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## Technological Forecasting &amp; Social Change



# Information technology and external search in the open innovation age: New findings from Germany

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## ARTICLE INFO

## Article history:

Received 6 July 2016

Received in revised form 20 December 2016

Accepted 30 December 2016

Available online xxxx

## Keywords:

Information technology

External search breadth

External search depth

External knowledge sources

Digital innovation

Collaborative innovation

Open innovation

## ABSTRACT

In light of the fact that firms increasingly use information technology (IT) for open innovation initiatives, this paper explores how IT investment influences their external search from multiple perspectives: breadth, and depth along vertical, horizontal and societal dimensions. The basic premise is that IT investment has inverted U-shaped relationships with external search breadth and depth. On the one hand, IT investment enhances firms' ability to acquire more information from external knowledge sources. On the other hand, however, IT investment can bring abundant information from external knowledge sources to firms, making it increasingly difficult to widely and deeply use the information from available sources. Beyond a certain threshold, excessive IT investment is likely to cause information overload, forcing firms with limited attention to narrow down and go less deeply into their external knowledge sources. By using a large-scale panel data set from German firms, we find empirical evidence corroborating our theory.

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## 1. Introduction

In today's fast-changing markets, knowledge plays a central role in the creation of innovation opportunities and competitive advantage (Grant, 1996; Dong et al., 2017; Dong and Yang, 2016; Messeni Petruzzelli and Savino, 2014; Nonaka, 1994; Nonaka and Takeuchi, 1995; Wang et al., 2016). To overcome the limits of a firm's internal knowledge, external knowledge sources are often needed to complement own cognition and competences (Chesbrough and Crowther, 2006; Nonaka and Takeuchi, 1995; Savino et al., 2017). As a result, open innovation is indisputable to search for external knowledge on global scale (Chesbrough, 2003; Hagedoorn, 2002; Kovács et al., 2015; Martini et al., 2016). In the open innovation research, the concept of external search has been used to address this practice (Laursen and Salter, 2006, 2014).

External search has been examined from different perspectives such as breadth and depth (Katila and Ahuja, 2002; Laursen and Salter, 2006), where external search breadth reflects how widely a firm uses external knowledge sources and external search depth reflects how deeply a firm uses external knowledge sources. Although past research has documented that external search breadth and depth are positively

associated with innovation performance (e.g., Foss et al., 2013; Laursen and Salter, 2006, 2014; Leiponen and Helfat, 2010, 2011; Rosenkopf and Almeida, 2003; Rosenkopf and Nerkar, 2001), prior work has paid little attention to the antecedents of external search breadth and depth. This is an important gap in the search literature. If external search breadth and depth are critical for innovation, it is unclear what firms can do to enhance them. Given the fact that external search has become a common practice across industries, it is of great importance to enrich our understanding about the antecedents of external search breadth and depth.

Firms need to invest considerable amount of resources in search for external knowledge (Laursen and Salter, 2006; Savino et al., 2017). Whether such investment for external search, however, pays off is also unclear in the search literature. Information technology (IT) has been recently found as a key resource input to firms' innovation activity (e.g., Dong and Wu, 2015; Joshi et al., 2010; Kleis et al., 2012; Tambe et al., 2012; Xue et al., 2012). In particular, firms' IT investment has been found to be associated with their absorptive capacity to acquire external knowledge (Dong and Yang, 2015; Joshi et al., 2010; Roberts et al., 2012). For example, firms such as Proctor & Gamble (Huston and Sakkab, 2006), Dell and Starbucks (Dong and Wu, 2015), open themselves up to a wide range of external sources of ideas by investing in all kinds of IT resources. While it has been shown that IT investment is critical for innovation performance, how IT investment influences external search – the missing link that generates the innovation

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performance, especially the breadth and depth of external search respectively, is unclear.

This paper aims to fill these gaps by theorizing and empirically examining the nuanced impacts of IT investment on external search breadth and depth. We not only distinguish breadth and depth of external search but also extend our conceptualization of external search depth by considering vertical knowledge sources (suppliers and customers), horizontal knowledge sources (competitors), and societal knowledge sources (consultancies, universities, other research institutions, etc.) respectively, because firms that deeply use one type of external knowledge sources do not necessarily use another type deeply. Since prior literature has revealed that a firm's IT resources are complementary to each other and functional as a whole system (Aral and Weill, 2007), we focus on the overall IT investment rather than the investment in a specific technology.

We draw on the attention-based view of the firm (Ocasio, 1997, 2011; Simon, 1947) to propose that the impacts of IT investment on external search breadth and depth are likely to be of inverted U-shape. On the one hand, IT investment enhances firms' ability to acquire more information from a wider scope of external knowledge sources. On the other hand, however, IT investment can bring abundant information from external knowledge sources to firms, making it increasingly difficult to use information from available sources. Beyond a certain threshold, excessive IT investment is also likely to cause information overload, forcing firms with limited attention to narrow down and go less deeply into their external knowledge sources. We construct a large-scale panel data set from all German industries consisting of 2657 firm-year observations to test our theory. The results provide strong support for the inverted U-shaped relationships between IT investment and external search breadth and depth.

Our study makes several important contributions to the search literature. First, we contribute to the search literature by showing that IT investment is a key driver of external search breadth and depth along multiple dimensions. Thus, scholars should take this into account when conducting research on external search and open innovation and managers should be aware of the fact that too much IT investment can be as bad as too little when investing resources in search. Second, we further contribute important insights on the impacts of IT investment on external search breadth and depth, as IT investment is not the more the better but only beneficial up to a point. Excessive IT investment may do more harm than good by causing information overload, making the breadth and depth of external search decline. Finally, we enrich the empirical evidence in the search literature by utilizing a relatively new data source from Germany, complementing past research based on the data from Belgium (Cassiman and Veugelers, 2002), Denmark (Foss et al., 2013), Finland (Leiponen and Helfat, 2010, 2011), The Netherlands (Poot et al., 2009), the U.K. (Laursen and Salter, 2006, 2014), and the U.S. (Rosenkopf and Almeida, 2003; Rosenkopf and Nerkar, 2001).

The rest of paper is organized as follows. In the next section, we theorize the impacts of IT investment on external search breadth and depth and develop associated hypotheses. We then describe the methods used in this study. Furthermore, the results are presented. Finally, we discuss the theoretical and managerial implications, as well as limitations and directions for future research.

## 2. Theory and hypotheses

### 2.1. External search breadth and depth

Open innovation model highlights the interactive nature of firms' innovation process, suggesting that innovative firms rely on their interaction with external parties in the environment (Chesbrough, 2003). It also proposes that the advantages that firms gain from internal R&D will decline as many innovative firms spend little in R&D and succeed in innovation by drawing on knowledge from a wide scope of external

sources. Therefore, a firm's openness to its external environment improves its ability to achieve and sustain innovation. A central move toward open innovation model is a change in the way firms search for new ideas from internal sources to external sources.

Multiple perspectives exist in the search literature. In the open innovation context, a firm needs to search more widely and deeply to leverage external knowledge sources that are critical for its innovation. Accordingly, Laursen and Salter (2006: 134) developed the concepts of *external search breadth* defined as "the number of external sources or search channels that firms rely upon in their innovative activities", and *external search depth* defined as "the extent to which firms draw deeply from the different external sources or search channels". These two concepts jointly represent firms' openness to external environment, with a focus on search channels, such as suppliers, customers, competitors, consultancies, universities and other research institutions, etc., reflecting the variety of channels used by a firm in its external search. Each channel is deemed as a separate search spectrum encompassing distinct norms, habits and rules, requiring different practices to render the search effective (Laursen and Salter, 2006).

We extend this typology of external search by further considering different dimensions of external search depth, which involves distinct interaction with different external parties. Unlike external search breadth simply reflecting the scope of available sources, external search depth can be multi-dimensional. Firms that deeply use one type of external knowledge sources do not necessarily use another type deeply. Following Cassiman and Veugelers (2002) and Poot et al. (2009), we distinguish *vertical*, *horizontal* and *societal* dimensions of external search depth, as vertical knowledge sources include suppliers and customers, horizontal knowledge sources include competitors, and societal knowledge sources include consultancies, universities and other research institutions, etc.

### 2.2. IT investment and external search breadth

Open innovation model highlights that fact that the network of relationships between a focal firm and its external environment plays an important role in shaping innovation (Laursen and Salter, 2006). IT investment is a key input to building a knowledge network as it allows firms to improve their absorptive capacity to acquire external knowledge (Dong and Yang, 2015; Joshi et al., 2010; Roberts et al., 2012), through, but not limited to, establishing relationships (Rai and Tang, 2010; Rai et al., 2012), improving communication (Barua et al., 2004; Malhotra et al., 2005), and better integration (Rai et al., 2006; Saraf et al., 2007). IT investment also makes a firm in favor of external search as the eased knowledge transfer can substantially lower the information deficiencies (Li et al., 2006) and the possibility of opportunism occurring (Brynjolfsson et al., 1994), thereby enhancing the trust to exchange knowledge between the focal firm and external parties. Firms with greater IT investment are therefore likely to get access to a wider scope of external knowledge sources.

The attention-based view suggests that the firm can be seen as a system that structurally distributes attention (Ocasio, 1997, 2011; Simon, 1947), where attention refers to the ability to process differential sources of information and simultaneously extract information that is useful for certain tasks (Garcia et al., 2000). This view has acknowledged that managerial attention is the most precious resource in the firm (Dong, 2016), and the allocation of attention is a key factor in explaining why some firms can successfully adapt to environmental changes through innovation (Laursen and Salter, 2006). The decision makers in firms, therefore, need to "concentrate their energy, effort and mindfulness on a limited number of issues" (Ocasio, 1997: 203). With increasing external knowledge sources due to IT investment, they are processing more and more information and may find it more and more difficult to handle new external knowledge sources. When IT investment is excessive, they may be even overwhelmed as a result of information overload, and have to narrow their attention down to a smaller number of

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