University-Industry-Government: The Triple Helix Model of Innovation

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Introduction

In ancient Mesopotamia, a triple helix water screw, invented to raise water from one level to another, was the basis of a hydraulic system of agricultural innovation that irrigated ordinary farms as well as the Hanging Gardens of Babylon, one of the seven wonders of the ancient world. [i] The triple helix as a physical innovation is superseded by the triple helix of social innovation. On one level triple helix is a metaphor for university, industry, and government interacting closely while each maintains its independent identity. The triple helix message is that universities, firms and governments assume some of the capabilities of the other, even as each maintains its primary role and distinct identity.

Each sphere thus gains increased ability to interact, collaborate and support innovation that arises in other spirals. Scientific knowledge becomes ever more central to innovation and the concept of innovation is broadened from the business application of new technology to enhancement of the social arrangements that enhance innovation. The university begins to play a new more direct role in the "capitalization of knowledge" by organizing technology transfer to existing firms and by starting new firms in addition to its traditional supporting role of transferring knowledge.

Government and industry have been the major social institutions since the 18th century. Why does the university play now play a key role in increasingly knowledge-based societies. We shall argue that the competitive advantage of the university over other knowledge producing institutions, such as R& D units of firms and government laboratories, is its fundamental educational purpose: the university has the students, who are a continual source of innovation, both within the university and through their regular movement to other institutional spheres upon graduation. This paper outlines a universal model of

innovation, a triple helix of university-industry-interactions, emerging from different starting points in laissez faire and statist societies.

Entrepreneurship in the Triple Helix

These developments take place at different rates and with different emphases. In Sweden, new universities and regional colleges, such as Linkoping and Blekinge, have taken up the task of capitalizing knowledge and made it a special feature of their academic program. Entrepreneurship training programs and encouraging the transition of joint student training projects into firm-formation are among the innovations. Older foundations, such as Karolinska and Uppsala universities have also become involved, undertaking major initiatives often in collaboration with other academic institutions in their region and beyond. They include science parks, inter-university research centers and networked universities.

A similar transformation can be identified in the emerging role of government as public venture capitalist, an instigator and financier of new firms based on new technology. Implementation of the venture capital concept created an organizational model that was an amalgam of elements of the three spheres, at least in the founding days of the industry. The idea of the venture capital firm was invented in the 1930's in the US through discussions among university, industry and government actors that focused on the need to create an entity that would provide seed capital and business advice to potential scientific entrepreneurs. A seed venture capital function been strengthened by public means as the private industry moved downstream, leaving seed capital to business angels that could not fully meet the need.

Entrepreneurial initiatives are not only the actions of individuals who form companies in the industrial sphere. Entrepreneurs can also be universities and government organizations and entrepreneurship can take place as a collaboration of individuals and organizations in various institutional spheres. Thus, there are also organizational entrepreneurial initiatives as well as individual ones. In Sweden, where individuals are unlikely to take an initiative without group support, there is a tradition of collective entrepreneurship.

Indeed, a collective entrepreneur is always a salutary impetus for a knowledge-based firm that requires both technical and business expertise that is unlikely to reside in a single person. Schumpeter emphasized the key role of the entrepreneur in seizing technological and market

opportunities. Contemporary entrepreneurs might be professors, engineers, researchers or inventors, and even some politicians. For example, Esko Aho, a recent prime minister of Finland is credited for invigorating that country's innovation system and then taking his ideas to the European level, through the Lisbon Agenda, to take Europe to the forefront.

The Rise of Knowledge-Based Society

The vertical hierarchies of the pre-industrial and industrial eras, the first based on tradition, the second on expertise, are gradually superseded in the transition from an industrial to a knowledge-based society. A renovation in social relations occurs comparable to the one that took place during the transition to industrial society. The primary factor in each of these transformations was the role of knowledge in society. In feudal society, the most important knowledge was the lore of tradition, the taken for granted relationships of superiors and inferiors in society and the obligations that each owed to the other whereas in industrial society, it was the erudition of bureaucracy, how to carry out specific tasks under supervision, the understanding of the basis of willingness to accept orders from above, on the one hand, and the capacity of management to give relevant instructions, on the other (Weber, 1947). [ii]

Three independent dimensions: economics, politics and status, belief in the reality of social differences based on any criteria, co-exist in a relationship of mutual causation. Political power generates economic wealth and the ability to live off politics; while ideas may be translated into economic and political power. Ethical ideas associated with Protestantism were an impetus to the rapid development of economic activity in the West in addition to accumulation of technological forces (Weber, 1958). [iii] Other bases for innovation and societal transformation have since been identified.

Indeed, innovation itself begins to take on a new meaning as the spirals of the triple helix intertwine, cooperating to enhance each others performance of their traditional roles. Even in its original sense of product development innovation is no longer only the special province of industry. Knowledge producing institutions have become more important to innovation as knowledge becomes a more significant element in new product development and in creating the organizational infrastructure for future product development. This expansion of the concept of innovation, in part, explains why university and government have become more significant actors in the innovation process. University, industry and

government play this new role in innovation collaboratively as well as individually.

The increased interaction among university, industry and government as relatively equal partners, is the core of the triple helix model of economic and social development. The triple helix thesis takes this model of interacting institutional spheres a step further to the new developments in innovation strategies and practices that arise from this cooperation. The triple helix also becomes a platform for "institution formation," the creation of new organizational formats to promote innovation, such as the incubators, science parks and the venture capital firms. These new organizations arise from interaction among university, industry and government to promote innovation and are themselves a synthesis of elements of the triple helix.

The Triple Helix

The triple helix model attempts to capture this transformation of roles and relationships among the emerging primary institutional triad of university-industry-government. University, industry and government are conceptualized as intertwined spirals with different relations to each other in the classic innovation regimes. In a laissez faire one triple helix regime, industry is the driving force, with the other two spirals as ancillary supporting structures; in a statist regime government plays the lead role, driving academia and industry. Spirals are rarely equal; one usually serves as a motive force, the innovation organizer (IO) around which the others rotate. The institution that acts as the core spiral changes over time as one spiral replaces the other as the driving force in a triple helix configuration.

The location of science based industry adjacent to universities and the growth of new firms from academic research and teaching activities exemplify the emergent institutional restructuring that is underway in societies that are increasingly knowledge-based. The university, and other knowledge producing institutions, is becoming a primary institution, a core spiral that in some circumstances replaces industry and government in the lead role as Innovation Organizer.

Non-linear Innovation

Innovation increasingly combines market and scientific orientations. In the face of skepticism from the military sponsors of artificial intelligence research in the mid 1970's, the

head of the computing office in the Defense Advanced Research Program (DARPA) of the U.S. Defense Department concluded that it would be to the mutual advantage of all for the academic researchers to take an interest in their sponsors practical problems. "…the shift will give the university research groups an engineering arm, a marketplace, customers, users. [That] integration will strengthen the basic work because there will be more feedback from real tests of the big new ideas…" (Waldrop, 2001:405). The author of this statement, a psychologist involved in the early development of computer science as an academic discipline, the redoubtable J.C.R. Licklider of Internet origin fame, joined DARPA from MIT, after a stint at Bolt, Beranek and Newman (BBN), a consulting and research firm (Hafner and Lyon, 1996).[1][iv]

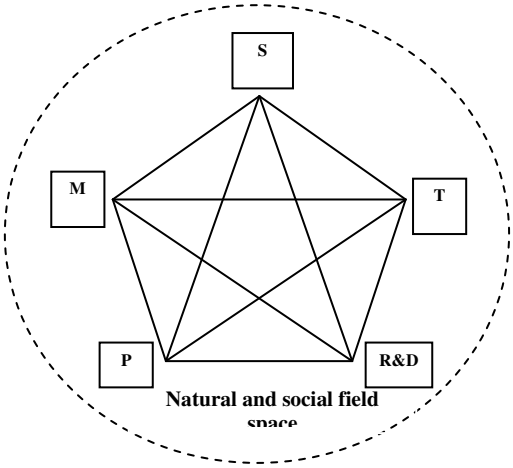

Figure2 Non-linear and Netlike Hexagonal Model of Technological Innovation

Figure3 describes a non-linear and netlike innovation model that may begin from different starting points among science, engineering, R&D, production and marketing activity. For example, John Bardeen, one of the inventors of the transistor, "believed it made sense to look first at the technological base and then work on developing the corresponding science, rather than…[the other way around] "finding something in science and then looking around for applications" (Hoddesson and Daitch, 2002)[v] Thus, an innovation may take place in the order of market→technology→ science→technology→R&D→ production→ marketing or marketing→technology→ science→R&D→ production→ marketing and any other way.

[1] BBN was considered the "third shop," an equal of Harvard and MIT, in the Cambridge U.S. artificial intelligence community (1986) Prof. Marvin Minsky, Electrical Engineering and Computer Science, MIT, Interview with Henry Etzkowitz..

Triple Helix-Fields[2]

The triple helix model posits three spheres, overlapping and interacting freely, with each "taking the role of the other," producing hybrid organizations such as the science park, spin-offs, university-run enterprises and the incubator from these interactions. However, this model lacks precise indicators and measurement techniques. Field theory from physics has been used to develop a method for triple helix analysis that may serve as a base for future research on triple helix interactions (Zhou, 2001). [vi]

Triple helix field theory depicts helices with an internal core and external field space (Figure4). The model helps explain why the three spheres keep a relatively independent and distinct status, shows where interactions take place and explains why a dynamic triple helix can be formed with gradations between independence and interdependence; conflict and confluence of interest. Conversely, the model can be used to help identify when a sphere is in danger of losing its identity.

The university can play industry's role, in assisting firm formation and technology transfer, but not as a true enterprise. The same holds for industry and government. Industry may form university-like teaching and research entities; but it is unlikely to stray too far from its core mission. This explains the decline and even disappearance of these auxiliary enterprises in economic downturns.

An institutional sphere may lose its distinct character if it can not maintain its relative independence. For example, an academically oriented start-up may focus too exclusively on research and lose its way to the market. It is also very difficult for highly dependent spheres to interact in the external field space, since the confusion of functions or roles inevitably results in a disordered system. This explains why universities place their endowment funds in separate entities that operate on financial principles, separate from the academic enterprise.

On the other hand, technology transfer has been seen to be an extension of academic research and teaching task and thus has been retained within the academic core. Taking the

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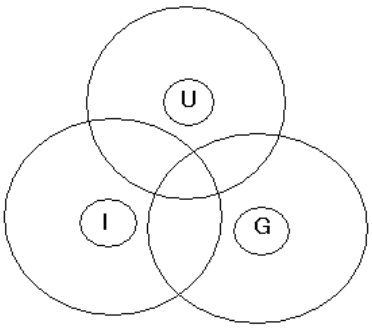
[2] This Section draws upon Etzkowitz and Zhou "Regional Innovation Initiator: The Entrepreneurial University in Various Triple Helix Models" Theme Paper for Triple Helix VI Conference, Singapore 16-18 May 12007 www.triplehelix6.com

role of the other does not necessarily imply loss of a sphere's core identity; the notion that taking even the smallest step may result in an irrevocable transformation. Rather it may be an indicator of institutional change and renovation. The taking on of a new mission or role may enhance, as well as detract, from old ones. A careful balancing and willingness to experiment is the, apparently contradictory, yet only healthy prescription.

When a field exists with energy around it; the field can act upon its surroundings. In an electric field, for example, the action on charges put in a field space is represented by the force of an electric field. The endured force per unit charge is defined as the intensity of the electric field, describing the strong or weak degree to which the field influences the charge. Thus, intensity of field is introduced, indicating the degree to which helices promote innovation activities. If E represents the total field intensity, and Eu, Ei, Eg respectively



Figur 4 Triple Helix-Field Interaction Model

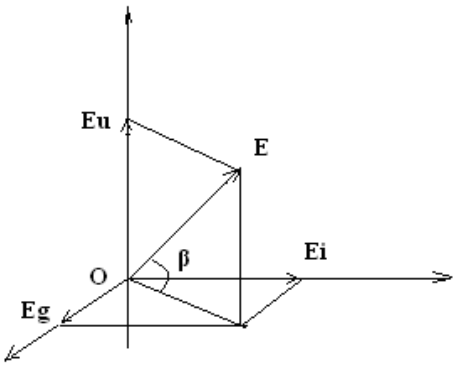


Figure 5 The Intensity of Triple Helix Field

represent the intensity of university, industry and government actions, then E=f(Eu ,Ei ,Eg), the result of the interaction (Figure5; Zhou, 2002). [vii]

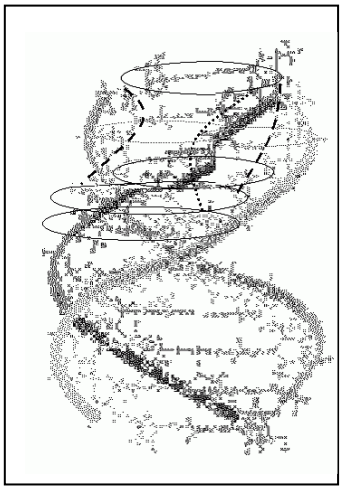
Field theory illustrates the importance of limiting the transformation from laissez-faire to overlapping spheres or too sharply reducing a statist model, to retain each sphere's independence while facilitating interaction. For example, if government is too strong, then a statist model might be formed. If the interactions among three helices are too weak, there is not enough force to integrate them, leading to a laissez faire situation.

Analyzing lost or weak factors, "gaps," and filling them helps create balanced triple helices. A regional innovation organizer (RIO) and regional innovation initiator (RII) exercise different yet related gap filling capabilities. A RIO provides convening capabilities while an RII must have sufficient prestige and authority to aggregate resources and initiate an

enterprise.

The governors of New England convened regional academic, industrial and governmental leadership in a series of meetings from the late 1920's but it was Karl Compton, the President of MIT, who eventually catalyzed ideas for science-based firm formation and mobilized regional leadership to act. Conversely, when the New York Academy of Sciences convened a series of meetings of representatives of university, industry and government to support knowledge-based economic development, in the mid 1990's, it was unable to make the transition from RIO to RII and take discussion into action.

Triple Helix Circulation



Knowledge capitalization has various sources in industry, universities and government institutes. When knowledge is transformed into capital; persons from any originating organization may be potential entrepreneurs and firm founders. A Triple Helix in which each strand may relate to the other two can be expected to develop an overlay of communications, networks, and organizations among the helices." [viii] The figure they gave also reflects the spirally developing triple helix: a synthesis of evolution in the vertical axis and circulation in the horizontal.

Triple helix-field interaction sheds light on why there is circulation, but it does not show what factors participate in it and how it works. Figure6 depicts a triple helix circulation that occurs on "macro and micro" levels. Macro circulations move among the helices; while micro circulations take place within a particular helix. The former create collaboration policies, projects and networks while the latter consists of outputs of individual helices.

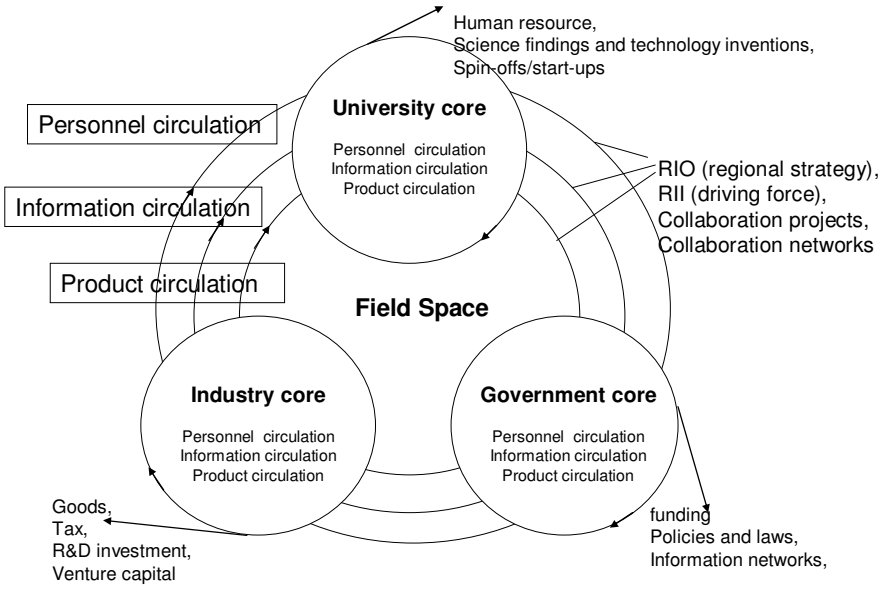


Figure6 Triple Helix Circulation

Personnel Circulation: People Flow

Personnel circulation around the triple helix has been called a "revolving door". The American sociologist C. Wright Mills (1958) strongly criticized this phenomenon as resulting in corporate dominance of government and untoward military influence in industry.[ix] People flow may also introduce ideas from one sphere to another: sparking collaborative projects and promoting cross-institutional understanding. Indeed, lack of circulation of elites may be a cause of blocked development in countries whose leadership has nowhere to go once they complete their term in office.

At least three types of circulation can be identified: (1) Unidirectional or permanent movement from one sphere to another. On the university-industry interface, high-tech-firm entrepreneurs who were university professors exemplify the flow from university to industry e.g. A. Bose from MIT to his acoustical firm, while retaining a tie as adjunct professor. Reversely from industry to university, the archetypal figure is the co-inventor of the transistor, Shockley, who entered Stanford University as a faculty member from industry in 1963. (2) Double life or holding simultaneous significant positions in two spheres such as a half time position in industry and a professorship.

Provost Terman invited Carl Djerassi, Research Director of Syntex pharmaceutical firm to be a chemistry professor at Stanford as part of the strategy of building steeples of excellence in

focused fields with significant intellectual and commercial potential, in this instance steroid chemistry. Djerassi brought the firms R&D operation with him to Palo Alto from Mexico City and continued as Research Director as part of his arrangement with Stanford (Djerassi, 1992). [x] (3) Alternation or significant successive periods of time in more than one sphere, for example, Stanford Professor William Perry, after a significant business career and half-time professorship, served as Secretary of Defense and then returned to the university on a full-time basis.

Information Circulation: Innovation Networks

Collaboration is premised on information communication that, in the IT era, increasingly occurs through networks at various levels, from local to international. Some information networks are designed to announce government policies and funding sources; cutting edge research results from universities and their implications for new technologies and industries; collaboration needs from industry. Others are also designed to support innovative regions. For example, Oresund, the cross-border region linked by a bridge between Copenhagen and Malmö is both an information communication network between Denmark and Sweden and an innovative region (Törnqvist, 2002).

Output Circulation: Reciprocity among Actors

Reciprocity among actors and equality of contribution to innovation is another crucial factor. If there is a negative imbalance in contributions; a gap might appear in innovation; conversely a positive imbalance might stimulate other actors to increase their efforts. For example, the products of start-up firms in the nascent semiconductor industry in California initially caught the attention of the Department of Defense and NASA as a means to miniaturize equipment. The civilian expansion of that industry followed; scientific research results by scientists such as Shockley were recognized by industry e.g. the potential of solid state physics to create better telephone switching devices.

World War II was a key inflection point, transforming university- government relations. Prior to the war, most academic scientists were located in teaching universities, "…where they had no opportunity to do research. … relocated by the war, they suddenly found themselves in well equipped laboratories and moved rapidly to apply their pent up energies and talents to the R&D needed for the war effort" (Johnston, and Edwards 1987: 30). [xi]Exemplified by Vannevar Bush, academics initiated policies for war-time mobilization of scientific talent and sought to attain both civilian and military objectives in the post-war. [xii]

University faculty accepted funding and policies to support entrepreneurial activities from government since World War II, scaling up university research in key fields such as computer science (Braun and MacDonald, 1983). [xiii] The confluence of these forces transformed relatively modest university-originated regional innovation dynamics in Boston and northern California into economic dynamos. Silicon Valley has since metamorphosed into a global innovation organizer, importing start-ups and exporting future firm founders to other regions world-wide from the Silicon Valley Diaspora.

Triple Helix Startup

A triple helix regime typically begins as university, industry and government enter into a reciprocal relationship with each other in which each attempts to enhance the performance of the other. Most such initiatives take place at the regional level where specific contexts of industrial clusters, academic development and presence or lack or governing authority influence the development of the triple helix.

The first step toward a triple helix is usually collaboration, taking place through their traditional roles, among the institutional spheres most involved with innovation. For example, universities, firms and governments in a region may participate in discussions to enhance a local economy, develop a regional growth agreement or establish a technology council. As a result municipalities may agree to speed up building permitting processes for new plant construction; universities may undertake to train more students in an area relevant to the local economy; firms may negotiate new supplier relationships with each other as an incipient cluster. At this initial level of the triple helix, the three strands typically begin to interact in order to improve the local economy by enhancing the performance of existing industry.

The triple helix changes its spin as production of new knowledge and technology becomes more important. At this level of the triple helix, enhancement of the performance of the university and other knowledge producing institutions often becomes the key issue as part of a strategy to renew an older economy or create new economic activity on the basis of intellectual capital in one form or another, ranging from formal R&D in government, university and industrial laboratories to tacit knowledge emanating from existing industries.

As a new overlay of knowledge infuses existing industry and as various combinations of new and old knowledge become the basis for firm formation, the university and other knowledge producing institutions replace industry as the core spiral. Government and industry may then become involved in supporting academic development. The establishment of a research center, speeding up academic research production, is a typical strategy. The university gains additional resources from industry and government to enhance the performance of research, one of its traditional functions.

Taking the Role of the Other

The next step to development of the triple helix is internal transformation of the institutions in which, in addition to performing its traditional tasks, each "takes the role of the other." A second level of innovation in innovation arises as the triple helix actors take on new tasks. If a function is already performed by an institution that has it as its core competency, the utility of another institution taking it on as a secondary activity is the innovative contribution it may make to the performance of this role

In addition to instigating new activities, "taking the role of the other" contributes to the traditional missions as when participation in the capitalization of knowledge leads to the development of new academic research and educational programs. Each institutional sphere is thus more likely to become a creative source of innovation in innovation and to support the emergence of creativity that arises in other spirals. Going beyond traditional missions, universities were the source of the venture capital and incubation movements that were enhanced by the support of industry and government.

As they take the role of the other, each institution maintains its primary role and distinct identity. The fundamental role of the university as an institution for the preservation and transmission of knowledge remains its core mission. Thus, universities continue their special mission of socialization of youth and knowledge dissemination even as they take on some business and governance functions. Similarly, government is the ultimate guarantor of societal rules of the game and industry is the primary source of productive activities. Thus, industry continues to produce goods and services and also does research but also increasingly provides training at higher levels, reflected in the fact that many companies now have their own "universities", at least in their special area of expertise. Government is responsible for providing the rules of the game but also makes available venture capital to

help start new enterprises.

From Bi-Lateral to Tri-lateral Interactions

Bi-lateral interactions among university-government, university-industry and government-industry increase through role-taking. Even as the core identity of each institution is maintained, it is enhanced in new ways through relationships with other spheres. Thus, the university trains organizations in incubators as well as individuals in classrooms. Moreover, as the university engages in technology transfer it becomes a source of new product development which is, of course, a traditional industrial function. The entrepreneurial university, exemplified by the Massachusetts Institute of Technology, participates in the economic and social development of its region. Entrepreneurship as an academic mission is integrated with teaching and research. As the university assumes an entrepreneurial role internally; it naturally also becomes more closely involved with industry, especially since there is not such a great distance between the institutional spheres.

At MIT, the classic entrepreneurial university, involvement with industry occurred through a series of organizational innovations that legitimated the interaction between the two spheres. [xiv] This included the invention of the one–fifth rule regulating consultation as the resolution of a decades long controversy. The legal concept of the contract was utilized to formalize hitherto informal university-industry ties. The development of organizational capacities to interact with industry, through a liaison office to identify appropriate industrial partners, was a next step. This was followed by the utilization of intermediary organizations to carry out business with industry, such as the sale of intellectual property rights in the 1920's and 30's that the university was not yet prepared to conduct on its own. In the US university-government relations were often constructed from the models initially developed for relations with industry; in other societies the movement has been in the opposite direction.

The growth of university-government relations were intertwined with the formation of national identity in Germany in the early 19th century, with the so-called Humboltdian academic model integrating teaching and research. Apart from the land grant tradition, strong university government relations in the US emerged from the World War II military

research projects. These were undertaken at the behest of academic scientists who saw the potential to develop advanced weaponry through the application of science to military problems (radar), on the one hand, and as an ultimate outcome of theoretical advance on the other (the atomic bomb). University-government relations transcended the war-time emergency as academics realized that theoretical advance could arise from problem oriented research as well as vice versa.

As bi-lateral interactions take place, they tend to bring in the third element of the triple helix to solve problems and meet new needs. It is a global phenomenon that involves "learning by borrowing," importing and adapting organizational models from abroad as well as independent invention. For example, the incubator concept that had been imported from the US to Brazil was reinvented and made more relevant to local circumstances than the US academic model focused on high-tech form formation based upon academic research. Starting from an academic base of limited high-tech capacity, Brazilians soon transformed the incubator into a broader model to address issues of development and poverty.

Having realized that the essential purpose of an incubator was to teach a group of person to act as an organization, as an extension of the classic educational mission of the university as well as an expression of its new economic and social development remit, the model was applied to a variety of purposes within and without academia. Industrial associations entered the field, creating incubators to expand traditional clusters. Municipalities also established incubators as a job creation strategy. An NGO, in collaboration with a university high-tech incubator, applied the model to organize cooperatives, training poor people from the favelas to run their own organizations and create jobs for themselves. An association of incubators, ANPROTEC brought the different incubators types and their supporters together in a common framework.

The incubator movement in Brazil originated in the universities in the face considerable skepticism toward introducing a support structure to found new technology firms from academic research, expressed as charges of "privatization of the university." The incubator was legitimized when a municipal government took an interest and funded a building for an early incubator, allowing the project to move from temporary quarters, precipitating acceptance as an official unit.

Expansion and rapid growth of a university initiative to create incubator facilities took place as industrial associations and various levels of government become involved. Support from industry associations and state governments extended the concept from high technology firms to raising the level of technology in existing firms. The critique of incubation abated as university technology transfer organizations also established incubators to train low-income persons to organize cooperatives. A national government initiative then extended this project to universities across the country.

As the number of sources and levels of initiative increase among the triple helix actors, a meta-innovation system is created. The premise for the growth of such a dynamic is an active civil society in which initiatives are encouraged from various parts of society. The possibility of individuals and groups to freely organize, debate and take initiatives, is the basis for a triple helix including bottom up as well as top down initiatives.

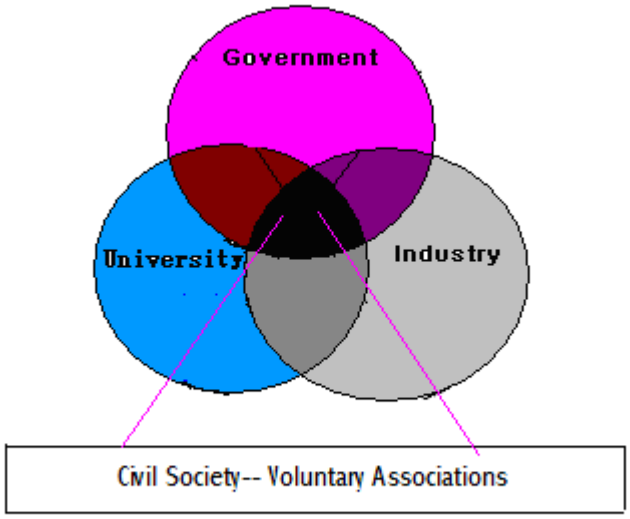


Figure 1-4 Social Structure of Triple Helix

A triple helix embedded in a flourishing civil society encourages the emergence of diverse sources of innovation. Creating an organization or network, representing different interests, to build support for a regional focus is a key element in such strategy. Individuals, typically from the triple helix spheres, come together to brainstorm ideas, formulate initiatives and seek out resources to promote regional development initiatives. Examples include the Pittsburgh High-tech Council, the Niteroi Technopole in Brazil, the Knowledge Circle of

Amsterdam and Joint Venture Silicon Valley in San Jose, California. The prototypical instance was the New England Council, founded during the 1920's, bringing together industrial, academic and governmental leadership to address the region's long-term economic decline.

Pathways to the Triple Helix

The path to the triple helix begins from two opposing standpoints (1) a statist model of government controlling academia and industry (Figure1-1) and (2) a laissez faire model, with industry, academia and government separate and apart from each other, interacting only modestly across strong boundaries (Figure 1- 2). From both of these standpoints, there is a movement toward greater independence of university and industry from the state, on the one hand, and greater interdependence of these institutional spheres, on the other. The interaction among institutional spheres of university industry and government, playing both their traditional roles and each others, in various combinations, is a stimulant to organizational creativity. New organizational innovations especially arise from interactions among the three helices (Figure 1-3) The common triple helix format supercedes variation in national innovation systems.

Our purpose here is to elucidate the transition to a triad of equal and overlapping institutional spheres. Double helices, lacking a third mediating element, tend toward conflictual relations.[xv] The question of the appropriate balance between industry and government, including the role of labor and capital in society, is expressed in theories and social movements that promote socialism or capitalism. A struggle between proponents of these two basic societal formats has ensued since the inception and growth of the modern state and industry, from the 18th century.[xvi] Nevertheless, there is a basic commonality of laissez faire and statist regimes despite apparently divergent formats. This structural similarity is exemplified by the interchangeability of government and industry in leading roles in various theories of reform capitalism and market socialism.

Statist and laissez faire regimes, the traditional competing models of social organization in modern societies, represent reverse sides of the government industry coin. Statist societies emphasize the coordinating role of government while laissez faire societies focus on the

productive force of industry as the prime mover of economic and social development. Both formats emphasize the primacy of these two institutional spheres, albeit in drastically different proportions. Thus, strong and weak roles for government and industry are the defining characteristic of statist regimes while the reverse relationship is the basis of laissez-faire societies.

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Statist Society

In some countries, government is the dominant institutional sphere. Industry and the university are subordinate parts of the state. When relationships are organized among the institutional spheres, government plays the coordinating role. In this model, government is expected to take the lead in developing projects and providing the resources for new initiatives.

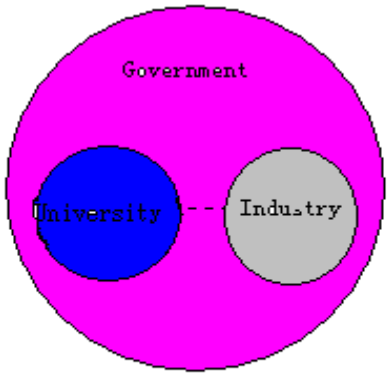

Figure 1-1 The Statist Model

Industry and academia are seen to be relatively weak institutional spheres that require strong guidance, if not control. The former Soviet Union, France and many Latin American countries exemplify the statist model of societal organization.

The statist model relies on specialized organizations linked hierarchically by central government. Translated into science and technology policy, the statist model is characterized by specialized basic and applied research institutes, including sectoral units for particular industries. Universities are largely teaching institutions, distant from industry. A central planning agency was a key feature of the Soviet version of the statist model. A decision was required from the central planning agency to arrange implementation of Institute research. Waiting on such a decision often became a blockage to technology transfer since the firms

and the institutes could not arrange the matter directly, at least not through formal channels.
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In the 1960's the Argentinian physicist Jorge Sabato set forth a "triangle" science and technology policy model applying the statist model to a developing country, arguing that only government had the ability and resources to take the lead in coordinating the other institutional spheres to create science-based industry. In Brazil, during the era of the military regime, the federal government science and technology policies of the 70's and early 80s, implicitly attempted to realize Sabato's vision. Large-scale projects were funded by government to support the creation of new technological industries such as aircraft, computers and electronics. The projects typically included funds to raise the level of academic research to support these technology development programs. A side effect was increased local training of graduate students to work in the projects.

The role of government increases in all countries in times of national emergency. The U.S, for example, reorganized itself on a statist basis during the two world wars, placing industry and university into service for the state. The Manhattan project to develop the atomic bomb during the Second World War concentrated scientific and industrial resources at a few key location, under military control, to accomplish this project. The recurrent calls for a Manhattan project to address such diverse problems as cancer and poverty suggest the attraction of the statist model even in countries with a laissez faire ideology. Indeed, the statist model can produce great results, with good leadership, a clear objective and commitment of significant resources.

The statist model often carries with it the objective that the country should develop its technological industry separately from what is happening in the rest of the world. In Europe this model can be seen in terms of companies that are expected to be the dominant national leader in a particular field, with the government supporting those companies, such as the Bull Computer Company in France. In this configuration the role of the university is primary seen as one of providing trained persons to work in the other spheres. It may conduct research but it is not expected to play a role in the creation of new enterprises.

Even in France, the classic statist regime, much of these expectations have changed in recent years. [xvii] Efforts have been made to decentralize elite knowledge producing institutions from Paris in order to create other alternative sources of initiative. Although not yet at the

level of the German Lander or the American state government, a new level of regional government gains resources and is able to take its own initiatives. Start-up firms, initially off shoots of military programs, begin to take on a life of their own.

Change in statist societies is impelled by need to speed up the innovation system by introducing new sources of initiative. Bureaucratic coordination concentrates initiative at the top and tends to suppress ideas that arise from below. Lateral informal relations across the spheres partially over-rode formal top down procedures. However, such working around the system was typically confined to relatively limited initiatives. When there was a need to undertake larger scale initiatives, the way was often blocked, outside of the military and space spheres that were given extraordinary priorities in the former Soviet Union.

Laissez Faire Society

Another starting point for the triple helix model is separation among institutional spheres . Ideology and reality often diverge, with the spheres operating more closely together than expected. In the U.S. , for example, skepticism of government often obscures the emergence of the triple helix. In reality the institutional spheres are closer together than is commonly held, but accepted U.S. belief is the model of government, industry and academia operating in their own areas without close connections.

In this model, the university is a provider of basic research and trained persons. Its role in connection with industry is to supply knowledge, mainly in the form of publications and graduates who bring tacit knowledge with them to their new jobs. It is up to industry to find useful knowledge from the universities without expectation of much assistance. Industry also is expected to operate on its own, with firms linked to each other by the market relationships of buying and selling. There is expected to be intense .competition among firms, with collaboration forbidden.

Corporations were forbidden by law to cooperate and collaborate with each other because it was expected that if they did communicate extensively with each other the first thing that they were likely to do would be to form a cartel and set prices of products, Thus, for the most part companies were discouraged from interacting, except through meetings of professional associations where people could get together according to their professional specialization. Thus, firms in an industry were expected to operate independently from

each other both in their R&D and product development.

As international industrial competition became greater, it was argued that some of these rules would have to be changed. In the 1970's, in the US: increased international competition from Japan led to a rethinking of appropriate relationships among companies in peacetime circumstances. The anti-trust rules were changed to allow companies to do pre-competitive research and then to allow joint product development. Industry was encouraged to re-structure according to the framework of strategic alliances among different companies. A concept of co-opetition was invented to denote that companies should not only compete, they should cooperate and collaborate.

In the laissez faire model the role of government is expected to be limited clear cases of so-called "market failure" when economic impetuses, by themselves, do not call an activity into existence. Government is expected to play a limited role of regulation or of buying products but not necessarily in the military area where there is much closer linkage. For example, the US military economy operates according to the statist model, through top down direction by government, with industry and universities playing a significant role within that coordination. [xviii]

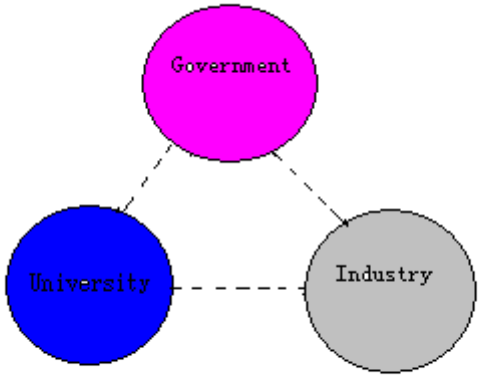

Figure 1-2 The Laissez-faire Model

Government is expected to play a larger civilian role only when an activity cannot be provided by the market. No-one is prepared to offer it for sale or perform the function; therefore it must be provided by government. It is on the basis of this argument of market failure that it is agreed that the government may provide funds to the university to support research because the market will not meet that need. Since it would not take place

otherwise, it is accepted that there is a limited role for government.

There is expected to be only limited interaction among university-industry-government in a laissez-faire regime. When there is interaction and inter-relationship among the spheres, it is expected to take place across strongly defended boundaries and preferably through an intermediary. For example, for many years before universities became directly involved in patenting research there was an organization called the Research Corporation, an independent not for profit organization, in between the universities and industry that found research in universities that could be patented and then arranged for its transfer to a company that found it of interest. Thus, industry and university did not relate directly but through an intermediary organization. Basically, it was argued that it was not appropriate for them to be in direct contact with each other. Nevertheless, if they needed to be in contact, it should be through someone else playing an intermediary role. Thus, to the extent that there were relationships, they tended to occur at arms length.

Attentions to boundary maintenance, separate spheres, distinct institutional roles, and firms as the locus of economic activity characterize laissez-faire society. Concern for boundaries is typically part of a larger complex of ideas and beliefs related to the purity of institutional spheres. Functions and spheres are believed to be related on a one to one basis i.e. industry=production; government=regulation; university= basic research. [xix] Expansion or crossover of functions from one sphere to another is ipso facto evidence of decline, for some, while, for others it is a sign of organizational and individual creativity.

Conclusion:

Innovation, the reconfiguration of elements into a more productive combination, takes on a broader meaning in increasingly knowledge-based societies. Only a small group of specialists in industry and academia were interested in innovation when it was limited to the analysis of product improvement. In recent years, the appropriate configuration of the relationship among firm formation, high technology and economic growth has become a subject of public concern and debate. Is the university losing its traditional role and independence as it becomes more closely involved, and presumably subordinate to industry and government; or is it attaining a higher level of status and influence in society, thereby enhancing it independence, as it takes on a more central role in society through its contribution to innovation?

As jobs are outsourced, what will be the future engine of economic growth, especially as "high tech," as well as manufacturing positions, are increasingly relocated to countries with highly skilled persons and lower wages? There is increasing awareness that a knowledge based society operates according to a different set of dynamics than industrial society, focused on manufacturing tangible goods. Knowledge-based economies are more tightly linked to sources of new knowledge; they are also subject to continual transformation instead of being rooted in stable arrangements. Under these conditions, encouraging an enhanced relationship of university to industry and fostering a continuous process of firm formation based on advanced technologies, often university originated, becomes the core of innovation strategy.

The growth of science-based technology, from the 17th century, intersecting with the emergence of independent institutional spheres in the 18th century, founded a new dynamics of innovation. These two dimensions came together in the creation of the Research University in the 19th century, incorporating experimental science. The teaching laboratory was invented, scaling up the integration of research and teaching, including research with practical implications, as the university gained autonomy from other social spheres (Rossiter, 1975). These twin developments augured the transition from a society based on vertical stratification in the pre-modern era to one increasingly based on horizontal relationships among inter-related institutional spheres.

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