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Organizational and institutional influences on creativity in scientific research

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ABSTRACT

This paper explores institutional and organizational influences on creativity in scientific research. Using a method for identifying creative scientific research accomplishments in two fields of science (nanotechnology and human genetics) in Europe and the US, the paper summarizes results derived from twenty case studies of highly creative research accomplishments, focusing on contextual patterns at the group, organizational, and institutional levels. We find that creative accomplishments are associated with small group size, organizational contexts with sufficient access to a complementary variety of technical skills, stable research sponsorship, timely access to extramural skills and resources, and facilitating leadership. A potential institutional threat to creative science is the increase in competitive research council funding at the expense of flexible institutional sponsorship. Implications for research management and research policy are considered.

1. Introduction

Scientific creativity is a key driver for scientific and technological progress, and also a precondition for advances in other societal domains. Yet, our knowledge and understanding of how research organizations and institutional environments, and changes in both, impinge upon capabilities of research groups to conduct creative research is fragmented. The complex relationships between productivity, social stratification, reward structures, and organizational context in scientific research were frequently studied until the mid-1970s within the institutional paradigm of the sociology of science (see, for example, Shepard, 1956; Meltzer, 1956; Merton, 1957; Meltzer and Salter, 1962; Stein, 1962; Pelz, 1964; Crane, 1965; Pelz and Andrews, 1966; Cole and Cole, 1967; Reskin, 1977; Zuckermann, 1977; Andrews, 1979; Long and McGinnis, 1981). Since then science studies have been dominated by a social-constructivist paradigm that focuses on the micro-conditions of knowledge production in laboratory settings and epistemic cultures (Latour and Woolgar, 1979; Knorr-Cetina, 1981, 1999; Knorr-Cetina and Mulkay, 1983). At the same time, the study of creativity has become popular in psychology, although organizational and institutional questions play only a marginal, if any role (Dunbar, 1997; Amabile, 1996; Sternberg, 2003; Simonton, 1999, 2004). It was only recently that new attempts were undertaken to re-establish an organizational and institutional perspective in the study of scientific accomplishments. For example, Hollingsworth (2000, 2002) and Hage (2006) have published on organizational structures that foster breakthrough research. Hemlin et al. (2004) have explored various institutional factors that are associated with what they call "creative knowledge environments". Yet, in their book on serendipity in science, Merton and Barber (2004) conclude that the institutional analysis of discoveries in science is still in its infancy. Many important questions remain about what creative scientific accomplishments are, how we can identify them, in which organizations they occur most often, and which institutional factors are influential in shaping cutting-edge research environments.

The desire to know more about the factors that contribute to scientific creativity is given further impetus by the substantial changes seen over the last few decades in the institutional and organizational conditions under which scientific research is conducted (Jansen, 2007; Laudel, 2006; Schimank, 2005; Etzkowitz, 2003; Owen-Smith, 2003; Langfeldt, 2001; Bourke and Butler, 1999). Public research funding is now increasingly allocated through competitive processes, rather than long-term institutional block-grants; increased research collaboration is encouraged through a variety of measures including through organized research centers, networks, centers of excellence, and interdisciplinary teams, to address diverse challenges of complexity, convergence, knowledge exchange, scale, scope, and internationalization in contemporary science; and evaluation systems for research performance are increasingly implemented as a supplement to peer review (Münch, 2008; Thèves et al., 2007; Lepori et al., 2007; Corley et al., 2006;

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Shapira and Kuhlmann, 2003; Chompalov et al., 2002; van Leeuwen and Tijssen, 2000; Henkel, 1999). In the context of heightened competitive pressures to foster science-driven business development and the rise of new global locations for research (especially China), research policymakers in developed economies hope that adjustments to research organizations and broader institutional environments for scientific research will not only promote more efficiency but also boost scientific excellence and creativity (Blau, 2005). There is an increasing need for recommendations about the design of science policy to support highly creative researchers and their groups.

This paper explores factors which influence the ways in which research groups conduct their work. Besides features of the research group itself, such as size and career stage of group leaders, our main analytical and empirical focus is on organizational variables and the institutional environment in which these groups operate, such as leadership, funding structures, or competitive pressures. Our study is built on a longitudinal multi-method research design based on survey, interview, archive and bibliometric data, and uses both quantitative and qualitative research methods including as network and regression techniques, and in-depth interviews and case studies (Heinze et al., 2007; Heinze and Bauer, 2007). We identified creative research accomplishments in two broad fields of science, analyzed why certain research groups are more creative than others, and investigated which factors in their work environment were influential for their accomplishments.

We begin the paper by reviewing contributions to the literature on scientific creativity and by highlighting selected key issues important for further research (Section 2). Second, we introduce our methodology (Section 3). Third, we discuss in more detail the results from our case studies of highly creative research accomplishments, focusing particularly on findings related to organizational and institutional influences on scientific creativity including work group factors, such as size of research groups or communication patterns, and organizational features, such as sponsorship or disciplinary variety (Section 4). Then, we discuss our findings in the light of previous results, and we demonstrate how our findings improve our understanding of creative knowledge environments (Section 5). Finally, we consider the implications for research management and research policy (Section 6).

2. Literature review: definitions, approaches and findings on scientific creativity

The importance of creativity in numerous areas of society has resulted in studies of creativity from diverse fields, including management and business (Sutton, 2002), arts (Maritain, 1977; Berka et al., 2003), politics (Otten, 2001; Nagel, 2002), and urban and regional development (Florida, 2002). However, there is a convergence in characterizing creativity as encompassing capabilities to do things that are new and useful (see Ochse, 1990 and Amabile, 1996, for a summary of definitions).

In the world of science, creativity is similarly defined in terms of knowledge and capabilities that are new, original, surprising, and useful (Hollingsworth, 2004; Simonton, 2004). As in other fields, standards and norms are established in science against which claims for innovative contributions are assessed, although science, more than other fields, has evolved procedures, disciplines, and institutions to accredit new knowledge (Whitley, 2000). In making judgments about scientific creativity, scientific peers use criteria such as plausibility, validity, and originality. There are well-recognized tensions here, since criteria of plausibility and validity tend to encourage conformity, while originality draws upon and encourages dissent. The history of science is replete with examples of path-breaking research achievements that were initially rejected by the scientific establishment because they challenged existing paradigms (Kuhn, 1962; Polanyi, 1969; Hessenbruch, 2004). In other cases, work that was initially proclaimed publicly to be highly creative was found, following more considered scientific review, to be flawed (Lewenstein, 1992). In short, the scientific community must be persuaded that novel and unexpected contributions have value, and claims that research is highly creative need validation over time and by other scientists.

There are varied approaches to examining and empirically measuring creativity. These include examining creative individuals, the products or outcomes of creative work, creative processes and creative knowledge environments (Stumpf, 1995; Hemlin et al., 2004). At the individual level, there has been much discussion – not necessarily with consensus – about the relationship between intelligence and creativity (Mansfield and Busse, 1981; Sternberg, 2003). There has also been a focus on the behavioral traits of creative individuals, including their level of curiosity, risk tolerance, motivation, and willingness to overcome failure, leading to arguments that creative people typically tolerate higher levels of contradiction, ambiguity, and uncertainty in their work (Sternberg et al., 1997; Weinert, 2000). Still, such individual characteristics are neither easily measured nor uniformly correlated with creative accomplishments, leading others to concentrate on tangible scientific publication outcomes and citations to identify highly creative researchers.

A prominent attempt to assess scientific creativity through outcomes is publication and citation analysis within an evolutionary-probability theoretical frame (Simonton, 1999, 2004). Simonton argues that scientists who are highly productive in publishing papers encounter a greater likelihood that one or more of their papers will come to the attention of other scientists, be cited, and recognized as creative. In other words, the more contributions to knowledge that a scientist produces, the higher his or her chances are that one of these contributions resonates well in the scientific community. This approach is not without criticism because, for example, some highly creative scientists publish only a few papers, while citation counts typically consider only journal publications and not books or other contributions, such as new scientific instrumentation. Another outcome approach is based on studying prestigious prize winners in science (Zuckermann, 1977; Hollingsworth, 2002). Of course, such prizes are highly selective – and there are surely more creative research accomplishments than Nobel committees can recognize. Hollingsworth (2002) addresses this problem by obtaining access to short-listed Nobel Prize nominees until the 1940s.

Creative processes, including the selection of problems, methods, partners and knowledge sources, have been another area of inquiry. Rather than focusing on innate individual traits, work on creative processes has highlighted the opportunity structures in collaboration networks that facilitate the generation and diffusion of novel ideas. Proponents of network brokerage argue that people who are placed at the intersection of heterogeneous social groups have an increased likelihood of drawing upon multiple knowledge sources, leading to the generation of new ideas. For example, managers who occupy brokerage positions are more often than others the source of good ideas (Burt, 2004; Rodan and Galunic, 2004). In contrast, proponents of cohesive collaborative networks argue for the benefits of trust, shared risk taking and easy mobilization in facilitating information and knowledge transfer. According to these studies, individuals with cohesive social ties are more likely to be involved in innovations (Uzzi and Spiro, 2005; Obstfeld, 2005). In reference to this ongoing debate, Fleming et al. (2007) argue that although brokering inventors are more likely to generate new ideas, the brokered network structure itself is less suited to diffusing these ideas. Therefore, network structures that enhance the generation of novel ideas may inherently diminish the likelihood of their diffusion.