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Intellectual capital or signal? The effects of scientists on alliance formation in knowledge-intensive industries

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ABSTRACT

Hiring employees with advanced education, training, and experience has been a prevalent human resource practice in dynamic science-based industries, and a growing body of literature has demonstrated the importance of scientists in such fields. Little research has attempted to distinguish the functional from the symbolic roles of scientists, however. We develop an integrative theoretical framework to separate the productive and legitimating effects of scientists on strategic alliance formation of firms. Results from a longitudinal analysis of more than 300 U.S. biotechnology firms between 1988 and 1999 suggest a positive relationship between ratio of scientists and R&D alliance partners as well as a positive relationship with finance alliance partners. Scientists influence partner attraction more strongly for firms that are less-well-connected, and they become less prominent in fostering finance ties as the industry practice of partnership becomes more institutionalized. We conclude that scientists serve more than just a research function in knowledge-intensive industries. Implications for building interorganizational networks and managing human resources in such industries are discussed.

1. Introduction

Science-based industries have grown robustly in size and influence over the past several decades. Hiring a relatively high percentage of people with advanced education, training, and experience has become a hallmark of such industries. As an illustration, taken from the data set we use here, about one-third of the employees in biotechnology firms in 2000 held a Ph.D. or M.D. degree.

The effect of human capital has been a long-standing interest in several disciplines (Becker, 1962), and a large literature demonstrates the importance of scientists in knowledge-intensive industries. Most studies emphasize either the real scientific labor contributions of scientists (Azoulay et al., 2008; Henderson and Cockburn, 1994; Oliver, 2004; Rothaermel and Hess, 2007; Zucker et al., 1998a,b) or the network contacts that scientists bring to facilitate productivity (Audretsch and Stephan, 1996; Murray, 2002; Rosenkopf and Almeida, 2003; Stuart et al., 2007). A handful of studies have examined the symbolic and legitimating role of scientists in enhancing the credibility of the firms that employ them, especially in volatile and uncertain fields (Deeds et al., 2004; Stephan and Everhart, 1998; Higgins et al., 2008). No one, however, has empirically analyzed the co-occurrence of the productive and legitimating functions of scientists. Nor do we understand the contingencies under which one may be more important than the other. This paper explores the functions of scientists in knowledge-intensive industries, separating their legitimating from productive effects.

Our focus on the productive vs. symbolic role of scientists reflects a classic divide between human capital and signaling perspectives that has characterized research on human capital at the individual level (Becker, 1962; Spence, 1973). From the human capital perspective, its importance lies in the knowledge, experience, and skills of an employee. Human capital in this view is a potent input to the production process. From the signaling perspective, the importance of human capital is the communicative value of an individual's credentials. Seen in this light, it signals that a credentialed person is both competent and committed. Moreover, possession of this signal improves one's life chances, regardless of one's actual knowledge. Collins (1979) described the late twentieth century as a "credential society," in which advanced educational degrees afford access to better jobs and higher income, independent of how learned people actually are.

We propose an integrative framework to understand the effects of scientists on strategic alliance formation in science-based industries, drawing on human capital, social network, signaling, and institutional perspectives. We extend the contrast between the human capital and signaling functions of employees from the individual level to the organizational level.

Strategic alliances are prevalent in knowledge-intensive industries because the scientific base of such industries is complex, dispersed, and rapidly expanding (Pisano, 1989, 1991; Hagedoorn

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and Roijakkers, 2002; Orsenigo et al., 2001; Powell et al., 1996). Both the productive and legitimating functions of scientists are potentially at work in the process of attracting alliance partners. On the one hand, many alliance activities involve the actual exchange and recombination of scientific inputs. Scientists contribute a stock of intellectual capital that includes scientific knowledge, skill, experience, and access to networks of scientific contacts and resources (Nahapiet and Ghoshal, 1998; Subramaniam and Youndt, 2005). On the other hand, potential partners make decisions to enter alliances based on their evaluations of a firm's quality and potential. Given that the cycle of innovation and commercialization is long and uncertain in some knowledge-based industries, a firm's scientists can send a signal of organizational legitimacy that reduces evaluative uncertainty and encourages partners to invest in an alliance.

We propose that the two functions of scientists lead to different predictions about the effects of scientists on alliance partners. If the productive function of scientists were their only contribution, we would expect firms with more scientists to have an advantage in attracting research and development (R&D) partners, as scientific labor is the main ingredient in R&D collaboration and the science would be most readily understood by other researchers. If scientists instead signal the firm's legitimacy, we would expect them to make a bigger difference in alliance formation when there is heightened uncertainty—for instance, when other signals of firm quality are lacking or obscure. To be sure, contingencies and historical development matter as well. The signaling value of scientists is likely to change with the rise of industry norms, which can shift potential partners' attention to different aspects of organizational legitimacy. We test these ideas empirically, using a group of more than 300 U.S. dedicated biotechnology firms between 1988 and 1999.

This study deepens our understanding of the effects of scientists on strategic alliances in knowledge-intensive industries. Both the productive and legitimating functions of scientists are likely to generate positive outcomes for knowledge-based firms; consequently, prior research has viewed scientists primarily as a stock of intellectual capital. In a series of studies, Zucker and colleagues have documented that scientists were instrumental in generating breakthroughs that led to the success of biotech firms (Zucker et al., 1998a,b, 2002; Zucker and Darby, 2001). By identifying the contingencies for the effects of scientists and empirically separating their productive and legitimating effects, we deepen insights into the signaling role of scientists (Stephan and Everhart, 1998). We also illuminate how the signaling/legitimating value of organizational practices can depend on the presence of other signals and prevailing industry norms. Studies have shown that alliance partners contribute to research productivity, access to new information, growth, and positive financial performance (Ahuja, 2000; Baum et al., 2000; McEvily et al., 1999; Powell et al., 1996). Understanding how scientists affect alliance activities is thus an important step toward maximizing their utility in science-based industries.

In next section, we offer an integrative framework to understand the roles of scientists in science-based firms. We then propose a set of contingencies that allow us to separate the legitimating function of scientists from their productive function in alliance formation. Subsequently, we describe the data set, methods, and results. We end with a discussion of the policy implications.

2. Theoretical arguments and hypotheses

2.1. The productive and legitimating functions of scientists

From the standpoint of human capital perspective, scientists serve a productive function through their provision of knowledge and skills. Human capital is the value added to a laborer when he or she acquires knowledge and skills useful to the employer (Becker, 1962; Schultz, 1970). Developed to parallel the individual-level concept of human capital, intellectual capital refers to "the knowledge and knowing capabilities" of an organization (Nahapiet and Ghoshal, 1998, p. 245). A firm's intellectual capital can be viewed as partially residing in the human capital of its technical labor force, which is a product of investment through advanced education, training, and experience in scientific and technological research (Subramaniam and Youndt, 2005). Such investment results in improved knowledge and skills that are especially valuable in science-based industries. Henderson and Cockburn (1994) argue that the locally embedded knowledge of intellectual human capital is an important source of a firm's innovative competence.

The productive contributions of scientists also include their network contacts and resources, which are emphasized by the social network perspective. A firm's scientists can embed the firm in scientific networks or "invisible colleges" (Crane, 1972). These invisible colleges are an informal network of researchers established around a common problem or research program. In scientific communities, information and research results traditionally have been shared widely among their members. David (2001) shows that the liberal sharing of knowledge within a scientific community is a powerful driver of innovation. These scientific links become part of a firm's social capital, which also contributes to the firm's intellectual capital (Subramaniam and Youndt, 2005). Rosenkopf and Almeida (2003) find that mobility of inventors enhances inter-firm knowledge flow, suggesting that scientists can provide access to their employing firms' body of knowledge. Audretsch and Stephan (1996) emphasized the role of university-affiliated scientists as links in networks among biotech firms and between biotech firms and universities. Several studies have shown how interpersonal networks of scientists have contributed to commercialization and technology transfer in biomedicine (Murray, 2002; Stuart and Ding, 2006; Stuart et al., 2007).

Drawing on the signaling and institutional perspectives, we can look at the activities of scientists with respect to conveying organizational legitimacy, defined as "a generalized perception or assumption" that an organization is desirable, proper, or appropriate to relevant stakeholders (Suchman, 1995). The classic signaling view was developed to account for how an employer evaluates a potential employee before hiring (Spence, 1973). Education is considered to be an effective signal of a potential hire's quality because it is observable and also costly to obtain and imitate. Institutional theory emphasizes the importance of legitimacy to organizations (Selznick, 1957; DiMaggio and Powell, 1983; Meyer and Rowan, 1977). Empirical studies demonstrate that legitimacy provides organizations with resource advantages and improves their survival and growth prospects (Baum and Oliver, 1991; Zuckerman, 1999). Organizations can strategically manage their resources in order to conform to the expectations of their stakeholders (e.g., Oliver, 1997). But organizations are also very much constituted by taken-for-granted beliefs and practices (Meyer and Rowan, 1977). We focus on how the former – sometimes referred to as "strategic forms of legitimacy" (Suchman, 1995) – can be combined with signaling ideas to shed light on the effects of scientists in knowledge-intensive industries.

Signaling ideas can provide insight into the tools organizations may use to acquire legitimacy. In turn, institutional theory offers purchase on how the strength of signals changes over time. The two perspectives are both concerned with evaluation of quality and potential under conditions of uncertainty. An organization can convince external evaluators of its credibility through displaying appropriate signals of organizational legitimacy. Effective signals need to be: (1) observable, so that an external audience can use