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LEARNING FROM TRANSITION: THE TRIPLE HELIX AS AN INNOVATION SYSTEM

INTRODUCTION: INSTITUTION-FORMATION

The triple helix thesis is that the interaction among university-industry-government is the key to improving the conditions for innovation in a knowledge-based society. Industry is member of the triple helix as the locus of production; government as the source of contractual relations that guarantee stable interactions and exchange; the university as a source of new knowledge and technology, the generative principle of knowledge-based economies. Although the triple helix originated as a model of discontinuous innovation in the U.S., based on networking among institutional spheres, it has also been utilized to integrate disconnected resources in collapsed innovation systems and to enhance incremental innovation in developing countries.

Triadic interactions are a method of creating or renewing innovation systems in both advanced industrial and developing societies. The construction of a triple helix includes the creation of institutions for the production and transmission of knowledge; a consensus building process through which potential partners come together to collectively identify niches and design organizational mechanisms to realize an innovation strategy. More than technological change; innovation includes organizational inventions in the private and public spheres. In contrast to biological evolution, arising from mutation and natural selection, social evolution occurs through "institution formation" and conscious intervention.

The role of government in innovation was highlighted when the state was virtually removed from the innovation picture with the collapse of communism in Eastern Europe.[1] Nevertheless, when central planning was eliminated, some Eastern European S&T experts realized that a role for government in fostering innovation was necessary.[2] However, given the discrediting of the maximal state it was difficult to justify more than a minimalist state, confined to basic security and welfare activities. It

became apparent that a new conceptual framework was needed to justify science and technology policy within a laissez-faire regime, focused on foreign direct investment (FDI) as its industrial policy. From two quite different statist and laissez faire starting points, a shift is underway to a common framework for innovation: university-industry government relations- the triple helix.

THE STRUCTURE OF THE TRIPLE HELIX

The triple helix model comprises three basic elements (1) a more prominent role for the university in innovation, on a par with industry and government in a knowledge –based society; (2) a movement toward collaborative relationships among the three major institutional spheres in which innovation policy is increasingly an outcome of interactions among the spheres rather than a prescription from government or an internal development within industry; (3) in addition to fulfilling their traditional functions, each institutional sphere also "takes the role of the other" operating on a y axis of their new role as well as an x axis of their traditional function.[3]

What is peripheral and what is central to innovation has been transformed in recent decades. The creation, dissemination and utilization of knowledge have become more directly involved in industrial production and governance.[4] This development has enhanced the significance of universities and other knowledge producing institutions to the other institutional spheres. The more explicit utilization of knowledge in industry and government, exemplified by the invention of the discipline of "knowledge management" and the growth of "intelligence" give knowledge producing institutions that have the organizational capacity to recombine old ideas, synthesize and conceive new ones a greater import.

Eastern European Universities lost most of their research functions during the Soviet era.[5] The breaking of the previous Humboldtian model of the unification of research and teaching was instituted both for reasons of political control, separating politically unreliable professors from students while utilizing their research abilities, but also from the belief that specialization of functions was a more efficient system. The future of Academy Institutes as independent entities or integrated into universities; the resuscitation of research in older universities and the emergence of new private universities, focused on teaching, have characterized transition in the academic sphere. In Eastern Europe and elsewhere, the restructuring of knowl-

edge producing and disseminating organizations, in relation to industry and government, is a key element of the triple helix transition.

Universities are increasingly playing an entrepreneurial role as the source of future industrial development, both by establishing organizational mechanisms to transfer knowledge and technology and by playing a strategic role in regional development. While the entrepreneurial university originated at MIT early in the 20th century, it is still at a relatively early stage of development. The Second Academic revolution, the assumption by the university of economic and social development missions, follows from the First Academic revolution, the internalization of a research mission. Nevertheless, the entrepreneurial university retains the traditional academic roles of social reproduction and extension of certified knowledge but places them in a broader context as part of its new role in promoting innovation.

EMERGENCE OF TRIPLE HELICES

The transformation of the university is accompanied by similar innovations in industry and government. As firms take their new role in continually adapting and raising their technological level, they become a bit closer to what a university does in adopting educational modes and in sharing knowledge among firms. As government plays a role in supporting firm formation, as well as regulator of the rules of the game, it becomes a public entrepreneur. These innovations in specific local contexts are soon reinterpreted and applied around the world.

The triple helix model for innovation emerges from different societal starting points but converges to a common format. First, there is Triple Helix I, in which the state encompasses academia and industry and directs the relations between them. The strong version of this model could be found in the former Soviet Union and Eastern European socialist countries as well as France. Weaker versions could be found in many Latin American countries and to some extent in Scandinavian countries such as Norway.

The second Triple Helix model consists of separate institutional spheres where government, university and industry operate apart from each other, or at least this is the ideology of how they are supposed to behave in the US. In this model the University provides basic research and trained persons. It is expected that firms in an industry should operate completely apart form each other in com-

petitive relationships, only linked through the market. Government is limited to only addressing problems that can be defined as market failures, with solutions that the private sector cannot or will not support.

TH III consists of overlapping institutional spheres; each taking the role of the other and with hybrid organizations emerging at the interfaces. In one form or another most countries and regions are presently trying to attain some form of TH III, with its university spin-off firms, tri-lateral initiatives for knowledge-based economic development and strategic alliances among firms (large and small, operating in different areas and with different levels of technology), government laboratories and academic research groups. These arrangements are often incentivized, but not controlled, by government, whether through new "rules of the game," direct or indirect financial assistance.

It is these latter two versions of the triple helix that currently generate normative interest. TH I is largely viewed as a failed developmental model. With too little room for "bottom up" initiatives, innovation was discouraged rather than encouraged. While the model could work relatively well for the early stages of catch-up (i.e. 1920s Soviet Union), it became a liability as innovation, both technological and organizational speeded up.[6] THII is a laissez faire model, often advocated as shock therapy to reduce the role of the state in TH I.

THE STATIST TRANSITION

In a "statist" triple helix government subsumes the other institutional spheres and attempts to coordinate them to promote innovation. In the late 1960s, Argentine physicist and science policy analyst, Jorge Sabato, developed a triadic innovation model as a development strategy for countries with weak industrial sectors. Government is expected to take a leading role in promoting high-tech development projects, especially in areas of national security, and bringing together the resources to realize objectives. In this model, universities typically play a supporting role, primarily providing trained person to work in the state bureaucracies, other large organizations and traditional professions.

Sabato took as his inspiration for his "triangle" model US World War II military R&D projects.[7] Perhaps, ironically, many of these projects had been initiated by academic leaders and the method of coordination adapted from university procedures, the committee system. Nevertheless, in the Latin American context of military regimes

during the 1960's government attempted to combine import substitution polices with procurement strategies to create new high-tech industries. Although efforts in computer hardware had to be abandoned the human resources trained through these projects were later shifted to smaller scale initiatives in software, after the military era. Aircraft design of a regional jet from scratch had an advantage over planes that had been downsized from larger models in the US, so that effort survived.

Nevertheless, when the military regime ended in the early 1980's the way was open to initiatives from below in an era of declining resources. Some of the university discussion groups that had been the source of opposition to the previous regime now became the source for new innovation projects, adapting concepts like incubators to the Brazilian scene. In Eastern Europe, the emergence of civil society as a base for innovation initiatives was more uneven. Initiatives typically arose as survival strategies, taking pieces of institute resources and attempting to privatize them. Often, the old structures were maintained, even at sharply reduced rates of financing. Foreign direct investment (FDI), based on highly skilled labor became the dominant industrial strategy. The recreation of a local bottom-up innovation model connected to academic and other knowledge resources largely remains to be accomplished. The rest of this paper offers some guidelines for initiating an innovation strategy beyond FDI.

The transition from a statist regime to one of relatively independent, overlapping spheres is barely underway in Eastern Europe. The term "transition" in Eastern Europe usually denotes a movement from a model in which the state encompasses industry and the academic and research institute sectors to a *laissez faire* model of separate institutional spheres. Science and technology policy had formerly been a high priority, the centerpiece of regimes legitimated by a thesis of a scientific-technological revolution. In countries such as Hungary, the purview of the state no longer extended to innovation under post-Socialist regimes.[8] Ironically, the very advisors, usually from the US who tell Eastern Europe to move to a system where the sectors should not interact, to be completely separate, are coming from countries where the reverse is occurring, where the institutional spheres of university, industry and government are increasing overlapped.

Although research and production were formally linked by intermediary organizations during the socialist era, the government's focus was on quantity production, not qualitative innovation. Bureaucratic structures and

controls had heretofore been an impediment to introduction of local inventions through technology transfer.[9]

In the face of an inefficient system for organizing technical change, movement across boundaries took place through informal connections, say from a branch research institute to an enterprise, taking place laterally rather than going through the official planning process. The transition was expected to take hierarchical structures apart and have the state, industry and academic sphere as independent entities. If the swing is precipitant, the statist model may cross over abruptly to a laissez fare mode, as for example occurred in Hungary after the collapse of communism and require reconstitution of government role in innovation at a later point in time.[10]

THE EASTERN EUROPEAN TRANSITION

The triple helix is instantiated both as an analytical framework and as a normative model. The paradox of Soviet and Eastern European science is the scale of resources, financial and human, devoted to the enterprise under socialism and the paucity of innovation achieved from that investment, outside of the military and space realms. A "scientific technological revolution," enunciated by Czech theorist, Radovan Richta, provided a linear framework for funding science at high levels with the expectation that it would translate into practical consequences. This socialist model had its conservative counterpart in Vannevar Bush's "endless frontier" thesis of funding science in expectation of long term practical results.

Whereas the socialist model of bureaucratic coordination that failed to transfer technology stayed intact, the hands-off US linear model of the early post-war was gradually modified into an assisted linear model with a loose organizational structure. A series of innovative polices and programs were adopted at the national and state levels to assist the translation of research into economic uses. By contrast, Eastern Europe underwent a sharp break from a bureaucratically organized innovation system to one with a lack of structure after the collapse of socialism. Borders opened up to an inflow of FDI on the one hand, to take advantage of a highly skilled, low waged labor force; higher level research personnel were not needed in this industrial model.[11]

Since the breakdown of socialism, many persons have emigrated, internally to other occupations and externally to scientific and technical posts abroad. Some of their technological innovations that were not taken advantage

of at home, under the previous system, have become the basis of start-up firms abroad. Receiving countries have developed informal and formal mechanism to insert immigrating technical personnel and the technological innovations that they brought with them into an entrepreneurial environment. In the US attorneys specialized in intellectual property and firm formation, with links to angels, have been the preferred mechanism. In Israel, a government sponsored "Magnet Program", supplying significant financing and organizational support within incubator facilities with highly competitive entrance requirements, achieved great success.[12]

The positive outcome of the Socialist era is the highly trained and creative scientific and technical workforce that was created.[13] A significant S&T workforce remains in place and an educational and cultural system for supporting science continues to operate.[14] Even if ill funded, it constitutes the comparative advantage of the so-called transition countries.[15] Nevertheless, the key issue is still: how to constitute a structure to realize innovations at home so that they do not have to be taken abroad for this purpose.[16] How to create a viable innovation system has been the topic of conferences such as one recently held in Croatia on innovation and the triple helix.

A Workshop in Zagreb synthesizing local and international experience was a useful first step toward focusing attention on innovation. A next step should involve additional potential partners from academia and industry in the discussions. This could lead to an analysis of gaps in the innovation system and opportunities to fill them. Success cases and the circumstances that fostered them should also be studied for their replicability. Organizational experiments should be encouraged following a venture capital model of seeking out a few winners from among a large number of start-ups. Models for organizational innovation from abroad should be investigated for utilization in Croatia The triple helix training scheme to incentivize the regional level, adopted by the Swedish Innovation Agency, Vinnova, might be considered for introduction.[17]

The analysis and consensus development process is best instituted at the regional level, perhaps as a pilot project in two contrasting regions. The concept of the "entrepreneurial university" and how to adapt and reorient existing institutions of higher education to take a more active role in society, especially in fostering an innovation culture and practice, should be a major part of the discussion. Also, important to discuss is the role that government can play both at the national and regional levels and

what new organizations and policy mechanisms might be introduced to foster innovation. Finally the role of industry must be considered; whether existing industry can be upgraded through the infusion of knowledge and what is the potential to create new industrial niches directly from the region's knowledge base and through hybridization with existing industries.

THE TRIPLE HELIX TRANSITION

Most regions have some fundamentals in place to foster innovation while others are missing. A "regional innovation environment" consists of the set of political, industrial and academic institutions that, by design or unintended consequence, work to improve the local conditions for innovation, as well as the gaps that they seek to fill. Both sides of the equation, the active and missing elements, should be included in a regional analysis. However, if one sphere is missing or constrained from participating, another may take its part. If a regional government is lacking, a university or industry association may take the lead in encouraging an industrial district to cooperate with universities or other knowledge producing institutions.

Regions may be viewed as "thick" or "thin" depending upon the presence or absence of innovation support structures, whether informal or formal. Thus, whether it makes sense for a region to create new organizational mechanisms depends upon whether firm formation is already taking place, for example, supported by a network of angels investors, or requires a formal support structure, such as an incubator facility, to take off. A region that is rich in business development requisites such as venture capital and an entrepreneurial culture may not have to develop explicit organizational mechanisms. On the other hand, a region that is lacking knowledge-based economic development activity may find it useful to develop an incubator or science park, in association with a university, to foster regional development.

CONSTRUCTING GROWTH SPACES

The ability to advance within and across technological paradigms may be conceptualized as occurring within three "growth spaces": knowledge, consensus and innovation. Knowledge spaces provide the epistemological source for technological development; consensus spaces denote the process of getting relevant actors to work together and innovation spaces, an organizational invention to enhance

the development process. Taken together, in any sequence, they comprise the basic building blocks for knowledge-based regional development, that focuses on analysis of gaps in existing innovation systems and the invention or adaptation of organizational structures to fill these gaps.

The innovation process can start from any of these spaces and move, non-linearly, to another. Although successful instances are often reinterpreted to look like spontaneous developments, especially in *laissez faire* societies, historical cases can always be traced to the active intervention of an individual or group, an innovation organizer (IO). The innovation organizer is the individual or group that takes the lead in conceptualizing a strategy for knowledge based growth and activating hitherto untapped resources to realize a shared vision. Karl Compton, the President of MIT and the New England Council or business, political and academic leaders played this role in depression era New England. Frederick Terman, the Provost of Stanford played a similar role in the early post war. An Ontario entrepreneur is credited with mobilizing resources to jumpstart that region's high-tech industry in recent years.

THE KNOWLEDGE SPACE

The role of universities and other knowledge producing institutions is one key to establishing an effective knowledge space. Rather than only serving as a source of new ideas for existing firms universities are combining their research and teaching capabilities in new formats to become a source of new firm formation, especially in advanced areas of science and technology. In New England in the 1930's the concentration of universities and research institutes, became the basis of an economic and social renewal project when it was realized that there some academic research projects had commercial potential. In Mexico, during the 1980's, after the earthquake, government decentralized some of the research institutes from Mexico City to other regions of the country. Soon after the move, those institutes started working on local problems, becoming a resource for the area economy.[18]

Nevertheless, although research resources provide a potential for knowledge based development, there mere existence does not insure the result. San Francisco, New York and the Öresund Region (Sweden/Denmark) have high concentrations of bio-medical research but with strikingly different outcomes. San Francisco has a long-term

and thriving biotech industry; Öresund has an emerging bio-medical industry and New York City has the bare beginnings. Columbia has a bio-medical incubator and New York University is opening one but these are scattered initiatives. On the other hand, the Medicon Valley project in the Öresund Region has brought together a series of initiatives in Lund, Malmö and Copenhagen in a strategic framework.[19]

THE CONSENSUS SPACE

Knowledge spaces are transformed from potential to actual sources of economic and social development through the creation of a "consensus space," a venue that brings together persons from different organizational backgrounds and perspectives to generate new strategies and ideas. A meeting place is needed to bring the different groups together, to analyze the problems of the regions and to arrive at a concept for taking the next step. In New England, the New England Council played the organizing role. In the state of Rio de Janeiro, there is currently a group of business people, academics and government officials who are meeting in the city of Niteroi, with the objective of creating a technopole.

Without bringing people together to formulate a project, the knowledge space may be underutilized. For example, New York City has one of the greatest concentrations of bio-medical research in the US.[20] However, there is very little economic development from that research. There has been no regional organizing process to take advantage of it. It has only recently been considered that it is necessary for area universities to be cooperating with each other, establishing joint centers as a first step to moving this research into the innovation space.[21] The need to fill gaps in the regional innovation environment also brought the research institutions of Long Island together to establish the Long Island Research Organization (LIRI), offering strategic management consulting to firms in the declining defense industry located in an inner suburban belt.

THE INNOVATION SPACE

The innovation space may be visualized as a dual set of ladders with cross bars between them. One ladder is the linear model of innovation; the other ladder is the reverse linear model of innovation. At each point along those ladders, we have placed small triangles to prepare the way for the base pairs. This is the element that makes these models

assisted linear models. These are the incubator facilities, the technology transfer offices, the research centers, the consortia. On one side, on the linear ladder there is a research center; on the other side on the reverse linear ladder there is a technology transfer office or incubator meeting the organizational innovations on the other ladder and that is where an innovation space opens up. Where these movements from both sides occur, the reverse linear side and the linear side meet and something new results, such as an incubator with research oriented and close to market firms interacting, that wouldn't have existed without these interactions being encouraged.

The task in the consensus space is to arrive at a course of action to fill some gaps in the local innovation environment. Often, as a result, a new organizational mechanism is invented, whether it is the venture capital firm in New England in the 1930's, the Soft Center in Ronneby or the incubator movement in Brazil, in the 1980's. The very process of including actors from these various backgrounds in the strategy review and formulation process provided access to the resources required to implement the eventual plan. By moving the "new product" approach from the industrial sphere and tying it to the academic research process, MIT introduced an assisted linear model of innovation.

In the late 1970s and early 1980s, the Competitiveness Center of SRI International advised Midwestern states, in industrial decline, how to organize regional cooperative groups to revive their economies. When the economic downturn hit Silicon Valley these policy researchers brought their model home and helped establish an organization, Joint Venture Silicon Valley (JVSV), bringing together high-tech company executives, local government officials and academics for a series of public meetings.[22] A project to promote computer networks "Smart Valley," grew out of these discussions, formalizing some of the informal networks crucial to the development of high-tech industry in the region.[23]

The innovation process folds back in on itself when one space becomes the basis for the development of an other. For example, science parks, which originated at Stanford University as mechanism for firms that had originated from the university to maintain connection to the university, as well as provide an income stream to Stanford, were subsequently founded at other universities to assist the firm formation process as well as provide a site for existing firms to locate R&D units to interact with university researchers. Stand alone science parks were also estab-

lished, primarily as a site for large corporate R&D units and branch R&D units of multi-national corporations. Recently, the science park process has come full circle as universities have been established at relatively academically isolated science parks such as Sophia Antipolis and Kista to provide a knowledge base for future firm formation.

THE EARLY 20TH CENTURY NEW ENGLAND TRANSITION

Potential growth spaces can be identified at the local, regional, national and multi-national levels and in cross-cutting developments that move diagonally through these levels. For example, it was already apparent in Boston, early in the 20th century, that it was necessary to replace firms whose technologies and products had been superceded, or whose businesses had moved elsewhere. An analysis of the Boston region found that the New England Council, a regional organization representing university, industry and government actors, played a key role in developing knowledge-based innovation strategy during the 1930's and 40s. In addition to the phases of development within a particular technological trajectory, there is also the issue of changing trajectories, crossing over from an old to a new one, to sustain a growth region. A region rooted in a particular technological paradigm is in danger of decline once that paradigm runs out.

Early 20th century New England had knowledge spaces, research fields with technological and economic development potential at universities such as MIT and Harvard. In the review that it undertook during the 1930's, the New England Council identified the region's comparative advantage in its concentration of academic research and a lack of support systems for firm formation as its weakness. The Council served as a consensus space where business, governmental and academic leaders came together to test existing ideas, try out new ones and develop solutions appropriate to the region's problems and opportunities. Finally, an innovation space was created that we are familiar with today as the venture capital firm. The process of filling gaps in a regional innovation environment may start with the knowledge space, move to the consensus space and then to the innovation spaces in a linear fashion or start from one of the other spaces and proceed non-linearly.

There is an endless transition in innovation systems. The Boston region represents perhaps the most successful case of a region developing the ability to renew itself across technological paradigms.[24] The mechanical and textile industries of the late 19th and early 20th century were superceded by the minicomputer industry which was in turn replaced by the biotechnology industry. A concentration of broad-based research universities, a highly developed venture capital industry and state government programs to support innovation shortened the time between technological paradigms.

The three spheres of university, industry and government are those which in most cases are the ones that are central to innovation. However, in some situations such as in Africa where organizational resources to promote innovation are limited, it has been suggested that the "Innovation Organizer" role may temporarily be played by international donors.[25] Nevertheless, the triple helix of university-industry-government should not be viewed as a rigid framework. If one element is missing and another has appeared then, by all means insert that element into the framework to make your analysis or plan of action. The following specific suggestions have been abstracted from previous international experience:

1. *Spread entrepreneurial education throughout the university.* When it exists at present, courses in entrepreneurship are typically only offered in the business and engineering schools, and even then separately form each other, losing the opportunities for technical and business students to interact and create new ventures collaboratively. Just as every student learns to write an essay, setting forth ideas and experiences, and a scientific paper, matching evidence to hypotheses, every student should also learn to write a business plan, setting forth objectives and providing a market test of their viability.
2. *Network incubators and incubator firms.* When incubators exist they are often isolated entities sponsored by an individual university, municipality or business firm. Networked incubators have the possibility to encourage firms to undertake joint projects that neither could accomplish by themselves. A technology platform from a firm in one incubator can be made into a business in another incubator. International incubator networks can give start-ups some of the reach of a multi national firm, helping them to find marketing representatives abroad.

3. *Incentivize regional actors to collaborate and cooperate.* Especially in larger regions where there may be more than one university, multiple governmental units and several leading firms or clusters, centrifugal forces may keep potential partners apart. National agencies need to be cognizant that the relatively small incentives that may serve to bring triple helix actors together in a small region may not work in a large region where different groups may compete for leadership status rather than work out an accommodation. On the other hand, they may be willing to accept an invitation to cooperate made by a sufficiently prestigious actor, such as a leading firm in Silicon Valley or the Federal Reserve Bank in New York City.
4. *Create an array of venture capitals.* Over-reliance on a single type of venture capital instrument can result in stasis and gaps in fields where traditional funds are not active. Multiple venture capital agents, based on different premises, can create a division of labor in which later and early stage needs are met as well as social and business goals. Venture capital is a broader field than private partnerships or temporary public programs to incentivize a private venture capital industry. A balanced portfolio of venture capital entities is essential to the full economic and social development of a region.
5. *Develop Multiple Knowledge bases.* Too narrow a knowledge base can leave a region bereft when a technological paradigm runs dry, temporarily or permanently. The availability of alternative knowledge bases gives the region the potential to shift form one technological area to another and avoid gaps. A broad based university with several critical masses of intellectual activity with potential for capitalization is the basis of a triple helix region that is able to periodically renew itself. The Boston area's shift from textiles and metalworking industries in the early 20th century to mini-computers in the mid-twentieth century and currently to bio-technology, based on the breadth of its academic resources exemplifies this strategy.
6. *Create an Entrepreneurial Academic Entity.* If an entrepreneurial university, interested in the capitalization of knowledge and playing a leadership role in the economic and social development of its region does not exist, then it has to be invented. A new university may be founded for this purpose as MIT was in the mid 19th century or Linkoping in the late 20th century. An existing university may also be encouraged to play this

role. Alternatively a group of universities may establish an entrepreneurial unit, like the Stockholm School of Entrepreneurship to takes this role on behalf of a local academic community.

CONCLUSION: GREAT TRANSFORMATIONS

The thesis of national innovation systems has its counterpart in national traditions of science, that distinctive formats can be identified within the boundaries of the nation state. Nevertheless, just a science as an international phenomenon has outweighed national variants; the triple helix of university-industry-government relations is emerging as a common format that transcends national boundaries. As this takes place there is a shift from bi-lateral to trilateral interactions from single and double helixes to university-industry-government joint projects like the land grant universities in the US, the research schools program in Sweden and the incubator movement in Brazil. Whether starting from statist or laissez faire regimes, the movement is to a midpoint of relative autonomy of institutional spheres, on the one hand, and stronger interrelations and creation of new hybrid formats embodying elements of two or more institutional spheres, on the other.

The emergence of university-industry-government relations – a tri-institutional model of society – is the great transformation of late 20th and early 21st centuries. This transformation includes a shift from: manufacturing to service occupations; the individual firm to strategic alliances; tacit to codified knowledge; technical to organizational innovation. A sequence of organizational innovations within and across the institutional spheres create a strong science and industrial policy regime in the U.S. State programs provide seed funding for projects close to industry and fill the interstices in federal programs that hew to the research frontier, with notable exceptions of military related research programs. Nevertheless, extensions of federal research programs such as the Small Business Innovation research program (SBIR) fulfill a public venture capital function by providing funds that can be used to start firms as well as meet agency research needs.

The triple helix transition followed from the emergence of government-industry relations – a bi-institutional model of society – that constituted the great transformation in the 19th century.[26] The Speenhamland law in England placed limits on exchange relationships in wage labor, guaranteeing workers a living wage. On the one hand,

the market became the organizing principle of social relations while, on the other, government moderated exchange relationships to insure a living wage. Government-industry relations thus created a compromise that insured social stability in the wake of an industrial revolution that opened up new social chasms and conflicts. It also encouraged a shift in social relations from status to contract, gemeinschaft to gesellschaft, mechanical to organic solidarity and the invention of the social sciences to elucidate these transitions.

All societies are in transition in the 21st century, with no fixed endpoint to change in sight. The functional differentiation of institutions in the early modern era is being displaced by integration and hybridization of functions in the post-modern era. Although this process begins from the starting point of opposing formats for relationships among a triad of institutional spheres in different parts of the world, a secular trend toward a common format for innovation systems in the 21st century can be identified. Triple helices emerge as a trajectory that influences the future course and direction of innovation. However, such developments while implicit in the transition to knowledge based society are not inevitable. Although high tech-complexes consist primarily of cluster-like relations among firms and networks of technical entrepreneurs, their origins can usually be traced to institution-formation initiatives taken by university and government, as well as industry partners.

The transition from a laissez faire model to one of overlapping institutional spheres was initiated more than a century and a half in New England, beginning with the organizational effort in the 1840's to found a public/private technological university, realized with the founding of MIT as a "land grant school in 1862. A similar process, can be identified in the interactions of the Stanford Engineering School with local technical industry, some of which it helped found, from the late 19th century. The mid-twentieth century projects to create the Research Triangle in North Carolina and Sophia Antipolis in France involved strong participation by regional and national governments; whose role declined as the efforts became successful.

The enhanced role of the university as a knowledge creation dissemination and innovation organization, emanating from its classic institutional characteristic of rapid human capital flow through that encourages creation and diffusion of new ideas. An industrial penumbra arises around universities as they become involved, often in a

leadership role, in regional coalitions for economic and social development. The construction or renovation of an existing university into an entrepreneurial format can be seen at various academic levels, ranging form leading classic universities such as Lund University in Sweden to emerging regional universities such as the University of Massachusetts, Boston.

Although the creation of a knowledge-based society has opened up new divides between advanced industrial and developing societies; it has also opened up the possibility to use existing knowledge resources such as academic institutions, present in virtually all countries, to overcome gaps.[27] Universities in developing countries, such as Zambia, have the opportunity to play a leading role in development but often must overcome attachment to classic university formats that are sometimes stronger than in the societies in which they originated.

Invention of policy ideas and mechanisms to create as well as enhance nascent triple helixes in societies where one or more institutional sphere, such as industry, may be largely lacking is the great challenge to innovation theory and practice of all perspectives.[28] The triple helix model posits that universities in transitional and developing countries take a leading role in catalyzing regional growth spaces.[29] As new universities are founded, greatly expanding higher education in all societies, universities in developing countries such as Ethiopia, must envision a broader role for themselves in the development process, than the narrow human capital function sanctioned by the ivory tower model.[30] The next great transformation will include developing, as well as advanced industrial countries in the promotion of innovation through the creation of entrepreneurial universities embedded in inter-institutional linkages.[31]

FOOTNOTES

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