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The effect of co-inventors' reputation and network ties on the diffusion of scientific and technical knowledge from academia to industry in South Africa

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ABSTRACT

In this paper, it is found that the co-inventors' and coauthors linkages and *h*-indexes highly enhanced the flows of academic knowledge into industrial patents in South African firms. The findings are based on an in-depth analysis of 1702 patents and 332 science sources that had linkages with patents filed by South African enterprises at the USPTO and elsewhere between 1976 and 2010. The data on co-inventors and co-authors networks/ties as well as their *h*-indexes can improve prior art searches and the patent examination process. Such ties can boost knowledge diffusion in large R&D and innovation clusters and hubs, globally.

1. Introduction

The patent system has been playing an important role in accelerating and enhancing the global stock of inventions and industrial innovation, particularly in the extent knowledge-based economies. Generally, patentable inventions build upon scientific and technological progress occurring both in national and foreign jurisdictions and that are generated in academia as well as in industry. Such progress constitutes an important criteria used in the modern patent examination process to validate claims of novelty made through prospective inventions being filed for patent protection in most modern patent offices [1,2]. Understanding the forces that shape the flows of such input into patented inventions is an important subject in technology policy, in the management of the R&D systems as well as in the patent examination process.

Over the past decades, this issue has predominantly been studied in the industrialized societies and the related findings generally recognized that the flow of academic knowledge into patentable inventions disproportionately originated from R&D entities that geographically were located close to the enterprises that were actively involved securing patent protection of the resulting inventions. Such inputs outweighed those from R&D entities that were located in remote areas [3]. This view widely may influence the decisions of patent attorneys, examiners and other practitioners during their search for prior art in respect of prospective patent applications. It is also increasingly being used in law suits in assessing prior art.

The aim of this paper is to identify and propose additional factors that can influence the flow of a university's discoveries into industrial patents in today's knowledge-based economy in which the knowledge production process is becoming more and more globalized and network-dependent and thus dependent on many parameters. Universities' responsibilities are rapidly expanding, resulting in the involvements of their staff in complex and global networks in the public and private sectors, where they provide solutions to various issues. The aim set out in this paper is particularly influenced and prompted by a peculiar pattern of the flows of scientific discoveries and technical inventions into South African patent applications filed by South African enterprises from 1976 to 2010 as shown in Fig. 1. Only about 3% of such flows originated in local (i.e. national) universities and 97% plus came from academic entities that geographically were located on other continents. The acronyms used in Fig. 1 refer to national, regional or international patent offices and where the most-cited inventors were residents.

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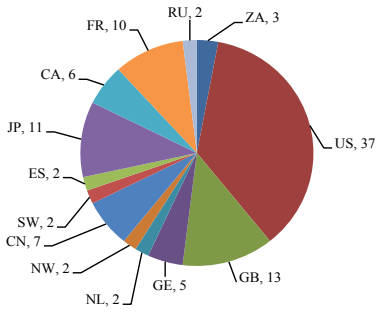

CA = Canada, CN = China, ES = Spain, FR = France, GB = Great Britain, GE = Germany, JP = Japan, NL = the Netherland, NW = Norway, RU = Russia, US = United States of America, SW = Switzerland, ZA = South Africa

Fig. 1. Distributions (%) of geographic origin of inventions that appear in South African patent applications filed by South African enterprises from 1976 to 2010.

The country of residence of the inventors, co-inventors and/or owners of the patents were obtained from the patent application data and in-depth search using databases such as web of science, scopus; company, university and other institutional archives as well as surveys of experts in the fields.

Overall, inventors who were affiliated or employed in the South African enterprises disproportionately consulted the technical knowledge of American nationals, whose input amounted to 37%. The next highest inputs were from areas that were also geographically very distant from South Africa. Notably these were: Great Britain (13%), Japan (11%) and France (10%). The input from South African R&D entities of only about 3% was very similar to those from countries that were geographically very distant from South Africa, such as: the Netherlands, Spain and Russia, that had 2% each. These results indicated that geographic proximity had a limited effect on knowledge flowing from academia to industry in South Africa.

An in-depth analysis of the citing and cited inventors revealed that most of the cited and citing individuals worked on joint research projects in their past. This indicated that other strong factors might have greatly influenced the flows of discoveries from academia to industry. Identifying these factors and understanding how they affected the aforesaid flows can contribute to the improvement of the patent examination process. Notably, this can help patent examiners and attorneys to broaden their searches of prior art, and enhance the patent examination process by reviewing subsidiary sources of prior art flowing into industrial inventions. It can also inform science, technology and innovation management and policy making.

The pattern of flows of technical knowledge into patentable inventions by South African enterprises outlined in Fig. 1 also raised the following two questions.

Were the South African inventions relevant to industry?

What were the other forces that shaped the patenting practice of South African enterprises?

To answer these questions, a hypothesis was created using the network model of knowledge flow pioneered by Zhuge [4], which frames such flows as a passing of structured information through the nodes that generally are comprised of knowledge workers. Identifying additional socio-cognitive attributes, which are likely to affect such flows of prior art between academia and industry, particularly in large innovation clusters is central to this work. Based on the aforementioned observation, inventors' linkages and status in their networks were proposed to be among the potential driving forces for such flows.

In Section 2, several factors that enhanced the overlaps of the networks of researchers and inventors from universities and industries as well the roles of such overlaps or ties and the globally perceived leadership of (co-)inventors and (co-)authors on the flows of academic discoveries into industrial patents are discussed. In Section 3, the method used to gather data and test the hypotheses is outlined. In Section 4, the results are discussed and in Section 5 a conclusion and implications are summarized.

2. Exploring the catalytic role of co-inventors and co-authors' *h*-indexes and networks' ties in the diffusion of academic discoveries into industrial patents

2.1. Overlaps of networks of universities and industries researchers

The major forces behind the increased involvement of university staff in various networks in the public and private sectors in contemporary societies could be distilled from the modern literature of university-industry technology transfer. Some of these forces are briefly discussed in the follow-up of this sub-section.

First, the limitations in growth of public spending per researcher that have been observed globally over the past three decades [5,6], harsh criteria for accessing public grants, escalating costs of acquiring advanced research infrastructures and increased pressure exerted on academic productivity are important drivers of university-industry linkages worth considering. Particularly, universities had to yield research outputs capable of enhancing industrial innovation, resolving various societal needs such as threats to health and the environment. This, in turn, compelled universities to seek out alternative sources of funding, mainly from the donors and other development partners from the private and public sectors through various entrepreneurial activities.

Generally, such activities were facilitated through the establishment of novel institutional mechanisms such as: university technology transfer offices, university licensing offices and industrial liaison offices that were founded by universities and partners and/or self-founded. In the latter case, such offices would raise their own funding through various services that they would provide to researchers and entrepreneurs, such as the development of business plans, patent search and protection and other due-diligences, facilitating licensing agreement, marketing, development of spin-off companies, etc. University researchers, research directors, vice-chancellors, and even students can become intensively involved in different forms of lucrative activities that were unusual to their orthodox orientations, such as intellectual property protection and commercialization, consulting, industry chairs, joint research ventures with firms or government, creation of spin-off firms or membership in the boards of directors in private or public organizations. This movement that was also known as academic or university entrepreneurship deeply embedded university researchers in complex networks that generally had a great potential to accelerate the flows of generic and proprietary knowledge within national innovation systems [5,7,8].

Second, the increased complexity and interdisciplinary of new research areas, mainly those related to the high-technology and medium-technology sectors, led to high demand for inputs from the basic, applied, experimental and commercial-scale research. Such demand resulted in increased involvements of university staff in various types of linkages generally aimed at enhancing technological and innovation capabilities and competitiveness in industry, among other important societal benefits. Likewise, these changes increased the involvement of industry and some governmental entities in the production or co-production (with university) of technological systems having strong scientific underpinning, mainly in the areas of energy technology development, demonstration and innovation; clinical trials, pollution control, and