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Insights into relationships between disruptive technology/innovation and emerging technology: A bibliometric perspective

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ABSTRACT

“Disruptive technology & disruptive innovation” have been of scholarly interest for years, but there is still a need to better understand the nature of disruptions and their relationship to emerging technology processes. This paper pursues these issues by analyzing the interplay of technological emergence, disruption, and innovation. Applying bibliometric methods, the paper explores the conceptual foundations, themes, and research communities within these research domains. The results highlight the multiple theoretical foundations of research around technological change processes, disruption, and emergence. These differences among the domains invite conceptual cross-fertilization and consideration of interdisciplinary approaches to technological (and commercial) emergence.

1. Introduction

In traditional conceptual frameworks, disruptive innovation (DI) could occur in any established marketplace as a result of technological or non-technological factors (Christensen, 2003; Christensen and Leslie, 1997). If a certain technology plays a critical role in a disruptive innovation, it could be defined as “disruptive technology (DT)” (Bower and Christenson, 1995). Disruptiveness in innovation and technology is complex and not fully understood (Christensen et al., 2015; Danneels, 2004). The relationships between disruptive technology/innovation and emerging technology (ET) are seldom compared and discussed in prior literature. Those literatures have not extensively addressed possible differences between DT and DI and ET, and ambiguous usages for a specific technology (e.g. nanotechnology, big data, etc.) often occurred in past decades (Fan et al., 2015; Linton and Walsh, 2008). Understanding the complexity and theoretical foundations starts by reexamining the individual contemporary streams of academic literature. Understanding the academic perceptions of disruptions—through analyzing the relationships among technological emergence, disruption, and innovation processes—allows furthering the research agenda and clarifying the conceptual ambiguities. “Emerging technology,” “disruptive innovation” and “disruptive technology” have evolved as frequently used concepts in scientific literature on management and

Science, Technology & Innovation (“ST&I”) policy analysis. In many contexts, including academic and professional literature, the “entangled” usage of these concepts may obfuscate their meaning to researchers and practitioners. A case in point is made by searching the Web of Science (WOS) to reflect how several timely technologies are presented as either emerging or disruptive—depending on the theoretical vantage points of the authors.

Table 1 raises interesting questions:

- If each of these technologies can be addressed as emerging technology (“ET”) or disruptive technology (“DT”),¹ do these terminologies have the same connotations?
- Is there an evolving relation between ET and DT—i.e., a specific technology could become a DT, starting from an ET role, over a period of time, or vice versa?
- Are there research communities that prefer using ET rather than DT, or vice versa, and why?
- Based on the intellectual structures composed within each domain (ET and DT), are there any unveiled intersections, significant differences, or research blind-spots? Do differing intellectual structures convey important attributes of technological frontiers?

Although the terms have been used since the 1990's and widely

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¹ “For this discussion, we distinguish DT; later we combine to treat Disruptive Technology/Innovation.”

Table 1

Count of publications in selected emerging or disruptive technologies using either an emerging or disruptive technology framework.^a

	Emerging technology	Disruptive technology
Nanotechnology	354	15
Big data	10	7
Internet of things	19	1
Electric vehicle	31	1
3D printing	13	6

^a Indexes = SCI-EXPANDED, SSCI, A & HCI, ESCI; Timespan = 2006–2015.

adopted in the literature, exploration of the differences and relevance of the concepts of ET and DT is limited (Markides, 2006). Focusing on DT in particular, our theoretical understanding of the impact of new technology and when emergence turns to disruptions is scarce. This prompts questions: Which vantage point should we adopt to understand the terms? Are conceptual differences between these entities sufficient to consider them as separate topics?

This study uses a bibliometric approach to analyze ET and DT/DI concepts to clarify the conceptualizations and present possible implications for best treatment of emerging technology processes. Using co-citation analysis and bibliographical coupling, the study looks at Web of Science (“WOS”) publication data on ET and DT/DI. The study finds clear, but weak, linkages between the concepts emanating from each domain. From a theoretical standpoint, the concepts remain mostly separate. As operational concepts ET and DT/DI have significant linkages.

2. Literature review

Since the 1990's, the concepts “emerging technology” and “disruptive technology” have become frequently used, but seldom analytically evaluated for possible overlaps. We suspect that casual usage of these concepts is frequent, especially in engineering and management literatures.

2.1. Disruptive technology

Disruptive technology can be defined as “...a technology that changes the bases of competition by changing the performance metrics along which firms compete.” (Bower and Christenson, 1995; Danneels, 2004). Yu and Hang (2010) review the concepts of DT tracing the origins of this mainstream theory from Schumpeter (1942), McKinsey and Foster (1986), and Henderson and Clark (1990) to the seminal work of Christensen (Bower and Christenson, 1995; Christensen and Leslie, 1997; Christensen and Overdorf, 2000). The concept of DT itself was introduced in the late 1990s, later modified by Christensen (2003) to disruptive innovation (DI) to more holistically include not only technological disruptions. Since then, DT seems to have been increasingly absorbed into the conceptualization of DI (Christensen et al., 2002, 2015; Christensen and Overdorf, 2000; Danneels, 2004). In the past three years, in Fig. 1, articles related to disruptive innovation (DI) have increased faster than articles related to DT. It is unclear if this is due to researchers just shifting terminology or if this is the result of true theoretical differences, such as can be identified between the innovation system and technological innovation system literatures (Suominen et al., 2016).

The terminological confusion highlights the conceptual ambidexterity and ongoing dialogue about the theory behind the DT and DI concepts (Yu and Hang, 2010, 2011). As noted by Markides (2006), there are different types of DI and disruptive technological innovation is only one manifestation of a disruption. Markides highlighted that to lump business-model, product and technological disruptions as one is probably a mistake. What is clear is that the literature struggles to distinguish between the concepts of DT and DI. For example, in the

review by Yu and Hang (2010), DT and DI are used synonymously throughout the text. Due to this ambiguity, it seems unavoidable that any analysis of DT spills over to touch upon DI aspects. We are unsure if the terms should be regarded as segmental, hierarchical, or synonymous.

2.2. Emerging technology

The ET concept targets various characteristics, including the potentially dramatic impact a new technology has on the socio-economic system, significant uncertainties, and novel features (Boon and Moors, 2008; Martin, 1995; Porter et al., 2002; Small et al., 2014). In a literature review, Rotolo et al. (2015) integrated prior work from several authors to present a conceptual framework of emerging technology with the five characteristics of *radical novelty*, *relatively fast growth*, *coherence*, *prominent impact*, and *uncertainty & ambiguity*.

Actually, the relevant literature on ET is much more than the literature related to DT and DI, the time sequence of articles on ET is shown in Fig. 2, which depends on a similar topic search to that used in Fig. 1.

Basically, ET sounds more popular than DT and DI, and seems more frequently used in different disciplines. However, DT and DI are not equal to ET, and the differences of conceptual definitions between DT and ET seem significant; furthermore, the linkages between DT & DI and ET could be interesting and valuable. Rotolo et al. (2015) made an effort to synthesize from various definitions of ET and to highlight the multiple domains of research where the concept has been used. The authors found explicit definitions of ET applied in various different domains, such as science and technology policy, management, economics, and scientometrics. Partly due to the large number of domains that have adopted the concept, viewpoints are extensive. Hung and Chu (2006) and Porter et al. (2002) take a science policy view to emergence and focus on the economic influence and impact on competition brought on by novel technologies. Both Hung and Chu (2006) and Porter et al. (2002) look at impacts at a macro-level, linking to a broad base of literature, such as Martin (1995), who posited ET as technology with broad societal impacts.

Another viewpoint on ET emerges in the marketing and management literature, in which emergence is often observed from a technological adoption perspective. For example, Li (2005) accentuates the impacts of network externalities in emerging technology markets. A micro level view is offered by Riordan and Salant (1994) who look at the dynamics of companies in adopting new technologies into their portfolios. There is also extensive literature connecting emerging technologies to innovation management, such as Cozzens et al. (2010), who move the discussion more towards technology management. To a significant extent, literature uses ET as an operational concept rather than a theoretical one – i.e., how to identify and measure emergence? For example, the highly cited technological forecasting study by Daim et al. (2006) overlooks the definitional aspects of ET and limits its focus to an operational explanation of tracking technology pathways from invention to adoption. A similar operational view is also shared by Robinson et al. (2013) and Huang et al. (2014). Arguably, for much of the technology forecasting research, emergence remains a practical, operational concept.

2.3. Linkages between emergence and disruptions

Comparison of ET and DT is not prominent in the literature, although implicitly we understand the linkages of the concepts. Can a technology be disruptive but not emergent, or vice versa? Are ETs and DTs both reflections of radical change mechanisms? Do we require them to translate into innovations (practical applications)? Do we expect grand societal impacts of ETs and/or DTs? Intuitively, disruptions that are defined as technologies that shape how companies compete, and emergence, a technology with radical and prominent impact, seem

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