



# Technology push and demand pull perspectives in innovation studies: Current findings and future research directions

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## ABSTRACT

This study updates the debate on the sources of innovation. Using techniques like factor analysis, multidimensional scaling, and pathfinder analysis, we examine the most influential articles that have dealt with the topic. Our analysis provides three main findings. The first more precisely highlights the role of demand as a source of innovation. The second illustrates how competences enable firms to match technology with demand and capitalize on technology and demand as sources of innovation. The third unveils a distinction between external and internal sources of innovations. The sources of innovation can be purely external or internally generated competences that enable the firm to integrate external knowledge within its boundaries. Our work contributes to the classic debate by providing a more granular understanding of how technology and demand interact. In discussing our findings, we link our framework to strategy, innovation and entrepreneurship studies that expressly call for a better understanding of technology and demand factors in value creation and capture.

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## 1. Introduction

For years, scholars investigating the economics of technical change conducted their pioneering research by juxtaposing the forces that were to shape two alternative perspectives (e.g., Schmookler, 1966; Meyers and Marquis, 1969; von Hippel, 1976; Mowery and Rosenberg, 1979; Rosenberg, 1982). On the one hand, those who referred to the so-called technology-push perspective pinpointed the key role that science and technology play in developing technological innovations and adapting to the changing characteristics of the industry structure. On the other hand, scholars embracing a demand-pull approach identified a broader set of market features, including characteristics of the end market (particularly, the users) and the economy as a whole, that affects the performance of innovation.

The juxtaposition of these two approaches to innovation fostered a fruitful debate that reached its apex in the Seventies. Those years have witnessed a confirmation of the role of science and technology in generating innovation and a growing skepticism regarding a pure demand-pull perspective. In particular, the

latter raised a number of theoretical and empirical concerns. For instance, given the interrelated nature of the curves of demand and supply, Mowery and Rosenberg (1979) claimed that is technically complicated to distinguish a demand-pull situation from a technology-push one. Relatedly, Dosi (1982, p. 150) remarked that research in the demand-pull tradition failed “to produce sufficient evidence that ‘needs expressed through market signaling’ are the prime movers of innovative activity”. Along with this chorus of critiques, but approaching the issue from a disciplinary angle, Stigler and Becker (1977) claimed that *de gustibus non est disputandum*: namely, when the discussion goes so far as to examine differences in tastes among people, economists should leave the floor to those who study and explain tastes – namely, psychologists, anthropologists and phrenologists.

The debate therefore reached a sort of deadlock in the Eighties. At that time it seemed clear that while most technical innovations were driven by science and technology, the role of demand and more broadly of market and social forces was complementary in that respect. For instance, when it is a matter of selecting a specific technological trajectory, “the role of economic, institutional and social factors must be considered in greater detail. A first crucial role (...) is the selection operated at each level, from research to production-related technological efforts, among the possible “paths”, on the ground of some rather obvious and broad criteria such as feasibility, marketability and profitability” (Dosi, 1982, p. 155). Similarly, Kline and Rosenberg (1986) advocated a shift from linear models of technology and demand to a more interactive model between these two potential sources of innovation.

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Overall, science and technology seemed to be “the” source for the vast majority of technological innovations and demand was the best companion to drive innovation in the right economic and institutional directions.

Despite the growing consensus about this mutual dependence with an emphasis on technology as the ultimate source of innovation, the way the selection process and, more broadly, the interaction might have occurred was primarily described *conceptually* and was discussed mostly at a *macro* level. Instead, due to the increasing importance of technology within organizations (Arora and Gambardella, 1994; Chesbrough, 2003; von Hippel, 2005) and the impressive growth of fields focusing on the economics and management of technology (Fagerberg et al., 2012; Martin et al., 2012), in this paper we aim to review the influential articles published on the sources of innovation in recent years. The question that motivated our research is to see whether these more recent studies have enriched our understanding of technology and demand as sources of innovation and have explained more specifically how the two can be leveraged in order to commercialize successful innovations.

Our review follows mainstream methodologies of bibliometric analysis (e.g., Acedo et al., 2006; Nerur et al., 2008; Di Stefano et al., 2010). In addition to better clarifying the role of demand as a source of innovation, our findings show that a clearer balance between the two approaches has apparently now been reached from both an *empirical* and a more *micro* standpoint. Indeed, in addition to confirming the dual nature of innovation sources (technology push and demand pull), our findings highlight that scholars have paid particular attention to studying and demonstrating how firm competences enable firms to match the two sources and thus deliver the right innovations to the market. In this respect, researchers seem to have focused their attention on different approaches to knowledge integration: those who start with a clear focus on the external environment and try to absorb knowledge within firm boundaries and those who start from internal sources and focus on integrating external knowledge. While in the former case, external sources remain the ultimate source of innovation, in the latter case internally generated competences seem to be the sources of innovation.

The rest of the paper is organized as follows. We explain in detail our methodological approach (Section 2); we then present our findings with respect to the three analyses we ran (Sections 3–5); finally, we conclude with a discussion section in which we call for: studies on the microfoundations of innovation, research linking innovation and entrepreneurship, and the pluralism of methodologies for the understanding the topic under investigation.

## 2. Overview of the method

Co-citation analysis is a bibliometric method used to examine relationships between articles or authors contributing to the development of a research field, based on the assumption that two often co-cited documents are related to each other and address the same broad research questions without necessarily sharing the same opinion (White and Griffith, 1981). The more often they are cited together, the stronger the relationship and the more likely they are to belong to the same research front, sometimes referred to as an “invisible college” (Crane, 1972). In this paper, we focus on the most influential contributions dealing with the sources of innovation and use co-citation analysis to show the “invisible colleges” within the research domain (Crane, 1972; de Solla Price, 1963), pointing out the structure of the field and the relationships binding its components together. As suggested by Di Stefano et al. (2010, p. 1199), although this analysis does have its limitations, “if compared to alternative techniques (such as key informants’ judgments), citations are less prone to systematic biases in providing an objective assessment of the influence of publications or authors (Baumgartner and Pieters, 2003)”.

Following the methodological prescriptions (e.g., McCain, 1990), we run co-citation analysis by performing the following six steps: (1) selection of the unit of analysis; (2) retrieval of co-citation frequencies; (3) compilation of raw co-citation matrix; (4) conversion of the raw co-citation matrix into a correlation matrix; (5) carrying out multivariate analysis of correlation matrix; and, finally, (6) interpretation and validation. In order to identify the most influential contributions on the topic (McCain, 1990), we looked at the most frequently cited studies, based on the common assumption that citation counts are a valid measure of their importance and influence (Garfield, 1979; Ramos-Rodríguez and Ruiz-Navarro, 2004). Data were collected from the Social Science Citation Index (SSCI) of Thomson-ISI Web of Science database, with specific reference to all articles in the business and management categories. Our analysis is solely based on articles. It omits books, book chapters, and working papers, which cannot be extracted from the database. Our analysis covers the full time span available in this database (from 1956 to 2010).<sup>3</sup>

In order to search for topical papers, we crossed three subsets of words thus ensuring that the retrieved articles refer to at least one of the words in each subset. The first subset defined the boundary of our search domain and included contributions whose title, abstract, and keywords<sup>4</sup> included words with the prefix “innovat” (such as innovation and innovative). The second subset looked at sources of innovation in the technology domain, with the words “technolog” or “scien”. Science and technology have indeed independent as well as interactive effects on firm innovation performance, thus creating the need to examine the role that both of them play in innovation (Makri et al., 2010). The third subset investigated sources of innovation in the demand domain, with the words “demand”, “consumer(s)”, “user(s)”, “custom” (to allow for customer(s), customization, etc.), “preference(s)”, “commercialization” or “complementary assets”.<sup>5</sup> By screening the Thomson-ISI SSCI database according to these defined criteria, we obtained a set of 1555 contributions, published from 1976 to 2010. Previous studies used subjective criteria to determine the most influential papers from such a rank ordering, selecting for example the top *n* cited papers or papers with a minimum of *n* citations (e.g., McMillan, 2008; Ponzi, 2002). Consistent with this approach, we selected the top 100 papers from the comprehensive list (Ramos-Rodríguez and Ruiz-Navarro, 2004). In point of fact, despite representing less than 10% of the retrieved papers, this set of contributions accounts for 47% of the total number of citations gathered by the more comprehensive set of 1555 papers. This is consistent with our aim of identifying the underlying foundations of research in this domain (e.g., McCain, 1990). The resulting set of contributions, published between 1991 and 2006, includes the most influential papers on the sources of innovation and is shown in Table 1.<sup>6</sup>

<sup>3</sup> We excluded journals published in the area of Information Systems, as they were outside the scope of our research. Results of a robustness check including journals belonging to Information Systems show the emergence of an additional stand-alone cluster of contributions in that area, interested in the adoption of information systems.

<sup>4</sup> It has to be noted, however, that the coverage of abstracts in the Social Science Citation Index commenced from January 1992. This implies that papers published before that date are searched based only on title and keywords.

<sup>5</sup> In order to account for the influence of the themes of “Open Innovation” (e.g., Chesbrough, 2003) and “Open Source” (e.g., von Hippel and von Krogh, 2003), we also performed an additional analysis by adding the keyword “open” to the list of keywords related to demand. However, since this stream of literature is relatively new, the results did not substantially change with only by two additional contributions, focusing on openness to networks of suppliers rather than demand. Consequently, we did not include the keyword “open” in our search, consistent with the aim of identifying the most cited, established and hence relevant papers for our focus.

<sup>6</sup> As robustness checks, we replicated all the multivariate analyses on panels of factors defined in alternative ways (e.g., using weighted citation scores or Herfindal indexes rather than un-weighted citation scores; looking at only top journals or

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