The Role of Universities in the Knowledge Triangle

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Citation: Vonortas N. (2017) The Role of Universities in the Knowledge Triangle. *Foresight and STI Governance*, vol. 11, no 2, pp. 6–8. DOI: 10.17323/2500-2597.2017.2.6.8

The concept of the Knowledge Triangle formalizes the interaction between the long understood "core" missions of Higher Education Institutions (HEIs): teaching, research and public service. In particular, the Knowledge Triangle refers to the generation of knowledge by HEIs through their activities in education, research, and in a wide variety of interactions with the wider public that assists in the application of new knowledge in the form of new products, processes, and services. Each of these three elements interacts with and influences the others. The resulting bi-directional or circular knowledge flows between the three core elements of the knowledge-building process constitute the Knowledge Triangle (see Cervantes, and Polt and Unger, Figure 1, this special issue). Of course, these flows depend on tools to mobilize resources to create value for the members of the knowledge network (stakeholders), including actors from the public, private and academic sectors.

While these are long-known attributes of the higher education system, their quality, intensity and impact on the creation of new knowledge varies widely across countries and regions. The importance of the Knowledge Triangle concept is that it emphasizes the contribution of education to research and to innovation creation. While traditional policies have focused primarily on education's contribution to enriching human capital and research's contribution to the advancement of science, more recent decades have witnessed a surge of policy interest in the innovation function of universities. Hence, most headline policies have tended to focus on increasing the contribution of research to innovation, highlighting legislative reforms such as the Bayh-Dole Act in the United States and the creation of technology transfer offices and other interfaces between university research and private sector innovation [*Pascoe, Vonortas,* 2014].

There is a wide variety of channels for knowledge transfer and commercialization by universities [*Kergroach et al.,* forthcoming]. Drawing on the OECD [OECD, 2013, Table 1.1] and the US National Academies [NRC, 2010], one can list the following:

Traditional, Core Channels of Knowledge Dissemination

- *Publications.* Published papers, books, conference proceedings, reports.
- *Conferencing, networking*. Professional conferences, informal relations, working or casual contacts.
- *Consulting*. Research or advisory services by public/academic researchers to industry. One of the oldest and most widespread channels.
- *Industry hiring, student placement*. May be institutionalized to include internships, joint supervision of theses, collaborative research.
- *Development of standards*. Documents based on various degrees of consensus defining things such as terminology, measurement, testing, and interface standards.
- *Company formation by students and recent research-trained alumni*. The attention given to this channel has intensified.

Less Traditional, "Third Mission" Channels of Knowledge Dissemination (Commercialization)

- *Collaborative research*. Universities and companies undertake joint research projects. The research may be co-financed.

- *Technology research partnerships*. The formal creation of partnerships with a varying number of members such as research corporations; the formation of long-term research agreements; and public-private partnerships.
- *Contract research*. Industry commissions research in pursuit of a solution to a specific problem; this activity is distinct from most types of consulting.
- *Patenting and licensing*. The bread and butter of technology transfer offices. This became popular only relatively recently. It ranks low on the agendas of universities and industry but high on those of governments.
- *Company spin-offs from academic research*. It has only recently attracted the attention of policy makers. It is an infrequent phenomenon, certainly when compared to company formation by students and alumni.

The dividing line between these two categories is blurry and arguably artificial. One can always find examples of the second category existing far back in universities' history. It must be stressed that:

1) Knowledge transfer from universities and PRIs has always been present.
2) Knowledge transfer occurs in both directions, permitting mutually beneficial relationships due to the sharing of research findings and business information.
3) The traditional channels of knowledge transfer remain the most important (by far) to date and will continue to be so in the foreseeable future.
4) There is a sharp distinction between the two categories of channels in the sense that the entries in the second category much better fit the modern terms of "knowledge commercialization" and "academic entrepreneurship".

The Bayh-Dole Act was intended to facilitate technological innovation in the United States by standardizing intellectual property ownership of inventions resulting from federally funded research. Until then the government retained title to such inventions regardless of who performed the research. Access to research was typically provided through non-exclusive licenses. Public agencies and departments had no fewer than 26 different policies regarding the use of federally funded research [*Schacht,* 2009]. The Act was meant to replace the bureaucratic red tape and enhance knowledge utilization with a single national policy, allowing the inventor to retain intellectual property ownership.

The Bayh-Dole Act became one of the most widely acclaimed pieces of legislation, versions of which have been widely adopted around the world. Nevertheless, it is the creation of spin-off companies that has recently attracted the most attention with respect to knowledge dissemination from HEIs in the context of their third mission. Proponents argue that the genetic characteristics of such firms in the early years following their foundation will tend to reflect the competencies and interests of the company founders, resulting in companies much more closely connected to the knowledge economy and high value-added activities [*Gokhberg et al.,* 2016]. Questions that remain open include: (1) Is this conjecture actually true? Do university spin-offs have better chances of survival than other newly founded companies? Are they relatively more successful (grow faster) than other such companies?

The articles in this special issue visit the Knowledge Triangle from various perspectives and in various national/regional contexts, painting the picture of a rich milieu that delineates and supports the three aforementioned functions of universities.

The paper by Wolfgang Polt and Maximilian Unger provides a conceptual discussion that lays out the definitions of the Knowledge Triangle concept and its connection to other frameworks such as the national innovation systems. It stresses a systemic approach to the *orchestration* of knowledge creation and innovation processes by relating the three spheres of education, (academic) research and knowledge creation, training and (business) innovation. The paper provides a rich picture of the actors in the Knowledge Triangle, the role of universities, public research institutes, public authorities and the private sector, as well as the relevant policy instruments.

Closely related, the paper by Mario Cervantes takes a broad view of the Knowledge Triangle across OECD countries. It goes to the fundamentals of the concept, its roots, its usefulness in underwriting policy. It stresses that HEIs are diverse actors with diverse missions and that the "optimal" structure of HEIs in relation to innovation is likely to be country-specific. In other words, there is no single model of HEIs or of the Knowledge Triangle. Despite this diversity, it turns out that education, research and innovation activities at HEIs are highly concentrated (intense) across OECD countries, reflecting a combination of historical and scale factors, government policies, and institutional policies. These notwithstanding, concentration could simply reflect the non-egalitarian academic ethos of "winner takes all". The article then discusses a number of broad changes affecting STI policy and HEIs.

In their paper, Chataway, Parks and Smith ponder how open science may affect university-industry collaboration. This is a rather relevant subject given the increasing pressure to make science "open",

including pressure from funding organizations. Although the required degree of openness varies and what exactly is a more open approach is open to interpretation, there is now a near consensus that, at the very least, open access must apply to published research results. Furthermore, some funders increasingly require access to research data as well. Other stakeholders call for more transparency and less duplication in research. The article outlines evidence supporting the argument that open science presents a set of convincing alternatives to the traditional models of research activity and conventional metrics for academic success and career progression. The paper also tries to set out key questions underlying the rate and direction of change in open science. The authors argue that the impact on industry-university collaboration will depend on several key decisions made by stakeholders and policymakers.

The remaining four articles deal with aspects of the situation in four different countries. The paper by Natalia Shmatko and Galina Volkova analyzes the motivation patterns of researchers based on data from the Russian section of the international project "Careers of Doctorate Holders". It investigates the evolution of this motivation during different career periods. The eight most common patterns of motivation are identified as the basic motivational structures for researchers. Most of these patterns relate to the focus on the creative and innovative nature of scientific work. The second important component is independence and relative autonomy, typical for research activity. Economic motives are rarely important when choosing an academic career; however, they play an instrumental role in the actual implementation of research. The paper argues for the creation of adequate conditions so that scientists can realize their full research potential and recommends the creation of measures to improve scientists' reputation.

The paper by Perez Vico, Schwaag Serger, Wise and Benner examines Knowledge Triangle configurations at three Swedish universities. The article states that although the Knowledge Triangle remains a priority for universities, explicit national policies addressing the integration of education, research and innovation are absent, with the responsibility of integration falling on universities themselves. The authors observed the significant diversity in how knowledge principles are orchestrated across universities. The three functions are handled more or less separately, with weak coordination from university management teams. Tensions emerge as the responsibilities of operationalizing the Knowledge Triangle falls on individuals who sometimes lack the appropriate mandate and resources.

Finally, the last two papers by Anra and Yamin and by Eghbal, Hoveida, Siadat, Samavatiyan, and Yarmohammadian, respectively, look at faculty incentives and behavior at Jambi University in Indonesia and three public universities in the city of Isfahan, Iran. They find strong effects of organizational culture on performance. Moreover, the improvement of human capital management processes can lead to faculty members' perceptions of increased organizational justice and, ultimately, improved research performance.

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