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University-industry collaboration and innovation in emergent and mature industries in new industrialized countries

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ABSTRACT

As the economies and indigenous technological capabilities of the new industrialized countries improve, national universities and public research organizations are expected to become increasingly important for supporting indigenous firms to move into more dynamic and high-opportunity industries. However, the characteristics of collaboration with universities may be very specific depending on whether the industry partner is engaged in mature or emergent activities. In this study, we explore and discuss the role of university-industry collaboration for the development of innovation in mature and emergent industries in new industrialized countries. Evidence from 24 research groups in science and engineering departments in universities and public research organizations in Brazil provides preliminary empirical corroboration for the proposal that the contexts and role of university-industry collaboration in mature and emergent industries are diverse. Knowledge networks are underdeveloped in emerging industries, and public support for research projects is dispersed. This means that university research and development projects with firms in emergent industries are less likely than projects with firms in mature industries to be the result of academic initiatives and public calls for research projects, or to be wholly financed by major public research sponsors. In emergent industries, the role of students and firm employees is crucial for mediating between public research organizations and companies. The policy implications of these preliminary findings are discussed.

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1. Introduction

Newly industrialized country (NIC) governments are increasingly focused on fostering science–industry interactions and developing high-technology sectors (OECD, 2010; Gouvea and Kassicieh, 2005). Policy-makers in both developed economies and NICs have been concentrating on designing policies aimed at raising the quality of Public Research and Education Organizations (PREOs) research and training programmes, to make their role more entrepreneurial and of more benefit to national economic development, and to support the growth of high-technology activities (Eun et al., 2006; Wong et al., 2007). As the economies and indigenous technological capabilities of NICs improve, national PREOs are expected to become increasingly important for supporting indigenous firms to move into more dynamic and high-opportunity

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industries (Mathews and Hu, 2007; Mazzoleni and Nelson, 2007). However, the innovation environments in mature and emergent industries differ considerably in terms of their market and technology turbulence, knowledge input characteristics, main search strategies for innovation inputs, role of networking, and collaboration for innovation development (Utterback and Abernathy, 1975; Tushman and Anderson, 1986; Robertson and Patel, 2007; von Tunzelmann, 2009). The characteristics of collaboration with universities may be specific to whether the industry partner(s) belongs to a mature or an emergent industry.

There is an extensive body of literature on university–industry collaborations and some of these studies examine cross-sectoral and disciplinary differences in the patterns of knowledge transfer between university and industry in developed countries and NICs (e.g. Bekkers and Bodas Freitas, 2008; Dutrénit and Arza, 2010). However, to our knowledge, no work has been published on whether and how the establishment, content and organization of university–industry collaborations differ between emergent and mature industries. The present study tries to fill this gap. Its main objective is to provide preliminary empirical evidence on the specificities of university–industry relationships in mature and emergent industries in Brazil, one of the most important NICs.

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On the one hand, PREOs are often key actors in the process of industrial technological development and catch-up in specific industrial sectors (Mazzoleni, 2008). They can support the development of national technological capabilities and catch up, through the provision of training for scientist and engineers, support for personnel exchanges involving international researchers, experts and students, access to international research networks and new technologies, and advanced knowledge and skills in relevant science and engineering fields (Pavitt, 1998; Robertson and Patel, 2007). PREOs can provide support and advice to firms and governments on how to develop and employ technologies and avoid direct infringement of foreign Intellectual Property Rights (IPR) (Gouvea and Kassicieh, 2005; Mazzoleni and Nelson, 2007).

On the other hand, national institutional environments can provide incentives for firms active specifically in emerging and in mature industries and influence their performance. In particular, Chesbrough (1999) and Gittelman (2006) provide evidence of how the US institutional environment supports the development of new high-tech firms in biotechnology industry, and how the French and the Japanese institutional environments encourage the exploitation of the new market opportunities by large established firms in the pharmaceuticals industry.

The design and implementation of appropriate science and technology policies requires information about the context and characteristics of existing university–industry collaboration, and an understanding, especially, of the specificities of PREO-industry interaction in both mature and emergent industries. Employing the OECD's best practice in relation to technology transfer (e.g. creation of university Technology Transfer Offices (TTOs), definition of IPR, support for university spin offs) might be less effective for supporting university–industry collaboration and the growth of national high-technology sectors in NICs (OECD, 2005; Mowery and Sampat, 2005).

Given the scarce empirical evidence, especially in the case of NICs, this paper should be seen as a first step towards understanding whether and how the characteristics of university–industry interactions in mature and emergent industries differ, and as providing preliminary evidence to guide managers, and science and technology policy makers in NICs. The present study focuses on Brazil, where since 2003 policy has been aimed at improving national technological capabilities and supporting the development and growth of high-technology industries (Brazilian Government, 2003; Gouvea and Kassicieh, 2005).

Using data from semi-structured, face-to-face interviews with a sample of 24 coordinators of research departments in science and engineering faculties in universities, and in public research organizations, first, we analyse the context of science-industry collaboration, i.e. the motivations for, goals, main barriers to and facilitators of such collaboration in Brazil. Second, we examine the organizational changes undertaken by PREOs to promote improve 'entrepreneurial attitudes' among academic researchers. Third, we explore the specificities of university-industry collaboration in emergent and mature industries.

Our study contributes to the literature on the economics of knowledge transfer by highlighting differences in the forms and objectives of university-industry interaction in emergent and mature industries, and by providing preliminary evidence that certain knowledge transfer mechanisms are particularly crucial for mediating PREOs and firms in emergent industries.

The paper is organized as follows. Section 2 reviews the existing knowledge, and develops expectations about the characteristics and role of university–industry interactions in mature and emergent industries. Section 3 examines the specific institutional context of university–industry collaboration in Brazil. Section 4 presents the data and methodology used in this study. Section 5 discusses the motivations, object of and barriers to

university-industry collaboration in Brazil, and the organizational changes implemented in PREOs to facilitate research cooperation with industry. Section 6 contrasts the characteristics of university projects involving firms active in emergent and in mature industrial and technological sectors. Section 7 discusses the policy and management implications of the preliminary findings and concludes the paper.

2. University-industry interaction and the technological challenges in mature and emergent industries

In this section, we review the differences between mature and emergent industries in terms of the process of building industrial innovative capabilities, and discuss and develop expectations about the specific role of the university in the development of technological and innovative capabilities in industry, in light of these differences.

The innovative environments of mature low and medium technology industries and emergent high-technology industries differ considerably in terms of market and technology turbulence, and the characteristics of knowledge inputs. Consequently, search strategies for innovation inputs, the role of networking and collaboration for innovation development, and eventual innovative outputs also differ (Utterback and Abernathy, 1975; Tushman and Anderson, 1986; Strebel, 1987; Eisenhardt and Martin, 2000).

The emergent industry environment is characterized by strong competition in technology and product developments and strong market turbulence. As industries mature, and a dominant industry design emerges, technological uncertainty decreases and competition increasingly is based on cost, and incremental product innovations (Utterback and Abernathy, 1975; Strebel, 1987). Thus, technologies and markets evolve more quickly in emergent than in mature industries (Eisenhardt and Martin, 2000), but there is no evidence that innovation is more frequent in the former compared to the latter (McGahan and Silverman, 2001; Robertson and Patel, 2007).

Also, the types of knowledge inputs required for firms' innovation development, ways of accessing knowledge sources, and the results of firms' innovative efforts may be quite different across the industry lifecycle. Tacit and disembodied knowledge would seem particularly important for innovative activity in the early stages of the industry lifecycle and, consequently, personal contacts (i.e. telephone calls, participation in meetings, demonstrations) may be decisive for knowledge transfer (Audretsch, 1998; Mangematin and Nesta, 1999; Furman and MacGarvie, 2009). Furman and MacGarvie (2009) show that in the early years of the US pharmaceutical industry, US universities supported the development of firms' research and development (R&D) labs via training of scientific and technical staff and collaborative research. Given the importance of disembodied knowledge and personal contacts for innovative activity, geographic proximity often characterizes emergent industries (Prevenzer, 1997). In the early stages of an industry life cycle, new knowledge inputs and resources, such as university research, may enhance the agglomeration of innovative activity, while the new knowledge embodied in skilled workers favours clustering in all phases of the industry cycle (Audretsch and Stephan, 1996; Audretsch, 1998). Regardless of the characteristics of the knowledge, however, low absorptive capacity makes firms reliant on personal contacts (and thus proximity) to absorb external codified knowledge not related to its core competencies (Eisenhardt and Martin, 2000; Mangematin and Nesta, 1999).

In mature industries, firms tend to rely on embodied and codified knowledge to innovate (Robertson and Smith, 2008). Consequently, innovation development and maintenance of competitive advantage mainly involve the fusion of new and old

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