As the university expands its role in the economy, from a provider of human resources to a generator of economic activity, its relationship to industry and government is enhanced. Paradoxically, as the university becomes more influential in society; it is also more subject to influence, with academic autonomy increased in some instances and reduced in others.

A transformation in the functions of university, industry, and government also takes place as each institution assumes the role of the other. The university takes the role of industry, transferring technology to infuse existing firms with new life and helping form new firms in incubator facilities. Government takes the role of industry, helping to support these developments through funding programs and changes in the regulatory environment. Industry takes the role of the university in developing training and research, often at the same high level as universities.

The university itself is developing in a bi-evolution. One line of development is expansion of missions, including the incorporation of a "third mission" of economic and social development along with education and research. A second line is the parallel shift in each academic mission from an individualistic to an organizational

[1] This paper draws for data on studies of university-industry-government relations sponsored by the U.S. National Science Foundation; the Center for Business and Policy Studies (SNS), Stockholm; VINNOVA, Sweden; and a visiting professorship at the Federal University of Rio de Janeiro, sponsored by IEL, the Brazilian Industrial Foundation.

focus, e.g. from educating students to training firms. The emergence of networking among universities, in distance learning and incubation, presages a tri-evolution. In taking on these new roles and relationships, the university becomes a more important actor in society.

**Making the Linear Model Work**

Expanding upon the linear innovation model, research moves out of the university through consultation as well as publication. This may take place informally between a professor and former students, in industry, or through formal arrangements organized by a liaison office. Moving from knowledge to technology, intellectual property rights may be put into the form of a patent and licensed by a technology transfer office. Finally, knowledge and technology, combined with an entrepreneur, can be made into a firm and sent out from the university through its incubator facility.

The transformation of university-industry linkages from a linear to an interactive innovation model can especially be seen in the evolution of the university business incubator from a linear to a non-linear model and from an isolated to a networked entity. In addition to mentoring university-originated firms, the incubator brings in firms from outside the university, allowing both types of firms to interact and learn from each other. Moreover, links among incubators allow joint development and transfer of technology.

**The Entrepreneurial University**

As the university becomes more closely involved in the transfer of technology and the founding of new firms, it attains a new entrepreneurial identity (Etzkowitz, 2001). A growing number of U.S. universities are also willing to use a small portion of their endowment funds to capitalize new firms, typically in association with other investors. This can be seen as the latest stage in a long-term movement of endowment managers to a more risk intensive investment strategy, having previously shifted from a concentration on preferred stocks in the pre-war period to common stocks in the post-war. Business expertise that was formerly localized within the university is now

being expanded to achieve higher growth goals, based upon financial capital that can be created from academic research as well as from other sources.

Over time, as the entrepreneurial paradigm takes hold, interface capabilities spread throughout the university. Within academic departments and centers, faculty members and other technical personnel are assigned special responsibility to assess the commercial salience of research findings and encourage interaction with external partners. Centralized interface capabilities play a leading role initially but their role declines as decentralization typically follows success.

An internal entrepreneurial dynamic is generated as academic unit takes responsibility to raise some of their own funds. At Stanford university individual departments or groups of departments each established their own liaison program with industry. Beyond establishing links with existing organizations, the university also assists the creation of new organizations. Hybrid entities, such as the University at Albany incubator facility combine academic research groups, government laboratories, and existing firms to gain "critical mass" in a research field with economic potential.

Industrial and government are also developing similar intermediary capabilities. Companies collaborate on research projects as they realize that they cannot always do all the work needed for the development of new products by themselves (Nonaka and Takeuchi 1995). An increasing number of firms operate as quasi-universities, sharing knowledge that formerly would have been kept secret. Rules for interaction are more easily understood and negotiated among overlapping institutional spheres.

Nevertheless, there is a continuing distinction among the institutional spheres, with universities retaining their fundamental interest in developing new knowledge. For example, teachers at Karlskronna-Ronneby, a Swedish regional university specialized in software, select industry projects that will both solve a practical problem and lead to a fundamental advance in knowledge. Working on these projects under the guidance of their professors is the basis for the training of their students, a contemporary reinterpretation of the agricultural research model in high technology.

The comparative advantage of the university is its flow through of students, each a potential inventor, in contrast to the relative stability of personnel in governmental and industrial laboratories. This built-in renovation mechanism helps create an innovative environment, especially since each research student is expected to produce an advance in knowledge or technology in order to graduate. By hiring permanent research staff without faculty status, universities gain some of the advantage of the Institute model, the ability to concentrate resources without the constraints of academic time-tables and multiple demands that both students and faculty face.

## The Second Academic Revolution

US universities have undergone two major transformations in the past century. Building upon the development of the Research University in the late 19th and early 20th century, a second revolution, the incorporation of a mission of economic development is underway. A system of university-industry relationships has emerged since the early twentieth century, based upon models for academic consultation (the one-fifth rule), patenting and firm formation originated at MIT by Vannevar Bush and his colleagues at MIT. The Research Corporation introduced the principle of utilizing income generated by patents to seed-fund new research.

As the university enlarges its role in innovation, controversies arise such as the propriety of the extension of the academic mission from dissemination to the capitalization of knowledge. New rules and roles are defined through the resolution of such controversies. The emergence of controversy indicates that normative change is at hand. Indeed the early development of disputes has been noted as a positive factor in facilitating the acceptance of controversial activities such as stem cell research (Wade, 2001).

Funding stringency has been the focus of attention in explaining recent changes in the university and its role in society. Although the increase or decrease of funding certainly has an effect on academic and other institutions, such trends can just as easily rigidify existing structures, expanding or contracting them along existing lines, as well as inducing their reform (Martin and Etzkowitz, 2001).

The reorganization of the university is more fundamentally driven by changes in knowledge production and utilization as new forms of knowledge are created through the intersection of academic, industrial and government interests. A new set of scientific disciplines (molecular biology, computer science and materials science) has been created that simultaneously exhibit both theoretical and practical implications, rather than the latter emerging after a long time delay. Traditional disciplines such as chemistry are renovated along these lines as they are infused by elements of the new disciplines.

**The Bi-evolution of the University**

In addition to the academic revolutions that involve the development of new missions within the university, there is a parallel organizational transformation in how the university operates. A bi-evolution of the university is occurring in the shift from an individual to a group focus in all three academic missions. The shift is most obvious in the sciences where graduate students, post docs, and technicians often surround the professor.

There is a similar transformation from a narrow to a broad focus in the mission of economic and social development. Instead of concentrating on an individual patent or piece of technology transfer, a one-time event, the university plays a leadership role in forming regional organizations. For example, in Portugal, the University of Aveiro has played the role of "regional innovation organizer" bringing the local business community and municipalities together to formulate a regional development strategy.

The shift from a sole focus on educating individuals to a dual focus on groups has been more difficult to discern since it typically takes place in academic contexts, such as incubators, that have not traditionally been viewed as part of the educational function of the university. Nevertheless, the university's educational role increasingly includes the development and growth of new organizations in its incubator facility and sending them out into the world. This organizational training occurs outside the classroom setting and for purposes other than education. For example, at a special graduation ceremony at the Pontifical Catholic University of Rio de Janeiro of firms from the university's incubator facility one company had come out of an applied

physics research group to develop oil exploration technology while another firm was in software development. Just as the university trains individual students and sends them out into the world, it is now doing the same for organizations.

## Networked Universities

The next step is to extend the incubation process from individual university incubators to networks of universities and their incubators. University incubator facilities, which provide a support structure for the growth of high tech firms and entrepreneurship in local regions, typically lack the ability to assist their firms to reach partners and markets in other countries. This is especially a problem in developing countries and small nations. There are approximately 1,500-university incubator facilities worldwide. These include more than 300 in the U.S. and 200 in Brazil. Facilities are rapidly being established in Europe and Asia. There is especially rapid growth in incubators in China, at present. Africa lags behind, although an informal incubation process has been identified at the University of Zambia, for example (Konde, 2001).

The concept for a World Incubator Network (WIN) is to do for incubators what an incubator does for its firms: provide a support structure to enable them to extend their activities into a broader arena and thereby enhance their chances of success. A small staff would coordinate and facilitate introductions and collaborations among its members. For example, an incubator firm in one country might need a partner to assist in developing its product or might wish to locate a sales representative at an incubator in another country. At present such arrangements typically happen by chance.

## A New Focus on Regional Development

Regions may be viewed as “thick” or “ thin” depending upon the presence or absence of business development services. Whether it makes sense for an incubator to develop its own services largely depends upon their availability within the surrounding region (Coleman and Underhill, 1998). A region that is rich in business development requisites such as venture capital may not have to develop them in direct association with the incubator. On the other hand, a region that is lacking such tools may find it necessary to develop them in association with the incubator project in order to achieve the goal of knowledge-based economic development.

Imagery is also important in development of a region. Around certain concepts things start to grow. Politics comes together with industry and the university even as they also play their traditional roles, but now with something uniting them. The triple helix model of semi-autonomous spirals moves actors out of their institution bound mindset into a functional/processual view. The process of change in the triple helix appears strange: it is not solely market driven and not solely policy driven; no one runs the show by themselves. Indeed, there often are not strong market reasons to allocate resources to region (Klofsten, Jones-Evans, and Schärberg, 1999).

The premise of governmental activism is that the conditions for high-tech economic growth are not spontaneous creations; rather they can be identified and put in place by explicit measures. As regions formulate knowledge-based innovation strategies the constellations of actors, and their relative importance in the local political economy is transformed. With knowledge assuming increased significance as a factor of production, in both high-technology and older manufacturing industries, the traditional elements of land, labor and capital reduce in importance with various political consequences including the displacement of labor unions in regional growth coalitions by knowledge producing institutions such as universities.

Traditionally, local governments tried to improve the business climate by lowering taxes and attract plants to relocate by providing incentives. From the time it began to lose its industry in the early 20th century, New England's business and political leadership attempted to cure their region's economic ills through these methods. However, the region was simply too far from sources of raw materials, important to most manufacturing industries. Eventually, the region focused on its comparative advantage, its concentration of colleges and universities as the base to create new firms. A coalition of business, political and academic leaders invented the venture capital firm, during the early post-war, as the mechanism to realize this objective.

Creating new technology-based economic niches has become a third strategy for regional and local development. As the number of niches for science-based technology increases, the opportunity for more players to get involved also increases. Universities not traditionally involved in research are becoming more research

oriented, often with funding from their state and local governments, who increasingly realize that research is important to local economic growth.

**Development of the Triple Helix**

The triple helix model originated from research on university-industry relations in the U.S. In the Mexican context, however, it was clear that the topic could not be fully understood without taking the role of government into account. Conversely, in Eastern Europe, during the transition from socialism, some reformers were trying to remove government from a role in science and technology policy. Innovation systems were largely coming to a halt. Even though foreign direct investment was encouraged this seldom involved utilizing local R&D resources. More recently, political leaders are moving away from that rigid position and bringing government back into the picture to take advantage of the R&D resources left behind from the previous era.

In the United States, government-industry relations assumed increased significance in the 1990s even as university-industry ties came to the forefront of attention in the 1980s. In much of the European Community these two sets of bilateral relations developed in reverse sequence with academic-industry connections following upon the development of government-industry relations. Academic-industry-government relations in the U.S. are taking on the cast that government-industry-labor relations have long had in Europe.

During the 1970's and 80's academic-industry relations developed rapidly in the US in response to increased international competition. The incremental evolution of products within existing industries was inadequate to insure economic growth (Lamoreaux et. al. 1999). Academia was thus brought into new, relatively independent, alignment with industry. There was both a need to introduce new technologies into existing industries and to create industries based on new technology. Integration of research with application, through "public venture capital" is the basis of an immanent national industrial policy for civilian technology development, a model previously confined to the military sector (Etzkowitz, Gulbrandsen and Levitt, 2000).

Academic-industry relations have also spread to countries in Europe and Latin America with different cultural and academic traditions and industrial backgrounds

(Lissenburgh and Harding, 2000; Leydesdorff  Guoping (2001) . In some of these countries universities have been primarily teaching institutions with little tradition of research. On the one hand, the pressure on the university to assume an economic role has encouraged the development of research, especially in fields relevant to future economic development. On the other, it has led to the exploration of ways to base relations with industry on the teaching function of the university, especially in regions where industry is primarily low or mid-tech.  A triple helix dynamic has been set in motion from various starting points in countries with different institutional configurations.

There are four dimensions to the development of the triple helix. The first is internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of an economic development mission by universities. Universities and other knowledge producing institutions play a new role in society, not only in training students and conducting research, but also in making efforts in seeing that knowledge and human capital is effectively put to use.

The second dimension is the influence of one helix upon another, for example, the role of the U.S. federal government in instituting an indirect industrial policy in the Bayh-Dole Act of 1980. When the rules of the game for the disposition of intellectual property produced from government sponsored research were changed; technology transfer activities spread to a much broader range of universities, resulting in the emergence of an academic technology transfer profession.

The third dimension is the creation of a new overlay of tri-lateral networks and organizations from the interaction among the three helices, formed for the purpose of coming up with new ideas and formats for high-tech development. At the regional level examples include  Joint Venture Silicon Valley, established during the early 1990's economic downturn, the Knowledge Circle of Amsterdam, organized during the past decade, and the New England Council, founded in the 1920s, all including participants from small and large companies, local  government and academia.

The fourth dimension of the helix model is a recursive effect of these triple helix networks, (typically representing academia, industry and government in contrast to

traditional European corporatist models representing government, industry and labor) both on the spirals from which they emerged and the larger society. One effect is on science itself as a result of internal changes within academia, strengthened and diffused by government policy (Nowotny, Scott, and Gibbons 2001). The participation of the university in the capitalization of knowledge, the transmutation of research results into intellectual property, has called the traditional role of the academic researcher, and the boundaries between university and industry, into question.

**The Triple Helix Era: An Endless Transition**

The triple helix era is an endless transition of innovation, rather than a journey to an assumed ideal model of socialism or capitalism (Burt, 1992). There is no longer an assumption that there is a sole starting point of research, and an end point of the economy, on the one hand; or a starting point of central government policy directing academia and industry. The emerging perspective in science, technology and industrial policy is that specific actions may start both from the results of science to see that they are put to use and from the standpoint of problems in society and seeing how we can use knowledge to address them.

Coming from both sides, and seeing that in order to do this, the various institutional spheres in society must now work more closely together. It is increasingly the case that industrial firms need the application of knowledge to improve their production processes or to develop new firms on the basis of knowledge. Government programs have an important role to play, not only from the national level –top down—but also from the regional and local level—bottom-up. When top down policies meet bottom – up initiatives in cooperating in these efforts, that is perhaps the most dynamic and fruitful result. In Brazil, after the failure of science parks, university initiatives to establish incubators were supported by national, regional and local governments as well as industrial associations.

As the powers of knowledge change the agenda for economic development policy, the exercise of power, often indirectly through funding incentives and new intellectual property regimes, redirects the production of knowledge to new ends. The two-way

flow between industry and academia in computer science, materials science and molecular biology is not well captured by the "endless frontier" model of a linear flow from basic to applied research to production. Whether countries started from the model of the state incorporating industry and academia or a configuration in which they coexisted separately, the different helices have recently been moving in a common direction, overlapping each other, to stimulate both competition and collaboration. We are moving toward a new global model for the management of knowledge and technology in a triple helix of university-industry government networks.

**References:**

Burt, Ronald (1992) Structural Holes: The social structure of capitalism Cambridge: Harvard University Press

Coleman, William and Geoffrey Underhill eds. (1998) Regionalism and Economic Integration London: Routledge

Etzkowitz, Henry, Magnus Gulbrandsen and Janet Levitt. (2000) Public Venture Capital. New York Harcourt, (2nd edition 2001)

Etzkowitz, Henry 2001 "The Second Academic Revolution and the Rise of the Entrepreneurial University" IEEE Technology and Society Magazine, Summer

Konde, Victor (2001) "The Role of African universities in Technology Transfer: The case of the Internet in Zambia" Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University (unpublished manuscript).

Klofsten, Magnus, Dylan Jones-Evans, and Carina Schärberg (1999). "Growing the Linköping Technopole—A longitudinal study of the Triple Helix development in Sweden." Journal of Technology Transfer 24 (2/3): 125-138.

Lamoreaux, Naomi, Daniel Raff and Peter Temin (1999) Learning by Doing Chicago: University of Chicago Press

Leydesdorff, Loet, and Zeng Guoping (2001) "University-Industry-Government Relations in China: An emergent national system of innovations." Industry and Higher Education, 15(3): 179-182.

Lissenburgh, Stephen, and Rebecca Harding (2000) Knowledge Links: Innovation in university/business partnerships. London: IPPR.

Martin, Ben and Henry Etzkowitz, (2001) 'The Origin and Evolution of the University Species', *Journal for Science and Technology Studies* (Tidskrift för Vetenskaps- och Teknikstudier, VEST), 13, pp.9-34.

Nonaka, Ikurjuro and Hirotaka Takeuchi (1995) The Knowledge Creating Company (New York: Oxford)

Nowotny, Helga, Peter Scott, and Michael Gibbons (2001) Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty. Cambridge: Polity Press.

Wade, Nicholas (2001) "Stem Cell Studies Advance in Britain" New York Times, Tuesday, August 14; pp. A 1,14.