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Anatomy of use-inspired researchers: From Pasteur's Quadrant to Pasteur's Cube model

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ABSTRACT

Pasteur's Quadrant model, published by Stokes in 1997, presents a two-dimensional abstract conceptual framework that proved immensely helpful to study and discuss institutional and policy arrangements in science. However, during the last 10 years the PQ model was also applied in a series of large-scale, survey-based studies worldwide to classify individual modern-day researchers according to their research orientation and performance.

This paper argues that such applications are inadequate to capture key characteristics of individual researchers, especially those within the heterogeneous 'Pasteur type' group who engage in 'use-inspired' basic scientific research. Addressing this shortcoming, Pasteur's Cube (PC) model introduces a new heuristic tool. Departing from a three-dimensional conceptual framework of research-related activities, the model enables a range of typologies to describe and study the large variety of academics at today's research-intensive universities. The PC model's analytical robustness was tested empirically in two interrelated 'proof of concept' studies: an exploratory survey among 150 European universities and a follow-up case study of Leiden University in the Netherlands. Both studies, collecting data for the years 2010–2015, applied a metrics-based taxonomy to classify individual academic researchers according to four performance categories: scientific publication output, research collaboration with the business sector, patents filings, and being engaging in entrepreneurial activities.

The collective results of both studies provide more clarity on relevant subgroups of use-inspired researchers. The PC model can be used to guide empirical, metrics-based investigations of research activities and productivities, applies this approach to two case studies, and demonstrates the utility of the method while also reinforcing and enriching the growing body of literature showing that cross-sectoral and cross-functional research activities are more scientifically productive than research carried out in isolation of the context of use. Introducing the 'Crossover Collaborator' subtype helps to explain why Pasteur type researchers tend to outperform other types of researchers in terms of publication output and citation impact.

1. Introduction

During the previous century, general views and expectations with regards science have shifted from traditional 'public good' objectives (such as 'discovering nature' and 'defending the truth') to one where science is seen as commodity for public use and private sector utilization (Godin and Schauz, 2016). In the wake of this revised 'social contract' with its funders and stakeholders, science agenda's and research activities have become more aligned to pressing socioeconomic needs and practical problems – be it local communities, business interests, or other user domains (Sarewitz, 2016). The stronger focus on applications and utilization has ushered in new models of science funding as well as criteria to gauge the performance of research-active organisations and individual researchers. Although discovery-oriented 'basic' researchers may still aim for pure knowledge creation, their driving forces and underlying research questions are increasingly inspired by, or designed to address, specific societal issues or concrete problems. Such 'use-inspired'[1] research tends to have higher rates of 'non-academic' outputs (e.g. policy recommendations, practice guidelines or prototype technologies) and associated impacts outside the scientific community. And since these results can more readily be used externally, they lend themselves more readily to commercialisation,

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[1] The term 'use-inspired' is one of many variants, such as 'strategic research' and 'applications oriented research', to denote research activities that blends discovery-oriented 'basic' research and user-oriented 'applied' research. Opting for 'use-inspired' we follow the terminology by Stokes (1997).

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with or without the need for formal IP protection. Using research commercialization output indicators, several studies have provided evidence that such use-inspired activities show a positive correlation with marketable outcomes and economic impact (O'Shea et al., 2005; Powers and McDougall, 2005; Colombo et al., 2010; Wong and Singh, 2013; Cheah, 2016).[2]

Viewing 21st century science through a use-inspired lens, how should one perceive the value added of such researchers, especially their ability to generate socioeconomic impacts and returns? Given the conceptual and analytical complexities of micro-level impact assessment, this issue has proven to be quite a methodological challenge (e.g. Hughes and Martin, 2012). The main objective of this paper is to tackle this challenge by developing a more appropriate conceptual framework and related classification system of individual researchers. After introducing the underlying theoretical and conceptual framework in the next section, and the analytical models in Section 3, two case studies are presented in Section 4 with empirical results on researchers at European universities.[3] Section 5 presents a concluding discussion of the findings and implications for further work.

2. Theoretical and conceptual framework

2.1. From 'use-inspired' to 'entrepreneurial'

More than twenty years ago, Zucker and Darby (1996) aptly demonstrated the significance of the individual use-inspired researcher as a unit of analysis by introducing their US-based 'star scientists' as those who had published many genetics discoveries as well as being the best corporate partners in biotechnology. These highly productive, researchers tend to have high levels of 'intellectual capital' and the 'transformative powers' to connect and integrate science to technology and innovation (Rosen, 1981; Zucker et al., 1998). Follow-up studies carried in the United Kingdom emphasized the crucial role of these 'linked scientists' (Zucker et al., 2002) in connecting academic scientific knowledge and know-how to a firm's internal R&D. Focusing on the intellectual and cognitive profile of use-inspired academic researchers presents meaningful way for better understanding why some of these individuals are more prone than others to be(come) application-oriented, market-oriented and entrepreneurial (Baron, 2004). Jain et al. (2009) argue that establishing the foundations of academic entrepreneurship requires closer scrutiny of the university scientist as a key actor and micro-level unit of analysis, although clearly such researchers constitute a very heterogeneous group of individuals (Shinn and Lamy, 2006; Markman et al., 2008).

Abreu and Grinevich (2013) define 'academic entrepreneurship' as "any activity that occurs beyond the traditional academic roles of teaching and/or research, is innovative, carries an element of risk, and leads to financial rewards for the individual academic or his/her institution". Adopting this broader view, entrepreneurship not only includes application-oriented 'formal' activities (such as patenting and patent-based licensing, ownership of university spin-out companies), but also other 'informal' academic engagement activities such as conducting contract research, joint research with industry partners, membership of corporate advisory boards, or consultancy firms. Apart from being more widely practiced, Perkmann et al. (2013) see academic engagement as being more closely aligned with research activities, and geared towards accessing additional resources to supporting the research agendas of academics. In their survey, providing micro-data on some 22,000 participants in the United Kingdom, Abreu and Grinevich (2013) found that academics working in user-oriented or applied areas are more likely to be involved in all types of entrepreneurial/engagement activities than more traditional researchers.

Apart from being an accomplished scientific researcher, with a sufficient level of 'intellectual capital', what are those 'transformative powers' or other individual characteristics of researchers help them frame and shape their research activities in order to pursue opportunities for commercial applications and entrepreneurship? Why are some more likely than others to be(come) engaged with user communities outside science, business sector partner or other external 'third parties'? The general concept 'human capital' captures important features of this capacity to generate value from outcomes of research activities. Becker (1993) refers to human capital as "the stock of competencies, knowledge, abilities, and skills gained through education and training".[4] Adopting this perspective, and focussing on human capital in scientific and technical staff, Bozeman et al. (2001) evaluate career trajectories of scientists, and their sustained ability to contribute and enhance their capabilities, as an alternative model for evaluating science and technology projects and programs. Further studies show that the human capital attributes of researchers tend to be a critical resource to entrepreneurial success (Unger et al., 2009; Aldridge and Audretsch, 2010). Scientists and researchers with higher levels of human capital have a greater ability to recognize opportunities and a larger chance of gaining access to those opportunities for exploitation and commercialization of their research outputs (Busenitz et al., 2014). Azoulay et al. (2009) find that academics who file for patents tend to shift their research foci to questions of commercial interest.

A second explanatory factor, social capital, relates to social ties and networks (e.g. Hayter, 2016). Those with an abundance of social capital find easier access to new tangible and intangible resources that may enhance opportunity recognition and collaborative behaviour. Such benefits may for instance increase the likelihood of starting a new company or sitting on scientific boards of business enterprises. Several studies have shown that social capital may boost academic entrepreneurial activity (Karlsson and Wigren, 2012; Aldridge and Audretsch, 2011).

Studies have shown that their personal values and beliefs about the benefits of research commercialization also influence entrepreneurial behaviour (Renault, 2006). Scholars point towards their 'role identities' (a primary 'academic self' and a secondary 'commercial persona') and to 'hybridization processes' identity shifts where academic researchers increasingly share the same values as their business sector counterparts (Colyvas and Powell, 2007; Owen-Smith, 2003). Jain et al. (2009), applying a social-psychological framework to explain their finding that the academic productivity and commercial activity of university scientists reinforce one another. According to a study by Grimaldi et al. (2011), the development of entrepreneurship competencies at the university level is significantly influenced by the extent to which individual researchers and research teams are incentivized and willing to become involved in such activities. Overall, use-inspired researchers are likely to be engaged in activities with (potential) users of their findings, while remaining integrated in academic scientific communities.

Although the academic literature finds individual factors more important than institutional factors in explaining academic entrepreneurship (e.g. D'Este and Patel, 2007; D'Este and Perkmann, 2011), the propensity and ability for commercialisation and entrepreneurship is clearly also affected and driven by organizational or contextual determinants (Autio et al., 2014). Some fields of science are more prone to commercialisation inspired by considerations of use.

[2] The UK survey by Lam (2011) finds a non-significant but negative correlation with being actively involved in basic research, reflecting the ambiguous relationship between discovery-oriented research and commercial engagement. In some areas of science (notably the medical, health and life sciences) academics spent time on basic research as well as applied ('clinical') research.

[3] Throughout this paper the term 'university' refers to any PhD granting higher education organization (public or private) that engages in in-house scientific or technical research activities.

[4] According *to Organization for Economic Co-operation and Development*, 'human capital' is "knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (OECD, 2001).