Article

The Role of the University in the Innovation Ecosystem, and Implications for Science Cities and Science Parks: A Human Resource Development Approach

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Abstract

In the 21st Century, scientific discovery and technological development are fueled by unprecedented changes in knowledge, societal needs and wants, engineering designs, materials, and instrumentation. Such rapid global changes pose major opportunities and challenges for the innovation ecosystem—especially in developing countries. In particular, our models for human resource development and engagement must evolve so as to better prepare leaders in higher education institutions, research institutes, science cities and science parks, businesses and industries, and governments. Universities throughout the world must play a greater role in both the research and practice of human resource development and engagement for the knowledge-based and creative economies. This paper explores the current and potential talent development and talent engagement dimensions of universities in economic development, and research and practice in education and policy—with implications of such dimensions for science cities/science parks. The paper highlights the importance of a greater role for universities, in collaborating with business/industry and governments, in examining new economics-sensitive and values-sensitive models for education and human resource development so as to better understand and support innovation in global contexts.

Keywords: Innovation Ecosystem, Global Science and Technology Talent, Entrepreneurship, Human Resource Development, Science Cities, Science Parks, University

1. INTRODUCTION

The rapid expansion of scientific and technological developments makes it imperative to develop leaders that are prepared to support the development and evolution of complex socio-technological systems. Human Resource Development and Management are paramount to the global performance and management of any organization. Human Resource Development involves a "process of observation, planning, action and review to manage the cognitive capacities, capabilities and behaviours needed to enable and improve individual, team and organizational performance in work organizations" (Gibb 2006, p.1/3). This observational process, including a strong education dimension, is particularly important for the advancement of scientific discoveries and technological innovations. Furthermore, the process is tied to purpose-driven efforts to use scientific discoveries and technological innovations to address critical global issues. The scientific community understands that human resource development and university collaborations are important to address issues of primary concern in the global economy. Global dimensions of risks and their associated drivers have brought about a plethora of interest in human facets that were not traditionally explored by most. For example, there is a growing interest by governments and their different branches to understand demographic shifts and population growth. For example, in the 2010 Census of the United States the ethnic category "Hispanic" became the point of reference by which other ethnic

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or racial categories are described. It is understood that the Hispanic population has grown faster than any other population and it is estimated that they will be the largest population by the year of 2050. Understanding these trends is very relevant for research related to housing and general population profiles (U.S. Department of Commerce 2010).

The Innovation Ecosystem has set the platform for the surge of disruptive innovations. These have brought about many entrepreneurs who find it easier and easier to develop their ideas. We have seen a surge of start-ups all over the globe. Another facet of humanity that had been long understudied is becoming increasingly important in research and less formal forms of understanding. This facet is happiness. Understanding, assessing, and classifying "happiness" is tightly intertwined with understanding, assessing, and determining dimensions of global risk, security, and well-being. Researchers are gaining a better understanding of the relationships of "social capital" and well-being. Evidence points to two possible ways in which social capital increases people's well-being: intrinsically and instrumentally. The latter speaks to humans' needs for love, friendship, and community; the former speaks of how social capital contributes to the improvement of the overall social and economic performances of societies by facilitating economic cooperation, seamless business deals, and social security, to name just a few (Helliwell et al. 2012). These emerging efforts highlight and establish the importance of exploring the relationships between individuals, their societal notions of happiness, and how we measure them (e.g., GDP, Innovation indices, individual perceptions, etc.). We propose that it is important to recognize that this global context of risks, actions, trends, and happiness provides unprecedented opportunities and challenges for the innovation ecosystem. In particular, the global context challenges our assumptions and legacy systems as they relate to education, human resource development, and human roles in economic development and innovation. We highlight enhanced roles for the University, in collaboration with business, industry, and government, in global talent definition and recognition—as well as the University's role in talent development and engagement in a variety of economics-sensitive and values-sensitive contexts. Throughout this paper, we take a human talent or human resource approach, with special emphasis on the role of the University as a pivotal actor in the innovation ecosystem. We conceptualize the innovation ecosystem after the framework of (Jackson 2015). Summarizing the author's definition, an innovation ecosystem models the economic dynamics of complex relationships that emerge from the interaction of actors

or entities that allow the development and innovation of science and[1] technology. We frame the role of the University in the innovation ecosystem as an actor containing various resources that facilitate the inclusion of material resources (laboratories, lecture halls, economic capital, science parks and national labs connections) and human capital (researchers, professors, students, staff) with the potential to become catalysis for innovation ecosystems. In this context, as described by (Jackson 2015), the University comprises two intertwined but fundamentally differentiated economies: the knowledge economy, that has as its bedrock fundamental research, which is fueled by the University's human capital, and the commercial economy, which is driven by technological innovations, professionals' formation, and degree values.

2. PURPOSE, AIMS AND EXPECTATIONS

The purpose of this work is to contextualize how the innovation ecosystem affects global economies and to shed light into why scientific and technological innovations take place. We bring to the readers' attention how looking at local, national, and international risks, challenges, and breakthroughs in Scientific, Engineering, and Technological Innovations (SETI) may help us to re-evaluate or re-think the forces that drive us in the development of SETI. Particularly, we want the reader to question how our legacy systems—as they relate to education and human resource development—might impact economic development and innovation. In section 3 we examine some key elements of innovation systems with the aim of clarifying the role of leaders and engaged personnel at all levels. In section 4 we explore "leadership and economic development with a particular interest on the role of the University in the development and continuation of education of leaders in the innovation ecosystem. In section 5 we explore current and evolving roles for universities in developing and supporting new models for education, both inside and outside of the Academy. In section 6 we raise issues regarding global human resource development and explore the implications of these new models for science cities and science parks. In particular, we posit that "deep culturally sensitive innovation" is largely an untapped global resource for economic and social goods. In section 7 we examine some of the challenges and opportunities for developing countries in the innovation ecosystem. In section 8 we explore global

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[1] Added emphasis.

issues in technology, policy and innovation. Finally, we propose that the preceding sections provide the context for a unique opportunity for purpose-driven, values-sensitive innovation that could have significant economic and social implications for the future of innovation in developed and developing countries.

3. INNOVATION SYSTEMS & DRIVERS

There is an intense and growing global interest in innovation. Everywhere from organizations, to cities, to nations, comparisons are made about principles, environments, and outcomes of practices that are aimed at enhancing innovation. The human dimension in innovation is getting greater attention as nations both collaborate and compete in the global search for scientific, technological, and other talents. The Global Innovation Index 2014 subtitled "The Human Factor in Innovation" provides several good examples of the global emphasis on the human dimensions of SETI. In the chapter on "The Human Factor in Innovation", Martin Schaaper of the UNESCO Institute for Statistics' division of Science, Technology and Innovation Unit makes several points, of which we highlight the following:

- The more developed the region, the higher the percentage of the population that has completed tertiary[2] education.
- More and more students are enrolling in tertiary education
- On tertiary enrollment, again the richer regions are far ahead of the poorer regions, especially Sub-Saharan Africa.
- The regions with the highest number of people with tertiary education and with the highest enrollment ratios in higher education are also those with the most researchers as a proportion of the total population.
- Economies that are catching up are more dependent on technology transfer than they are on original R&D.
- R&D is generally unprofitable in countries with low levels of human capital.
- A very relevant factor for innovation is the movement of highly skilled people, whether they are students or experienced professionals.
- Economies at the lowest levels of development may be trapped in a vicious circle: low economic development

does not offer a context that provides enough incentives for young people to pursue higher education, and without a skilled population, economies will not grow.
- More information is needed about the demand for skills by employers and the supply of these skills by highly educated people.

In addition to the Global Innovation Index, 2014, there are numerous reports, including the following, that address human dimensions in enhancing national, geopolitical regions, and other areas: The Competitiveness and Innovative Capacity of the United States (U.S. Department of Commerce & National Economic Council 2012), Insights from International Benchmarking of the UK Science and Innovation System (Alas 2014), An International Comparison of Models of Innovation and Their Implications for New Zealand (Rinne 2011), Models for International Innovation Policy: Transnational Channels and Regional Platforms (Raunio et al. 2013), OECD Economic Surveys Korea (OECD 2014), Innovation Union Scoreboard (Hollanders and Es-Sadki 2013), National Innovation Systems Overview and Country Cases (Feinson 2003), Managing Open Innovation in Large Firms (Chesbrough & Brunswicker 2013), Creative Economy Report (UNDP and UNESCO 2013), and Creative Industries Economic Estimates (Department for Culture, Media and Sport 2014).

Many of the global issues of the 21st Century are inextricably intertwined with scientific discoveries and technological changes. These global issues include global risks, actions, and trends. The World Economic Forum's report Ten Global Risks of Highest Concern in 2014 provides a clear perspective of top issues to be aware of:

1) Fiscal crises in key economies
2) Structurally high unemployment/underemployment
3) Water crises
4) Severe income disparity
5) Failure of climate change mitigation and adaptation
6) Greater incidence of extreme weather events (e.g. floods, storms, fires)
7) Global governance failure
8) Food crises
9) Failure of a major financial mechanism/institution
10) Profound political and social instability (World Economic Forum 2014).

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[2] Tertiary colleges are those that offer both academic and occupational degree programs. Tertiary Institutes offer only occupational programs. They differ from Universities in various ways. On the positive side, they offer greater flexibility, access, equity, and an approach to research and public service different from the traditional University (Grubb 2003).

Each of these risks is well known across the globe. The year of 2008, for example, a financial crisis arose and while not necessarily immediately, it was felt in almost every single nation in the world. As a result of this crisis unemployment rates skyrocketed and postsecondary institutions saw rapid increases in enrollment rates. In some countries, after some years this translated into a large pool of highly qualified but unemployed individuals. Water crisis is another common risk in developing and some developed nations. The state of California is a good example of this risk. On 6 April 2015, Governor Jerry Brown announced the State's first ever mandatory water restriction as a policy to battle the State's worst drought that had to date extended for four years. Other western states such as Oregon and Washington also face water deficits (Dimick 2015). In light of these global risks, a number of global action initiatives have been implemented with the aim to respond and ultimately remediate a variety of global issues. The following initiatives are pertinent to this work: the Clinton Global Initiative, the World Economic Forum and the Global Action Platform: Food + Health + Prosperity. The Tracking Global Trends Report identifies six global trends and three underlying drivers that have helped to establish each trend and perpetuate it. The six trends or long-term developments are:

1) Emerging markets increase their global power
2) Clean technology becomes a competitive advantage
3) Global banking seeks recovery through transformation
4) Governments enhance ties with the private sector
5) Rapid technology innovation creates a smart, mobile world
6) Demographic shifts transform the global workforce (EYGM Limited 2012)

Below are the three underlying drivers that helped to establish and perpetuate the six trends or long-term developments:

1. Demographic shifts. Population growth, increased urbanization, a widening divide between countries with youthful and quickly aging populations and a rapidly growing middle class are reshaping not only the business world, but also society as a whole.

2. Reshaped global power structure. As the world recovers from the worst recession in decades, the rise of relationships between the public and private sectors has shifted the balance of global power faster than most could have imagined just a few years ago.

3. Disruptive innovation. Innovations in technology con-

tinue to have massive effects on business and society. We're now seeing emerging markets become hotbeds of innovation, especially in efforts to reach the growing middle class and low-income consumers around the globe (EYGM Limited 2012).

The branch of human resources, particularly human resource development and management, needs to initiate, promote, and support innovation in organizations, nations, and global collaborations are immense and particularly acute in developing countries. Challenges abound in both developed and developing countries. We have identified the following obstacles as presenting challenging situations that hinder the development of stable and sustainable innovation ecosystems:

• Legacy education principles and practices in schools, colleges/universities, business/industry and government that are far out-of-step with the knowledge dynamism characteristic of the current fervor in scientific discovery and technological change,
• Inadequate attention to purpose-drive, values-driven, context-sensitive (including economic and cultural sensitivity), and novel-path approaches to enhancing innovation, especially as it relates to innovation and economic development in developing countries,
• Inadequate attention to creative economies, especially as they relate to rethinking direction and values in all economies, and as they relate to economic value in developing countries,
• Inadequate leadership development (business/industry, academic institutions, and government) for the innovation ecosystem,
• Inadequate conceptualization of holistic engineering and its potential implications for global development (Sandler 2012). (What are the assumptions that underlie engineering design? What might we mean by global engineering design? Under what conditions are tools and instruments expected to perform, and for how long without repair?)
• Inadequate attention to understanding and reformulating the notion of "human capital" that can allow us to achieve a more robust concept that accommodates re-conceived notions of productivity and well-being.

Universities, in collaboration with business, industry, and government, should help to lead the ongoing rethinking, re-shaping, and re-definition of human talent and human resource development.

4. LEADERSHIP AND SCIENCE-TECHNOLO-GY-BASED ECONOMIC DEVELOPMENT: ROLE OF THE UNIVERSITY

The Triple Helix model of University-Industry-Government interactions has helped to establish a conceptual framework for viewing science/technology-based economic development. This Triple Helix model was developed in the 1990s by Etzkowitz (1993) and Etzkowitz and Leydesdorff (1995), including some elements developed by Lowe (1982) and Sabato and Mackenzie (1982). The ongoing work on the Triple Helix has evolved into what Ranga and Etzkowitz call the "Triple Helix Systems" (Ranga and Etzkowitz 2013). The authors define "Triple Helix systems according to the systems theory (Carlsson and Stankiewicz 1991; Carlsson et al. 2002; Edquist 2005; Bergek et al. 2005) "as a set of (i) components (the institutional spheres of University, Industry and Government, with a wide array of actors; (ii) relationships between components (collaboration and conflict moderation, collaborative leadership, substitution and networking); and (iii) functions, described as processes taking place in what we label the 'Knowledge, Innovation and Consensus Spaces'" (Ranga and Etzkowitz 2013).

Figures 1 and 2 below represent the multiple views of Triple Helix (taken from Ranga and Etzkowitz 2013).

The Triple Helix Model illustrates the importance of relationships in advancing the aims of innovation. There is an emerging body of knowledge that points to the roles of different types of human resource dimensions that include the role of leadership in advancing or suppressing innovation (Etzkowitz 2013; Ranga and Etzkowitz 2013; Etzkowitz and Ranga 2010; Munshi et al. 2005). While there still exists a tremendous need for additional research on the human resource dimension of the innovation ecosystem, we identify two ways in which universities are strengthening and expanding their roles in the Triple Helix Model. First, universities are becoming more engaged partners with industry and government for the purpose of hastening the pace from research into commercialization. This move is gradually demanding a new type of leadership in all sectors of the Triple Helix. Stony Brook University, for example, inaugurated in July 2nd, 2015 its state-
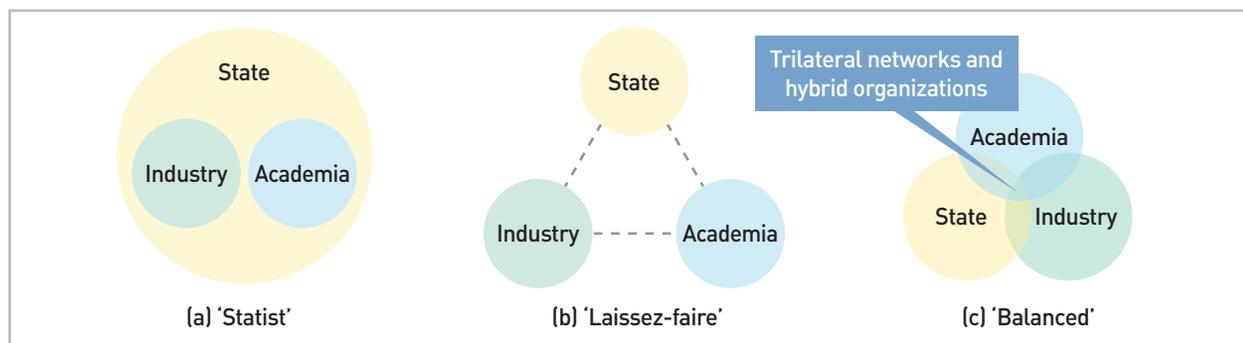

Fig. 1. Triple Helix configurations
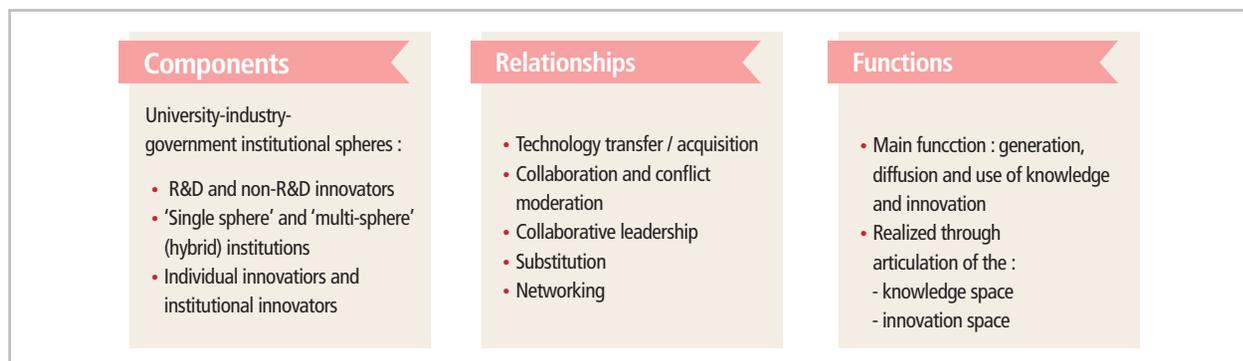source: Etzkowitz and Leydesdorff (2000)

Fig. 2. A synthetic representation of Triple Helix system
source: Etzkowitz and Leydesdorff (2000)

of-the-art, 70,000-square-foot new Computer Science Building. In relation to the new infrastructure and its many state of the art facilities, Senator LaValle said that besides helping students, researchers and staff, the new building "will also help fill our workforce needs, as we continue to attract new high paying technology jobs to our region and further establish Long Island as a magnet for innovation" (Almonte 2015). With the establishment of "five innovative research centers which include National Security Institute, Center for Dynamic Data Analytics, Center for Mobile Computing, Center for Smart Energy and Center for Visual Computing" (Almonte 2015), Stony Brook University sets the tone to work with industry and government in making Long Island, New York State, and the Nation a safer, stronger, and more collaborative enterprise. Second, universities are adopting an expanded view of education (within and beyond universities) that encompasses basic and translational research within the collaborative context that includes industry and government on educating people for dynamic 21st Century roles in science or technology based development. This is exemplified by the growing number of study abroad programs across most universities of the United States of America and the rest of the world. For example, through the Study Abroad & Exchange program at Stony Brook University, students can spend a winter break, a summer, a semester, a full academic year, or more studying at universities outside of the United States. This program presents Stony Brook University students the opportunity to study abroad on five continents. Highlighted nations are: China, France, Greece, Ecuador, Japan, Korea, Germany, Spain, Argentina, and Tanzania (Stony Brook University 2015). Europe has the Lifelong Learning Programme (LLP), previously known as the European Community Action Scheme for the Mobility of University Students (ERASMUS) programme. The LLP "was designed to enable people, at any stage of their life, to take part in stimulating learning experiences, as well as developing education and training across Europe". This programme allows European students to complete part of their Master level studies and Master thesis in other countries (European Commission 2014). University programs of these types speak to the University's understanding that the ways in which we have been defining knowledge and skills acquisition are increasingly changing from static into dynamic. Another aspect of the role of the University is seen in the commercialization of the University's knowledge economy as well as the different directions in which education is undertaken these days. These University roles are intertwined and reflected either together or individually in a variety of work (Link and Scott 2002; U.S. Department of Commerce and National Economic Council 2012; Etzkowitz and Rickne 2006; Bonas et al. 2007; Nauwelaers et al. 2014; Vásquez Urriago et al. 2010).

5. EDUCATION AND WORK FOR THE INNOVATION ECOSYSTEM, AND EDUCATION AND WORK FOR LIFE

The 21st Century has brought about tremendous change to humanity. The early 2000s saw the boom of the World Wide Web. There on, the rapid expansion of technological innovation has made technology available to more people. Education access has broadened dramatically thanks to the internet. Research has brought about cures and treatment to otherwise deadly diseases. However, our world now more than ever faces unprecedented challenges and opportunities in making the world a better place for all. To highlight some of these challenges, we introduced "Ten Global Risks of Highest Concern in 2014" as stated by the World Economic Forum (World Economic Forum 2014). In addition to the challenges and opportunities that surround these risks, there are new opportunities and challenges related to efforts to better understand, assess, and grow "happiness" (Helliwell et al. 2015). These challenges and opportunities demand a reconceptualization of education (formal, informal, and non-formal) raising fundamental questions regarding the aims, processes and contexts of education. Given the nature of the 21st century workforce, there has been considerable interest in non-formal learning (Werquin 2010; Singh 2005; Bamber 2012), but such work is at an early stage.

Our theories and practices of education, whether inside or outside of educational institutions, have not kept pace with the 21st Century, which is characterized by multi, intra, and inter disciplinary issues and global problems, highly dynamic knowledge systems, and technology-intensive environments. Many articles and reports point to a new reconceptualization of approaches to education (Dede 2007; Dede 2009; OECD 2008; Ware and Granthanm 2009; Pea 2014; UNESCO 2015). In addition, research directions propose better ways to integrate the consideration of values into technical education (Sandler 2012). One of the driving forces calling for a rethinking of education is the current fervor for global talent for sustainable innovation. Numerous reports address the issue of

workforce education and its implications for global innovations (Toner 2011; Oxford Economics 2012; Lewin et al. 2008; Aguirre et al. 2009; Stephan et al. 2014; Burke and Glennon 2012; Economist Intelligence Unit 2011). The current and growing demands for Global talent raise fundamental issues and questions about ways in which a diversity of talent, often geographically dispersed, can best be productive in meeting work challenges, especially those related to innovation (Freeman et al. 2014; Stahl et al. 2012; Hinds and Bailey 2003; Sobel Lojeski et al.2006).

6. HUMAN RESOURCE DEVELOPMENT FOR DYNAMIC, GLOBAL, AND KNOWLEDGE-INTENSIVE WORK

There have been major efforts to better understand the relationships between workforce skills and innovation (Toner 2011; Oxford Economics 2012; Burke and Glennon 2012; Aguirre et al. 2009; Stephan et al. 2014). Toner (2011) summarizes the findings from an overview of major themes in the literature that investigates the relationships between workforce skills and innovation:

The paper identifies a number of major findings in the literature. First, the predominant form of innovation in firms is incremental, and this points to the central role of the broader workforce in the generation, adaptation and diffusion of technical and organizational change. Second, achieving high academic standards within a country for the largest proportion of school students not only supports high participation in post school education and training but creates a workforce with greater potential to engage productively with innovation. Third, the extent to which a firm's workforce actively engages in innovation is strongly determined by particular work organization practices. Finally, there are large differences across advanced nations in workforce skill formation systems, especially for vocational skills. Such differences result in large disparities across nations in the share of their workforce with formal vocational qualifications, and in the level of these qualifications. The resulting differences in the quantity and quality of workforce skills are a major factor in determining the observed patterns of innovation and key aspects of economic performance.

The literature suggests that technical and organizational change cannot remain static in order for innovation to take place, as innovation appears predominantly in incremental form. It seems that achieving high academic standards points to the greater overall development of nations, particularly for their capacity to forge innovation. The literature suggests that nations with the greatest assets have a competitive advantage in the highly-skilled labor force market. Countries who are able to develop, import, and retain the highest assets of economic knowledge seem to place themselves at the forefront of innovation and this in turns boots their economic potential.

The global demands for new talent in science and technology challenge both our conceptualization of human capital and our models and practices of human resource development.3 Hence, decades-old discussions of human, cultural, and social capital (Bourdieu 1986; Coleman 1988) remain relevant to ongoing discussions concerned with technological innovation. We find ourselves in the midst of new discussions about models of human resource development. This reality calls for the development of new paradigms to re-conceptualize and better understand the current and emerging needs of human resource development. In spite of the lag in response of human resource development to human resource demand in the innovation ecosystem, there are indications that new models for developing and growing human talent are emerging (Thor 2009; Zheng et al. 2009; Bhagat et al. 2014; Dobbs et al. 2014).

The challenges and opportunities for human resource development in the innovation-driven global economies and socio-technological contexts are immense. These challenges demand a revival of our consideration of effective management and policy (Stahl et al. 2012; Van de Ven 1986; Atkinson 2014). Because of their foundational aim of validating and producing knowledge and their vital role in expanding societies' human capital, universities should play a key role in helping to re-think the aims, processes, and contexts of innovation management and policies in all of its dimensions. With their plethora of human capital and its two intertwined but fundamentally differentiated economies, universities, science parks, and science cities have the potential to become the bedrock supporting the sustainable development of the human resource capital demanded by the new knowledge paradigms, of which the innovation ecosystem seems to be a vital one.

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3 For a history of human resource development, with comments on the evolving nature of work, see (Torraco 2002).

7. DEVELOPING COUNTRIES: CHALLENGES, OPPORTUNITIES AND GLOBAL ENGAGEMENT

Developing countries provide immensely diverse contexts for informing both theory and practice in the innovation ecosystem. There is a growing body of work that seeks to interpret innovation in the context of development. The Innovation for Development report (OECD 2012) identifies six major topics for work on "innovation for development":

1) The contribution of innovation to economic growth and well-being
2) The impact of globalization on development and innovation
3) Inclusive innovation
4) Education, skills and human capital
5) ICTs for development
6) Institutional frameworks for innovation policy (OECD 2012).

Other reports address various dimensions of innovation and development. Kapur and Crowley (2008) identify several new challenges to higher education such as Changing Role of the State, Equity and Access, and Accreditation and Regulation. Other reports (Pilegaard Hansen et al. 2011; Friedenthal 2014; Cloete et al. 2011; Altbach 2007) address other dimensions of the University's role in development. In addition, some reports address the economic and policy aspects of innovation for development (United Nations 2014; Arocena and Sutz 2002; Sweden's Department for Development Policy 2010).

Developing countries are important venues for the reconceptualization of innovation. Such countries have the potential to get the world to confront fundamental questions about the purpose, as well as social dimensions of, engineering and technological design and applications (Sandler 2012), the use of materials, success criteria for instrumentation that must function in diverse global contexts, and characteristics of human talent for development-oriented innovation. The diverse economic, social, and political contexts of many developing countries pose questions about both the nature of talent needed and our models for a sustainable workforce, a workforce that might very well be highly distributed over the globe. The challenges and opportunities, together with a global engagement that challenges purpose and values in the innovation ecosystem, may provide contexts for re-thinking our theories and practices about innovation throughout the world. Perhaps, such re-thinking may offer insights into the emerging interest in the Creative Economy.

8. TECHNOLOGY, POLICY AND INNOVATION

Effective policies are essential to the promotion of purpose-driven, values-sensitive technological innovation. Yet, policy analysis and policy making are complex activities; they are complex even in the context of local or regional decision making. Policy making is often times bonded tightly to specific goals and values that are relevant to the policy consumers. Deborah Stone explains some of the intricacies of policy making:

Part II is about goals—not the specific goals of particular policy issues such as expanding health insurance coverage or lowering health care costs, but the enduring values of community life that give rise to controversy over particular policies: equity, efficiency, welfare (in the sense of well-being, not government aid), liberty, and security. These values are the standards of analysis most commonly invoked in policy debates. They are also 'motherhood issues': everyone is for them when they are stated abstractly, but the fight begins as soon as we ask what people mean by them. These values not only express goals but also serve as the standards we use to evaluate existing situations and policy proposals (Stone 2012, p.14).

Stone points out that the goal and value of policy making often are the driving forces defining policy implementation. An important aspect of her argument is that the end result of abstract policy making has to be carefully thought-out, imagined and potentially simulated to ensure that the initial policy making is mirrored in the policy implantation stage; she highlights that this aspect of policy making may not be as appealing to policy supporters for ensuring a sound policy making process is paramount so that policy making can closely mirror policy implementation. For these and other reasons, the global innovation ecosystem demands careful policy considerations on many fronts. First, there are fundamental issues as to what technologies ought to be developed and for whom are such technologies intended (Manyika et al. 2013; Manyika et al. 2011; Bilbao-Osorio et al. 2014). Second, there are the engineering and technology education issues that may inform the entire engineering enterprise, including accreditation issues, and education policy making. Finally, there are approaches, methods, and tools that are developed with the aim of guiding the total space of policy analyses and policy making (Stone 2012; Marburger III 2011).

Universities can play major roles in the policy arena, as both engines for research on technology and policy (Morgan 2010) and facilitators for policy discussions or debates. There are major programs that are trying to put forward these kinds of

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integrative efforts. More concretely, in regard to research programs in technology and policy, there are several global programs, including the following, that seek to integrate aspects of technology and policy in a holistic way: Technology and Policy Program at MIT, Department of Management Science and Engineering at Stanford University, Department of Engineering and Public Policy at Carnegie Mellon University, the Energy and Resources group at the University of California, Berkeley, the faculty in Technology, Policy, and Management at TUDelft in the Netherlands, and the Technology, Policy and Innovation program at Stony Brook University. These programs are very different at their core. Nonetheless they all share a common theoretical bedrock: interdisciplinary studies are an increasingly important aspect of policy making and social development. These programs propose inter and multi-disciplinary approaches to complex problems that may not be solved with uni-disciplinary approached.

9. CONCLUDING REMARKS

In this paper, we have sought to view the innovation ecosystem through the lens of human actors. In fact, the spotlight has been on human actors in the context of six major dimensions of the innovation ecosystem: 1) innovation systems; 2) leadership and economic development, especially as they relate to the Triple Helix; 3) education and workforce development; 4) human resource development; 5) developing countries; and 6) the interplay among technology, policy and innovation. We presented a body of research and expository articles or reports that point to the evolving character of these six major dimensions. Specifically, we describe emerging and evolving roles for universities in the global push for science and technology talent and entrepreneurship. In so doing, we have sought to provide both a synthesis of current work and an exploration of near and distant futures of the innovation ecosystem. It is our hope that this work will be of help to leaders and others who are attempting to advance science parks and science cities, especially those who seek strong and reciprocal relationships between developed and developing countries. Finally, it is our hope that the perspectives we presented here will generate new thinking about purpose-driven, values-sensitive R&D for a world where knowledge development and global interconnectedness are fueling scientific discovery and technological innovation.

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