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Do inventors talk to strangers? On proximity and collaborative knowledge creation

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ABSTRACT

This paper examines the characteristics of the collaborations between inventors in the United Kingdom (UK) by looking at what types of proximities – geographic, organisational, cognitive, social, and cultural–ethnic – between inventors are prevalent in partnerships that ultimately lead to technological progress. Using a new panel of UK inventors this paper provides an analysis of associations between these 'proximities' and co-patenting. The results show that while collaboration within firms, research centres and universities remains crucial, external networks of inventors are key feature of innovation teams. The analysis shows that external networks are highly dependent on previous social connections, but are generally unconstrained by cultural or cognitive factors. Geographical proximity is also weakly linked with external networks. Our results suggest that innovation policies should, rather than focus on spatial clustering, facilitate the formation of open and diverse networks of inventors.

1. Introduction

The age of the lone researcher, of the quixotic 'basement tinkerer' (Rabinow, 1976), or of the 'garage inventor' (Seaborn, 1979) is receding. The romantic notion that a new Nikola Tesla will emerge from the lab with the next AC motor (or a death ray) increasingly belongs to a bygone era. While in the late 1970s around 75% of EPO patent applications in the United Kingdom (UK) were filed by individual inventors, nowadays that figure is below 15%. More than 80% of all patents are registered to more than one inventor, suggesting that collaboration in research and innovation has become the norm. Increasingly larger teams are formed within firms or research centres. Complex networks of researchers involving different firms, often in collaboration with universities, public agencies, and research centres drive the world of invention in the early 21st century. As Seaborn (1979:88) puts it, "big science [has] eclipsed the garage inventor [. . .] Edison has been superseded by a team of white-coated theoretical physicists".

While the trend towards the formation of ever-larger research teams and inventor networks has been well documented, we know much less about the features of these teams. What are the characteristics of the inventors that decide to work in a team? Is collaborative research produced by inventors that talk to colleagues, or to strangers? These are the questions at the heart of this paper, which aims to shed new light on the patterns of collaboration observed among UK inventors.

In the paper, collaboration by inventors is captured by means of co-patenting over the past three decades. We explore the individual circumstances that members of a co-patenting team may share and which, according to the literature on innovation and proximity (Boschma, 2005; Boschma and Frenken, 2009; Torre and Rallet, 2005), can be grouped into different types of proximities: (a) geographic (the physical distance between inventors); (b) organisational (whether the inventors share the same organisational

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context, such as the same firm, university or research centre); (c) social (whether inventors have co-invented in the past or share other co-inventors); (d) cultural–ethnic (whether co-patenting inventors share the same national, cultural, and/or ethnic background); and (e) cognitive (the distance between the technology fields of the co-patenting inventors) proximity.

To explore these linkages, we develop a new empirical strategy, which builds on ideas developed in seminal papers by Jaffe et al. (1993), Singh (2005), and Agrawal et al. (2008). We use this to build a new panel of EPO patents microdata from the KITES-PATSTAT resource and we then analyse the incidence of the different proximities considered in co-patenting teams, controlling for a broad set of observable and time-invariant unobservable characteristics (the former through a vector of individual, organisational, and environmental factors; the latter by means of fixed effects). The empirics also employ the innovative ONOMAP name classification system to ascribe inventor ethnicity – and thus, ethnic/cultural proximity. We use social network analysis to identify the position of each inventor in pre-existing collaboration networks.

The paper represents – to the best of our knowledge – the first empirical work assessing the incidence of such a large set of proximities in collaboration patterns, and contributes to the existing literature in several different ways. It finds that, for inventors as a whole, organisational proximity is a key feature of co-patenting teams together with cultural/ethnic diversity. Conversely, geographical proximity is linked to co-patenting in combination with other proximities.

For 'multiple patent' inventors, we find that organisational proximity remains highly relevant, while cultural/ethnic factors are not relevant. Social network and cognitive proximities are more important characteristics of the teams formed by these inventors. The analysis also confirms the incidence of 'unconstrained' (i.e. free from ethnic factors) social proximity and social networks in collaborative activity. For this category of inventors the importance of geographical proximity only emerges as well in interaction with other proximities.

Our results have important implications for the analysis of innovation dynamics and, possibly, for the targeting of innovation policies. The empirical analysis suggests that knowledge and key competences for innovation processes are combined (and recombined) within the organisational boundaries of firms, research centres and universities. These are the key units of analysis of innovation dynamics. Assets internal to the individual organisational unit are complemented by processes of external search that take place within existing social networks that 'bridge' various organisations. The formation of these networks remains largely unconstrained by cultural or cognitive proximity considerations in order to ensure variety and avoid lock-in situations. In this picture the direct contribution of geographical proximity and spatially mediated processes remains limited: it only emerges in the form of hyper-geographical proximity (inventors in the same organisation are likely to be co-localised in the same premises) and as a reinforcement (or facilitator) for network-based interactions. These results suggest that innovation policies should place less emphasis on spatial clustering and localised collaborations and focus more on the capabilities internal to each firm and its ability to access 'unconstrained', open and diverse external networks.

The paper is structured as follows. Section 2 reviews the existing literature on collaborative working among inventors and outlines a conceptual framework for the analysis of the drivers of collaborations among inventors. Section 3 introduces our data and gives some stylised facts. Section 4 sets out our empirical strategy and model. The empirical results with a number of robustness checks are discussed in Section 5. Section 6 concludes.

2. Collaborative working among inventors and proximity relationships

Collaborative invention efforts have been on the rise for quite some time. The number of co-authored scientific publications, both international (Glänzel, 2001; Glänzel and Schubert, 2005) and within specific countries has been increasing in recent decades. In the US, for instance, Adams et al. (2005) find a 50% rise in the average number of authors per academic paper during the period 1981–1999. Similar shifts can be seen in patenting activity. In the UK 'co-invented patents' rose from around 100 in 1978 (24.2% of all patents) to over 3300 in 2007 (66.6% of all patents). Over the period as a whole, 57.3% of patents had more than one inventor. Co-patenting also increased across all major technology fields and the share of inventors working alone fell dramatically. During the period of analysis the mean size of patenting teams rose from under two to over four.

These trends are the result of the evolution of both public policy and corporate strategies. National governments have sought to develop the formation of innovation 'ecosystems'. This, in combination with the internationalisation of firms' activities and the tendency of multinational firms to couple with local partners in knowledge-intensive activities (Cantwell, 2005; Yeung, 2009), has encouraged the formation of research teams which expand well beyond the firm or their research centre. University-industry joint ventures and the growth of Triple Helix relationships involving firms, universities, and government (D'Este and Iammarino, 2010; Leydesdorff and Etzkowitz, 1998) have gradually become the norm.

These 'global' high-level trends have taken place in a context of in-depth change in the individual-level incentives for collaboration. The increasing sophistication of 'frontier' science reinforces the returns to specialisation and promotes collaboration as a means to handle a growing 'burden of knowledge' (Agrawal et al., 2014; Jones, 2009), as well as a form of 'risk sharing' for high-risk/high-gain projects. At the same time, the need to gain access to both highly complex research infrastructure and larger funding pools via collaborative grants (Freeman, 2014) strengthens the incentives for the formation of larger teams of researchers. Finally, research projects require increasingly more diverse sets of complementary skills and competences to be successful (Agrawal et al., 2008).

Scientists and researchers have responded to these changes by making collaborative research the norm both in the United States (Jones et al., 2008) and Europe (Brusoni et al., 2007; Giuri and Mariani, 2012). However, collaboration comes at a cost for all parties involved: the search for the best possible collaborator(s)/team members – whether this decision is taken by the inventors themselves or by managers within the boundaries of a firm – is an expensive process in terms of time and resources. Agents face benefits and costs when considering potential connection/collaboration (see Jackson (2006) for a recent review) and a number of studies have drawn on principal–agent theory to look at contract formation and partner selection at the individual level (Ackerberg and Botticini, 2002; Sedikes et al., 1999).

Moreover, collaboration is by definition a social act and, in addition to economic considerations, it is shaped by personal preferences and circumstances (Giuri and Mariani, 2012), an individual's position in an organisation, the nature and capacity of those organisations, the type of work they do, and a range of external circumstances – such as legal and funding frameworks, industry and policy trends.

Various 'proximities' assist in the creation of innovation networks by reducing team formation costs and overcoming coordination and control problems. Boschma (2005) distinguishes five types of proximity – cognitive, organisational, social, institutional, and geographic. He suggests first, that these factors may operate as substitutes or complements; and second, that