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The *Renaissance Man* is not dead! The role of generalists in teams of inventors

Eduardo Melero, Neus Palomeras*

Department of Business Administration, Universidad Carlos III de Madrid, Spain

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ABSTRACT

Is there a role for the multifaceted Renaissance Man in modern team-intensive innovation activities? This paper argues that generalist inventors, holding a broad knowledge set, make an especially valuable contribution to innovation teams in uncertain contexts. For a given level of team knowledge variety, the presence of generalists in an innovation team enables a more effective recombination of knowledge and attenuates the typical barriers affecting team-working processes. On the other hand, the lack of specialized contributions in such teams may hamper the process of adapting each recombined component in the search for an innovative solution. Thus, we expect teams including generalists to perform better than otherwise comparable teams in contexts where there is not a well-defined path to combine knowledge and the advantage of specialized contributions plays only a secondary role. We analyze the role of generalists in teams of inventors in the electrical and electronics industry by tracking the trajectories of individual members and the performance of their teams through their patenting activity. Our findings are consistent with the proposition outlined above.

1. Introduction

Modern research activities are mostly, and increasingly, organized in teams. As Wutchy et al. (2007) report, the majority of scientific papers and about half of patents nowadays are co-authored and co-invented, respectively. Jones (2009) argues that this trend is the consequence of the growing specialization of innovators. According to this view, the large stock of knowledge that has to be learnt in each discipline makes it increasingly costly to master several areas of knowledge. The result is that people who excel at multiple disciplines, the proverbial "Renaissance Men", are extremely scarce. In contrast, the majority of innovators are narrow specialists, who frequently need to work in teams with other specialists to cover the relevant technological space needed to develop increasingly complex innovations. One question arises naturally as an objection to this process: to what extent are teams of specialists able to collaborate effectively in the development of innovations? Singh and Fleming (2010) suggest that part of the advantage of teams of inventors with respect to lone inventors is due to the higher knowledge variety encompassed by teams. This, however, does not necessarily imply that innovation teams obtain their variety advantage exclusively from a combination of specialists. Individual co-inventors may have deeper knowledge if their prior expertise is concentrated in a given technological area (specialized contributions) or broader knowledge if such expertise is distributed among different technological areas (generalist contributions). Team-level knowledge variety[1] can then be based on the contribution of some generalist inventor(s) or the combination of specialized contributions. The above question, therefore, has not yet been answered.

In this paper, we suggest that the internal distribution of knowledge variety among team members is relevant for the generation of innovations in teams of inventors. In particular, we propose that teams including generalist inventors outperform teams that achieve the same level of variety by gathering specialists in settings where the innovation process involves an especially high degree of uncertainty. Otherwise, the presence of generalists will have no effect or even a negative effect on the final outcome, measured in terms of the economic relevance of the innovation generated. Our

[1] Following Harrison and Klein (2007), we use the term "knowledge variety" in this paper to refer to the diversity in the pieces of knowledge held by a team. Whereas "diversity" is a general term that reflects the existence of differences with respect to the personal characteristics of the members of a group (age, gender, education, knowledge background, etc.), "variety" refers specifically to the diversity with respect to characteristics that are not one-dimensional but multi-categorical (knowledge background or type of education would fall within this definition).

* Corresponding author. Tel.: +34 916249892.
E-mail addresses: eduardo.melero@uc3m.es (E. Melero), neus.palomeras@uc3m.es (N. Palomeras).

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main argument is that the knowledge breadth of generalists is particularly valuable for the recombination of knowledge in contexts where the procedures for solving problems are not clearly established. Nevertheless, as Jones (2009) points out, broad-knowledge human capital background can only be built at the expense of knowledge depth. This lack of depth of generalists may negatively affect the efficiency of teamwork in certain settings, where deep knowledge facilitates problem solving.

Even though teams of inventors are arguably the most relevant type of creative teams for social and economic development, very little is known about how they are organized at firms and how this affects their productivity. Only the abovementioned Singh and Fleming (2010) examine the productivity of teams of inventors versus that of lone inventors. The organizational behavior literature has extensively analyzed the effect of team-level knowledge variety on the performance of different types of teams (Harrison and Klein, 2007), though not teams of inventors. This literature associates high knowledge variety at the team level with the potential to recombine ideas that lead to highly creative results (Jackson, 1996; Paulus, 2000; Taylor and Greve, 2006) but also with motivation and communication problems that impair team performance (Stewart and Stasser, 1995; Jehn and Mannix, 2001). Similar to our approach, Rulke and Galaskiewicz (2000) devoted attention to how team-level variety is achieved, i.e., either by specialized contributions or by broad and potentially overlapping contributions, and the effect on performance. By looking at the composition of teams of MBA students performing business simulation games, they find that teams in which each member has experience in several functional areas outperform teams whose members are specialized in one functional area each. However, their focus on (simulated) managerial decision-making makes their findings difficult to extrapolate to teams engaged in knowledge generation.

The literature on network analysis has studied individual creativity, including that of innovators, as a function of their position in the social or/and knowledge structure. This position determines their degree of access to new and redundant information and, thus, their ability to generate further creative output (Burt, 2004; Obstfeld, 2005). Applying this approach to inventors of patents, Fleming et al. (2007) suggest that, in network structures characterized by redundant information, individual creativity depends on the set of personal characteristics of the inventor and their colleagues, including their knowledge diversity.

This article contributes to the literature on the management of innovation at the team level by enhancing our understanding of the impact on performance of the knowledge distribution among inventors in a team. We test our arguments using extensive data on technological innovations produced by teams and protected by patents. Patent data is useful to identify teams of inventors responsible for the creation of the underlying innovation as well as to measure the impact of the newly created technology. Moreover, in patent-intensive sectors such as the electrical and electronics industry (Hall, 2004), patents also make it possible to characterize the inventors' knowledge expertise in different technological sub-areas. Empirical results support our hypothesis on the moderating role of domain uncertainty on the relationship between the presence of generalists in a team of inventors and the economic relevance of the innovation they generate: the presence of generalists decreases the relevance of the team output in settings with low levels of uncertainty whereas their presence increases the economic relevance of the outcome in settings with high levels of uncertainty.

2. Theory and hypothesis

In a broad sense, innovation can be described as the result of a process where existing technologies are recombined in a novel way (Schumpeter, 1939). The quality of the result of any innovation effort, therefore, will depend crucially on the ability of the innovator(s) to select and combine existing pieces of knowledge (knowledge recombination) and adapt them to meet each other's requirements (adaptation of components). Additionally, the output produced by a team of inventors will also depend on how co-inventors deal with the usual team malfunctions that arise in the innovation process (inventors' teamwork processes). Prior research suggests that teams that combine a more varied knowledge set enjoy more room for recombination and more alternative paths to solve problems but they also risk suffering more from malfunctions (Paulus, 2000; Jackson, 1996). Below we develop the argument that the presence of generalists in a team of inventors affects the trade-off posed by knowledge variety. We also hypothesize that the role of generalists in this trade-off is moderated by the uncertainty of the setting where the team of inventors operates (domain uncertainty).

2.1. Knowledge recombination

This initial step in the development of an innovation can be understood as a procedure in which inventors identify and select the relevant pieces of knowledge and define the structure of the new combination in a way that offers a novel solution to an existing problem. As a problem-solving process, knowledge recombination will be more effective when at least one head can fit most of the relevant pieces of knowledge together (Simon, 1985). Conversely, if each of the different pieces needed for recombination is held by different co-inventors, the amount and quality of the interconnections that can be established between these separate portions of information is limited by communication constraints. In terms of Fleming and Sorenson's (2001) technological landscape concept, the big picture of the landscape that generalist inventors have in mind enables them to conduct a more effective search than that performed by different specialists stitching together several small sections of the same landscape. Understanding the general principles from different technological landscapes at the same time allows generalist researchers to make more informed choices about the combination of distant pieces of knowledge (Gruber et al., 2013). Because they are in a better position to evaluate the potential of alternative links connecting knowledge from different areas, they are expected to be better at identifying fruitful novel technological combinations.

Moreover, in a team setting, the presence of some generalist increases the expected amount of overlapping expertise (i.e., expertise in common areas) among the members of the team. Generalists, then, would play a "knowledge bridging" function that is particularly important for knowledge recombination because shared information is more likely to be retrieved than unshared information in team interactions (Stasser and Titus, 1985; Rulke and Galaskiewicz, 2000). Thus, the potential for both *individual* and *collaborative* knowledge recombination will increase with the presence of generalist inventors in the team.

2.2. Adaptation of components

Once the relevant pieces of knowledge are identified and the structure of the new combination is defined, teams of inventors have to adapt each component to the particular design of the new combination. As mentioned previously, teams including generalist inventors suffer the drawback of having less deep-knowledge contributions than do teams with equivalent amount and variety of expertise but including exclusively specialist inventors. This downside may particularly affect the task of adapting the different elements brought for recombination in a way that they effectively fit each other.

To the extent that the task of adapting individual technological components to the overarching entity can be modularized, the