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The Renewal of the African University:
Towards a "Triple Helix" Development Model

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Abstract

Traditional development models envision a staged series of steps, typically to be followed in sequence, that replicate the development experience of the industrialized countries in the West. Invented in an increasingly superceded industrial era, stage models may no longer be relevant to an increasingly knowledge-based society. Evolutionary models based on Schumpeter's thinking emphasize the recombination of elements in order to create new forms of economic organization. The triple helix model takes this process further by looking at the polyvalent nature of knowledge and to institutional sources outside of the economy, in particular the university, as a source element for recombination and innovation.

Keywords: triple helix, polyvalent knowledge, spiral model of development, the African university

Introduction

Invented in an increasingly superceded industrial era, stage models may no longer be relevant to an increasingly knowledge-based society. Evolutionary models based on Schumpeter's thinking emphasize the recombination of elements in order to create new forms of economic organization. The triple helix model takes this process further by looking at the polyvalent nature of knowledge and to institutional sources outside of the economy, in particularly, the university, as a source element for recombination and innovation.

Though universities are established, nurtured and fueled with public funds to serve as conduits through which scientific research is transformed to enhance the socio-economic

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interests of their respective countries and regions, this has not typically been the case in Africa. African universities have yet to take up the challenge of encompassing an economic development function in addition to teaching and research as their main mission. The slow nature of the triple helix transformation in Africa is understandable since in African development policies and strategies, universities are not usually considered as critical players and are thus relegated to the background. This stems from the fact that conventional development models envision a staged series of steps, typically to be followed in sequence, which replicates the century old development experience of the industrialized countries.

The process of globalization has resulted in a diminishing gap between scientific research and utilization. This has resulted in the recognition of the dual theoretical and practical uses for scientific research (Etzkowitz, Schuler and Gulbrandsen, 2000). We argue that in the current situation, it may be possible to leap-frog stages of industrialization that are now disappearing in the traditional countries of origin. Perhaps ironically, many advanced industrial countries, such as the UK, have lost much of their traditional industries and are now pursuing a science and culture based strategy of redevelopment based on universities and artistic quarters. By following the strategies of a century ago, the least developed world may be left behind again.[3] The thesis of this paper is that a development strategy for Africa can be fashioned by realizing the potential of universities for economic and social development.

From Stage to Spiral Model in Education

Some observers expect that least developed countries like Ethiopia need the chance to build dams and develop according to the same path as the advanced industrial countries did a century ago. The alternative thesis is that developing countries could pool their technology resources to take the lead in developing alternative energy technologies, such as photovoltaics, without disturbing the natural environment that is the basis for unique

[3] Certainly there can be a balance between the two approaches as, for example, in China and India that have pursued dual strategies of industrial and post-industrial development.

tourist industries such as the one that was emerging at Tis Abey adjacent to the Blue Nile Falls. When a new power station reduced the falls to a trickle, destroying their natural beauty and the livelihoods of local tourist operators, this opportunity was lost (Robinson and Island, 2006).

The form and content of education in the least developed world tend to mirror the prevailing concept of development underwritten mostly by Western actors. Most African countries inherited a colonial educational system that was oriented to the developmental needs of the colonial master. The goal of the educational system was to turn out clerks for the purchases of traditional agricultural export commodities, missionary proselytizing activities, and the colonial civil service. Technical education geared towards innovation and creative purposes was not on the colonial agenda. As Julius Nyerere wrote in 1967, colonial education was not designed to prepare young people for the service of the country. It was rather motivated by the desire to inculcate the values of the colonial society, and to train individuals for the service of the colonial state (see Davidson, 1990:187). For instance, until 1987, Ghana the first sub-Saharan country to attain political independence did not alter its educational structure modeled after the British system of education.

In Africa, the largest financier of education is the World Bank. As such, educational policies and strategies often mirror the bank's policy direction. The underlining presumption especially in the educational policy recommendations of the World Bank has been that mass primary and secondary education should precede the extensive development of tertiary educational capabilities. Though the bank is fully aware of the role of universities in economic growth and innovation, its educational policies in Africa have overly focused on basic education. This approach as we will argue ignores the role of universities, as a source element for recombination and innovation. The World Bank is aware that the contribution of universities to economic growth may increase with levels of technology and as countries achieved universal primary and secondary education (World Bank, 1995).

However, beyond calling for privatization and the introduction of fees and user charges, universities do not feature prominently in the priorities and strategies of the World Bank. To the bank, basic education ought to be the priority for public spending on education in those countries that have yet to achieve near-universal enrolment at the primary and lower-secondary levels (World Bank, 1995). This policy regulation underlies the stage model where growth is a discontinuous and dialectical process until a take-off stage of self-sustained advancement is reached (Rostow, 1960).

In fact, in recent times, countries such as Singapore and South Korea that pursued the basic education strategy approach to create a manufacturing work force have realized the limits of this approach and have recently shifted to a knowledge-based strategy, focused on creating research institutes and new universities as the basis for future development. This spiral model of education, which is emerging as an academic reform strategy in a number of developing countries is refocusing on undergraduate and graduate education. Some examples are the University for Development Studies in Northern Ghana, and the State University of Rio de Janeiro (Friburgo Campus). The University for Development Studies, for instance, focuses its efforts on topics that will help address issues of rural poverty and community development, including field work projects as well as classroom training in its curriculum. Thus, rather than developing undergraduate programmes focusing on existing industries, developed a graduate research programme based on information technology (IT) that could be utilized to raise the level of a variety of local industries as well as create a new IT industry, the programmes were projected to follow as a second step in the development of this campus (Juma, 2005).

It is clear that a continuous flow of science to the economy does not need to be achieved slowly through traditional staged development models but can occur more rapidly by expanding and re-orienting universities. The triple helix development model that we propose takes the Schumpeterian endogenous development model further by looking at institutional sources outside of the economy, in particular the university, as a source element for recombination and innovation. In Ethiopia, these efforts typically attempt to upgrade traditional industrial clusters by connecting them to foci of government funded

research located at universities and research institutes that are encouraged to become more entrepreneurial (Ethiopian Herald, 2006). Based on these transformations, we argue that the Newtonian linear model whereby, the site of knowledge production is entirely separated from that of application (Gibbons et al., 1994) is outdated and no longer relevant to Africa's search for strategies to unleash the potential of its universities. We call for a triple helix development model that incorporates basic education with university led economic development.

Universities as the locus of the Third Industrial Revolution

Different types of knowledge were effective in different periods of the three industrial revolutions. Science in the way we came to understand it was by all accounts quite modest in the classical industrial revolution. Similarly, the tight interaction, for instance between scientific knowledge and engineering postdate the middle of the nineteenth century (Mokyr, 2003). Much of the technological progress before 1850 (in the steam engines, textile, and wrought iron) came from practical know-how generated by engineers. There was little inference from empirical mental models in the form of laws of nature. Scientific contribution came mainly from empirical accidental generalizations. There was not much collaboration between scientists and engineers.

In the second industrial revolution, great macro-inventions such as the advances in organic chemistry were based on pivotal breakthroughs in the laws of nature, for example, the discovery of the structure of benzene molecule by the German chemist, August von Kekulè in 1865. Other inventions, like the steam engine or salicylic acid were generated by empirical generalizations and technical pragmatic schemes discovered by trial and error. The steam engine and the salicylic acid were originated mainly by engineers and professional chemists detached from the university. In any case even a macro-invention like the telegraph that was based on the discovery by Hans Oersted of electro-magnetism required many other micro inventions to become a concrete innovation, for example the technology for the transmission of the electric impulses. In the case of telegraphy or organic chemistry the micro inventions stemmed from the close collaboration between science and technology.

The first phase of the third industrial revolution is exemplified by such macro inventions as recombinant DNA and monoclonal antibodies, nuclear power, semiconductors and antibiotics based on important scientific discoveries. The collaboration between science and technology is intense. The centre of gravity of this collaboration is inside the university, with a supporting role of industry. However, government typically plays a role in encouraging, structuring and funding these discoveries. Even the micro-inventions that brought about the development of biotechnologies and information and communication technologies were generated mainly by university-industry relations. The reason why the centre of gravity is inside university is not only caused by the increased scientific density of the inventions, but also stems from change in academic functions from teaching and research to economic development.

This is even more imperative in the least developed world where universities seem to be stronger in terms of human resources than the other two institutional partners-government and industry. The entrepreneurial university makes science, technology and increasing innovation possible and readily accessible. Given that the technology base in Africa is narrow and most industries are basic, the triple helix model is flexible enough to accommodate other knowledge brokers such as those in the informal sector as exemplified by the development of the Internet in Zambia (Konde, 2004).

In the twentieth century there was a change of the process of innovation with the emergence of corporate, university, and government sponsored research and development (R&D), referred to by Mowery and Rosenberg (1998) as the “institutionalization of innovation”. Moreover there was the birth of a new type of scientist (the entrepreneurial scientist) who interfaced basic knowledge with the innovation agenda. Like the two faces of Janus, she was able to integrate two different and diverging perspectives the epistemological and the industrial one. It is plausible that in the future, we will see the reinforcement of the integration between different emerging generic technologies (second phase of the third industrial revolution). The acronym NBIC (Nano Bio Info Cognitive) of the new “converging technologies to improve human performances” introduced by National Science Foundation in 2002 in its technological foresight exemplifies the

phenomenon. Integration means more than collaboration between researchers in different fields and between university and industry. It also means the reinforcement of the global role of universities (from basic science to innovation and production), the development of less specialized universities with a wider disciplinary scope, and the birth of a new scientist who integrates knowledge and innovation, as in the entrepreneurial model (Viale and Etzkowitz, 2005).

The Emergence of Polyvalent Knowledge

In a science-based global economy, a flow of commercializable knowledge is the ultimate condition for long-term success. The emergence of polyvalent research fields with simultaneous theoretical, technological and commercial potential provides a substrate for the growth of science based clusters.[4] The recognition that knowledge is imbued with multiple attributes encouraged the multiple roles of academics and their involvement in biotechnology firms and of industrial researchers in academic pursuits.

Univalent knowledge follows a sequence from basic to applied research typically carried out in different time periods, at different sites, and by different people. The emergence of polyvalent knowledge called forth the concept of translational research (a less defined notion than applied research) and an activity that is closely associated with fundamental investigation and likely to be conducted in tandem. One hypothesis is that the presence of an entrepreneurial university, which generates new fields of research with theoretical and commercial potential, can make a significant difference to economic organization.

Polyvalent science was institutionalized in the U.S. during the post-war, along with funding agencies that offered diverse opportunities. Universities became involved in a closer relationship with government, whether the funds were provided by basic or applied funding agencies, by peer review or program officer initiative. When international

[4] In contrast to the division of knowledge into divergent epistemological spheres e.g. Pasteur, Edison and Bohr's Quadrants (Stokes, 1997); the polyvalency thesis holds for the unity of knowledge, with complementary aspects. Indeed, even the namesakes of these Quadrants spill over into others. For example, the "Edison effect" might well fit into Bohr's space. See also Viale and Etzkowitz, 2005.

competitiveness became an issue in the 1970's, government-funded science was expected to contribute to industrial renewal. Closer ties were forged between university and industry in order to overcome impediments to innovation.

As the triple helix evolves, institutions, organizations and roles are transformed. New tasks are often defined as conflicts of interest and obligation when viewed in relation to old. For example, when research was introduced as an academic task in the late 19th century, some said it diverted teacher's attention from students. A process of normative change takes place as controversies are resolved and new and old tasks are reinterpreted as complementary. Academic patenting is currently undergoing this transformation as professionalization of technology transfer creates an organizational search, marketing and business development capability.

As individual academics become involved, they perceive their findings in a new way, seeking out the practical as well as the theoretical implications of their work. Though the process is uneven, the persistence of pre-modern social structures may explain resistance to change in academia just as feudal relations impeded the transfer of modern technology to Southern Europe in the 19th century (Mazotti, 2004). Indeed, similarities in the social relations of feudal agricultural and academic systems may explain similar resistance to creation of formal mechanisms for inventions that could not be transferred through informal university-industry ties.

The transition from univalent to polyvalent knowledge also brings forth new issues and opportunities to be puzzled out (Beesley, 2003). The entrepreneurial university and the entrepreneurial scientist combine multiple purposes and sources of funding to support their research enterprises, helping to create the conditions for the emergence of polyvalent knowledge. A portfolio of overlapping basic research agency, industry supported, strategic research foundation, applied research agency and start-up firm supported projects is the underpinning of the contemporary academic research group.

At the macro-level, a diversity of potential sources of support is a pre-condition for the combination of resources at the micro-level. The insertion of a series of quasi-public research agencies in between the classic research councils and industry in Sweden, during the 1990's, exemplifies this transition. New organizational arrangements for collaborative research, formerly conducted at a distance, stem from the passage to polyvalent knowledge. The establishment of a research center, focused on an emergent field, integrating several research groups along with industry and government scientists is the next step to encompass the multiple tasks presented by polyvalent knowledge (Viale and Etzkowitz, 2005).

Since polyvalent knowledge is often produced in triple helix contexts such as the "incubator of centers", evolutionary models based on Schumpeter's idea of recombining elements in order to create new forms of economic organization may no longer be sufficient to engineer development and redevelopment in the least developed world. It is on this basis that we argue that there is the need to take the process of development and redevelopment further by looking at the polyvalent nature of knowledge. This demands that we turn particular attention to institutional sources outside of the economy, in particular the university, as a source of elements for recombination and innovation. Therefore, by bringing together academic, industry, and government researchers, we can develop broad-based theoretical knowledge with multiple utilities resulting in a dual transition of knowledge and organization (Etzkowitz, 2002).

Science and Technology Policy in Development and Redevelopment

Although technology has been a permanent feature in human progress since the period of hunting and gathering in bands, in a science-based knowledge economy, modern science and technology transformations have brought universities to the centre of innovation. While technological advancement is spurred by the competition and incentives of the global economy, the new tools of techno-science, based upon advanced knowledge, reinforce the need for development and redevelopment through university led innovation (Dzisah, 2003).

Many African countries face major obstacles expanding their economies beyond agricultural and mineral production, not only because they lack skills and institutions, but also because they have failed to integrate their universities into science and technology development and redevelopment policies. The result is that they are unable to take advantage of their universities as sources of recombination and innovation. As Richard Manning asserts, using the potential of biotechnology as a benchmark, one way to feed the increasing world population is to work with "third world scientists to feed their own people, while ensuring sensitivity to culture and environment that we missed in the first green revolution" (quoted in Machuka, 2001: 16).

For us, a triple helix of university-industry-government interactions is particularly crucial to developing organizational innovations that help reinvigorate a depressed regional economy. Bottom up initiatives led by universities are crucial for a science and culture-based development and redevelopment. This explains why in the United States, knowledge-based development represents a new initiative for state governments, beyond a relative few like Massachussetts that have been active for some decades. Virtually every state now has a S&T agency and at least one, and usually more than one, program that attempts to raise the level of S&T in the state and attract resources from elsewhere. A seemingly self-generating industrial sphere of high-tech business activity has its roots in academic and governmental initiatives (Etzkowitz and Dzisah, 2006).

Again looking at the US, it was not until 1980 that patent law emanating from constitutional authority was elaborated into an "indirect industrial policy", utilizing the universities as an intermediary between government and industry (Etzkowitz, 1994). In subsequent years, a variety of regional strategies have evolved to promote knowledge-based economic growth. The process is multilayered, with significant inputs from states and local governments, academia and industry. This arrangement not withstanding, the federal government for decades has emerged as the foremost sponsor of basic research and of applied research in specific areas such as agriculture, health and the military. The states have especially been active in the transformation of basic research into practical

and commercially viable applications (Feller, 1997; Geiger and Sá, 2005; Rees and Bradley, 1988).

In spite of this, a common perception is one of shortfall due to the increased competition for funds. As such, enhancing an academic focus at a local university with possible future relevance to local economic development is now viewed as similar to traditional physical infrastructure development. State governments view these intellectual capacity building efforts as akin to building highways and bridges to improve transportation and encourage business. In the past, state S&T efforts were typically funded through regular legislative appropriations, making them subject to cuts and even closure in an economic downturn. This is especially the case due to requirements that states, in contrast to the federal government, maintain a balanced budget. However, when the problem is framed in terms of science-based regional development, a research university becomes a necessity. This explains why the state of California recently passed through a ballot measure a $3 billion stem cell research initiative called 'proposition 71' to strengthen the biomedical research capacities of its universities (Etzkowitz and Dzisah, 2006)

In the African context, despite the diversity of local circumstances, university led development and redevelopment could overcome the problem of weak governments since the global orientation of higher education makes the university system more stable than political regimes. Government initiatives in the short term can be oriented toward providing economic incentives for science-based industrial development and the expansion of the resources of educational institutions to develop programs that will link scientific research to business development. In addition, given the limited human resource base, most of the relatively skilled personnel may be located in universities at the initial stages of the development of technologies rather than in industry (Konde, 2004).

Since African public universities have grown from about eight in 1960 to over one hundred in 2006, the time has come to increase their S&T, transfer and innovation efforts in order to further economic development and redevelopment. The formation of science-

based firms from university research should be the centerpiece of this strategy. As the development of the internet in Zambia has shown, even poor universities can adapt, innovate and commercialize advanced technologies to benefit their populations (Konde, 2004).

The Renewal of African Universities

African countries reeling under massive external debt turn to the Bretton Woods institutions for help. The World Bank and the International Monetary Fund (IMF) responded by asking that they undergo economic restructuring and reform under the Structural Adjustment Programme (SAP) policy framework. This reform affected most African universities whose budgets are entirely dependent on national governments. However, this period of retrenchment and decline in funding was followed by an unexpected renewal phase initiated by a half dozen African universities. University reforms included the admission of private fee-paying students, permission for faculty members to retain a share of incomes generated from private consulting income, and the introduction of night classes and private universities (InterAcademy Council, 2004).

But these reforms did not just happen but were part and parcel of larger economic, political and social reforms. For example at Makerere University in Uganda, the Innovation at Makerere program reorganizes its academic programs to contribute directly and immediately to national development within the framework of the government's decentralization process. It aims to train cohorts of public servants in health, agriculture and administration, to staff district offices. It is achieving this through major changes in curriculum and through 'sandwich training' programs whereby students undertake fieldwork in the districts throughout their academic training (InterAcademy Council, 2004).

In response to these internal transformations, many donors have rediscovered universities. It must be stated, however, that even with this new vision, which sought to explicate the role of African universities in economic development and redevelopment, the overriding interest of donors such as the World Bank was not totally removed from

economic growth and productivity. The emphasis changes though from investment in basic education to universities in order to achieve the goal of human capital development. However, the recognition of the role of universities as a source element for development and redevelopment culminated in a refocusing of higher education policies and strategies based on the concept of the knowledge society (see Constructing Knowledge Societies: New Challenges for Tertiary Education, World Bank, 2002).

In addition, a new USAID global initiative was also introduced to increase the number of scholarships for postgraduate study in the United States and capacity-building grants to retrain university faculties especially those in Agriculture. Four U.S. foundations have played a critical role in supporting the renewal phase of African higher education. In 2000, the Rockefeller, Ford, Carnegie, and MacArthur Foundations launched The Partnership for Higher Education in Africa. With a 10-year time frame, the foundations have committed US$100 million over the first five years to support universities pursuing reforms in Ghana, Mozambique, Nigeria, South Africa, Tanzania and Uganda. During the first two years (2000-2001), the four foundations together contributed US$62 million to higher education in the above six African countries (InterAcademy Council, 2004).

Information and Communication Technologies and African Universities

The World Bank financed establishment of the African Virtual University (AVU) in 1997 to provide quality higher education in science and engineering. The AVU has offered courses but does not yet offer full degree programs. The Institute for Food Laws and Regulations at Michigan State University has created six distance education courses on food laws and regulations (InterAcademy Council, 2004).

Another recent ICT application is the use of teleconference in providing lectures and seminars. Now African students can listen, and indeed interact with, global leaders in their fields while remaining in their home settings. Cornell University professors now provide lectures on cutting-edge topics in breeding and biotechnology to students participating in a regional Ph.D. program offered by the University of Natal, with support from the Rockefeller Foundation. There is scope to enlist more support from private

sector ICT companies in these areas of initiatives (InterAcademy Council, 2004). There is in motion a process of the renewal of the African university. African universities have desire as well as the potential to lead Africa's development and redevelopment if the appropriate triple helix relations are created.

Towards a Triple Helix Development Model

Traditional development models are dualistic in nature and are either exogenous or endogenous. Such models envisioned the process of socio-economic growth promotion and regeneration to be wedged in a circular flow. In these accounts, development and redevelopment is seen as consisting of series of historical stages where each particular stage is based on preceding ones. In their original formulations, and as has been replicated in the least developed world, the key actors have been central governments. The current inclination is to promote the private sector as the engine of growth. While this is laudable, it still omits the most critical agent in development and redevelopment--a university that is willing and able to be entrepreneurial by adopting economic development functions in addition to teaching and research (Etzkowitz, 2005).

As such, our thesis is that the traditional stages and evolutionary models of development may no longer be relevant in engineering economic growth and innovation in an increasingly knowledge-based society. For us these models are based on an increasingly superceded industrial era where socio-economic growth was premised on the abundance of arable land and the availability of a large pool of labour. If African countries continue in this vein, they may be left behind again. In a science-based knowledge society, these staged and evolutionary models do not go far enough.

Schumpeter (1934 and 1954) attempts to create new forms of economic organization by employing existing resources in different ways. According to him, the overall development of the economy is derived from emergent processes that arise from the developments of its constituent sectors. Central to this formulation is the fact that these developments are endowed with their own laws and principles. As a result, the development of the economy as a whole is a phenomenon emerging on the basis of the

interaction among its constitutive sectors (Becker and Knudsen, 2002). Schumpeter (1934 and 1954) anchors his model of endogenous economic development around a major actor-the entrepreneur. He uses this to explain his idea that changes in the social structure emerges from the actions and social interactions of the individual entrepreneurs living in distinct and yet interacting sectors of social life (Becker and Knudsen, 2002). While the Schumpeterian entrepreneur is the driving force in industrial society, we propose an entrepreneurial university led development model, in cooperation with other institutional spheres, in an increasingly knowledge-based society.

The triple helix development model is derived from Boston regional organizing experience in the 1930's and 1940s and comprises three basic elements: First, a more prominent role for the university in innovation. Second, a movement toward collaborative relationships among the three major institutional spheres in which innovation policy is increasingly an outcome of interaction among university-industry-government. Thirdly, in addition to fulfilling their traditional functions, each institutional sphere it also 'takes the role of the other' (Etzkowitz, 2005).

In a knowledge-based society, a triple helix development model in the current situation, may lead the way in assisting least developed countries to leap frog stages of industrialization that are now disappearing in their countries of origin. Critics have argued that that the university systems are academically oriented and industries are either non-existent or too weak and governments too bureaucratic to play respective roles envisaged by the triple helix model. However, as Konde (2004) has revealed, the problem does not lie with the model, but the fact that in Africa, these triple helix entities seem to be weak because their elements tend to work in isolation. The development of the internet in Zambia demonstrated that when these entities work together; they represent a significant force for change, similar to those found elsewhere.

Each institutional sphere maintains its core identify as it interacts intensively with the others. While the triple helix institutions at their nodes are active and recursively selective according to their own specific functions and institutional constraints, the

network system of university-industry-government relations provides the transaction spaces needed by these development actors to translate policies into goals. As such, a triple helix development model cannot be reified into a neo-corporatist arrangement because of its implied emphasis on the dynamics of change and the appreciation of differences in opinion, position, and interests of their partners (Etzkowitz and Leydesdorff, 2001).

A triple helix development model is based on the following trends:

(1) The transition from an industrial society to a knowledge-based society in which knowledge producing institutions, like universities, potentially play a greater role in innovation and development

(2) The transition from large scale physical technologies that mandate bureaucratic forms of organization to increasingly flexible smaller scale high technologies that can be utilized by smaller scale organizations

(3) the emergence of polyvalent knowledge, in such areas as biotechnology, computer science and nanotechnology, that is at one and the same time theoretical and practical; patentable and publishable

(4) the rise of an entrepreneurial university model that incorporates classic ivory tower and Humboldtian elements with a culture of entrepreneurship, innovation and technology transfer.

The Endless Transition

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 bilateral to trilateral interactions from single and double helixes to university-industry-government joint projects. For instance, in Ethiopia this involves the upgrading of traditional industrial clusters by connecting them to foci of government funded research located at universities and research institutes. This is aimed at making them more

entrepreneurial. Other regions have also responded to these changes with similar but different approaches. Examples include the land grant universities in the US, the research schools program in Sweden and the incubator movement in Brazil. It is clear that whether one starts from a statist or a laissez faire regime, 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. (Viale and Etzkowitz, 2005).

Nevertheless, practical knowledge continues to arise from the context of discovery in the "meandering stream of basic research" just as theoretical knowledge appears in the context of application. In countries where the government has previously dominated the other institutional spheres, there is a need for differentiation of institutions and the establishment of clear boundaries among the institutional spheres so that they can begin to interact from a position of independence and relative equality. 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.

The triple helix transition followed from the emergence of government-industry relations, (a bi-institutional model of society) that constituted the great transformation of the 19th century (Polanyi, 1957). The Speenhamland law in England placed limits on exchange relationships in wage labor, guaranteeing workers a living wage. On one hand, the market became the organizing principle of social relations. On the other hand, the government moderated exchange relationships to guarantee a living wage. Government-industry relations thus created a compromise that ensured 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 (Durkheim, [1893] 1997).

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 different starting point of relationships among institutional spheres, a secular trend toward a common triple helix can be identified. An open civil society paves the way for triple helix actors to organize and overcome blockages to the transformation of knowledge into innovation. The university will become ever more central to the innovation process and it will supersede many functions of the industrial enterprise. This transition reinforces the global role of universities; it brings with it the development of less specialized universities with a wider inter-disciplinary scope, and the birth of a new scientist who integrates knowledge and innovation.

The first and second academic revolutions introduced research and then economic and social development as academic missions. These revolutions fundamentally changed the nature of the university from its medieval foundation focused solely on the conservation and reproduction of knowledge (Rashdall, 1896). The third academic revolution integrates forward and reverse linear models in a programmatic and regulatory framework, synthesizing knowledge, organization and institutions: the endogenous, exogenous and mesogenous drivers of innovation. The university thus becomes an increasingly important platform for societal transformation (Viale and Etzkowitz, 2005).

Conclusion: The Renewal of the African University

The notion that African development and redevelopment has to follow traditional staged development models by replicating the development experience of the industrialized countries has affected the ability of African universities to take up the challenge of encompassing an economic development function into the mission of universities. We propose a triple helix development model that moves away from staged to a spiral model of education because a continuous flow of science to the economy can occur more effectively under a triple helix of university-industry-government relations. This model takes the Schumpeterian endogenous development model further by looking to

institutional sources outside of the economy, in particular the university, as a driver of innovation.

For us, a triple helix of university-industry-government interactions is especially crucial to developing organizational innovations that help reinvigorate a depressed regional economy. The formation of science-based firms from university research should be the centerpiece of this economic development and redevelopment strategy. This stems from our observation that traditional development models do not take into account the unique role of universities in generating innovations. A triple helix development model based on a spiral process that is university led, in cooperation with other institutional spheres is necessary to leap-frog trajectories of industrialization that are now disappearing in their countries of origin. The triple helix model provides a flexible framework for the transition of the African university from educating post-colonial elite to playing a more direct role in development, pointing the way for least developed countries to make the transition to a knowledge-based society.

Rather than development and redevelopment being the sole responsibility of central governments, a meta-innovation system is emerging from bottom up, top down and lateral initiatives in which science, technology and innovation policy is the outcome of the interaction among university, industry and government. A triple helix of university-industry-government relations is emerging as a common format that transcends national boundaries. The first and second academic revolutions have brought research, economic and social development together with education as academic missions. The integration of these functions is changing the nature of the university and its role in society. The potential for regional development in Africa, and elsewhere, resides in entrepreneurial universities taking the lead in infusing knowledge, innovation, technology and enterprise into the entire society.

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