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Technological Innovation Research in China and India: A Bibliometric Analysis for the Period 1991–2015

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ABSTRACT Although a substantial literature on the management of technological innovation exists, several scholars argue that much of this research has been rooted in Western contexts, where key assumptions are very different from those in emerging economies. Building on this viewpoint, we investigate the current state of knowledge on technological innovation in two of the largest and fastest growing emerging economies: China and India. We undertook a bibliometric analysis of author keywords and combined different quantitative approaches – frequency analysis, cluster analysis, and co-word analysis – to review 162 articles on technological innovation published about China and India for the period 1991–2015. From the analyses, the trends in technological innovation research in the two countries and the dominant themes of discussion were identified. These themes were further classified into eight sub-themes. Our key findings indicate a near absence of research on the management of technological innovation based on India, limited volume of research on indigenous aspects of innovation, and a lack of theory-building based on these countries' contexts. Several suggestions for future research are offered based on the gaps identified.

KEYWORDS bibliometric analysis, China, cluster analysis, India, technological innovation

INTRODUCTION

There is growing recognition of China and India's emerging significance in relation to innovation (Chaminade, Castellani, & Plechero, 2014), as evident from the rise of patents (Nair, Guldiken, Fainshmidt, & Pezeshkan, 2015; Yip & McKern, 2014) and location of multinational enterprise (MNE) R&D activity (Lamin & Livanis, 2013; Li & Xie, 2011). Nevertheless, there are significant differences between China and India, as reflected in ever-widening gaps in a variety of economic and innovation indices (Cornell University, INSEAD, & WIPO, 2016; Panagariya, 2007; World Bank, 2015) and in cultural and historical legacies (Hempel & Sue-Chan, 2010; Nair et al., 2015). These would lead us to expect differences in

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the two nations' approaches to product and technological innovation (Lam, 2000; Landes, 1998).

To date, however, there have been limited attempts to study whether, and to what extent, the emergence of China and India is reflected in the mainstream literature on the management of technological innovation, and what are their points of convergence and divergence. A couple of recent exceptions are the studies by Nair et al. (2015) and Chatterjee and Sahasranamam (2014), which identified emerging trends in innovation research in India. Against this backdrop, it is topical to investigate the extent of innovation management research in China and India, and the general directions of such research. Accordingly, in this article we address this research question: *how do trends in terms of the number, quality, and subject matter of research papers on the management of innovation in China and India compare with each other*? Our purpose is to elucidate the status of research on the subject in China and India, with a view to generating discussion and debate on areas that have the potential to attract researcher interest, and thereby generate new theories in the field.

Our study employs bibliometric techniques and quantitative methods to study technology innovation research in China and India. We use several quantitative methods, including co-word analysis, cluster analysis, and frequency analysis on keywords using a dataset of 162 articles focused on innovation from China and India during the period from 1991 through 2015. Bibliometric studies help us to map a field and direct the attention of researchers, and also help us to connect scholarship with wider institutional contexts in which they are embedded (Keupp, Palmié, & Gassmann, 2012; Nag, Hambrick, & Chen, 2007). Similar studies have focused on innovation in particular geographies. For example, the study by Hoffman and colleagues (1998) surveyed the literature on innovation and SMEs in United Kingdom, while another study by Bryson and Monnoyer (2004) examined the services literature on innovation from Europe. The advantages of having such studies focused on specific geographies are that they allow us to understand the state of knowledge about the particular literature stream related to that geography, make comparisons around aspects of the literature that the scholars have focused on, and discuss unique aspects of the literature pertinent to that geography.

Our study makes a number of contributions to innovation management research in emerging economies. First, this study is among the earliest to review innovation management research comprehensively across China and India, map it, and identify knowledge gaps. Second, our work highlights a significant gap in extant studies; namely, an unfortunate omission of the indigenous traditions of China and India, and their possible links with innovation. It indicates a more general observation – the relative scarcity of novel management knowledge from emerging economies influencing the global field (Frenkel, 2008; Kipping, Engwall, & Üsdiken, 2008). Third, while our study was based on bibliometric analysis, we made two key methodological innovations. In a departure from reviews based on traditional bibliometric analysis, which generally use extant theoretical frameworks to interpret the results of mathematical analysis (e.g. Keupp et al., 2012), we

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adopted an inductive approach to aggregate the results of our cluster analysis. This circumvents a theoretical problem when it is difficult to defend the application of extant theoretical frameworks to the subject of review. This is the case in our study where we claim that the contexts of China and India are sufficiently different from Western contexts in which most conceptual advancements on innovation management have taken place. The other methodological change was to engage and discuss pioneering work on the subject more deeply than is typical in bibliometric analyses, which often limit themselves to quantitative analysis of article indices or keywords.

The article is structured as follows. After describing the methodology for the review, we analyse the 162 articles on innovation management about China and India from top-tier management journals since 1991. On the basis of the quantitative analysis of keywords, we identify trends in innovation management research, key themes on which research has focussed, and knowledge gaps that exist in our understanding of innovation in these two countries. We conclude by summarizing the findings, and contributions.

DATA AND METHODS

It has been acknowledged that journal articles are likely to have highest impact on the field (Keupp et al., 2012; Podsakoff, Mackenzie, Bachrach, & Podsakoff, 2005), and that 'established influential journals tend to shape the theoretical and empirical work by setting new horizons for inquiry within their frame of reference' (Furrer, Thomas, & Goussevskaia, 2008: 2). Accordingly, we undertook a systematic review of the literature for this study (Keupp et al., 2012; Tranfield, Denyer, & Smart, 2003), limiting ourselves to double-blind reviewed articles published in top journals in the fields of general management and innovation, and to articles related to innovation in China and India. The journals chosen for the literature review were from general management and innovation categories as listed by Association of Business Schools (ABS) journal ratings 2015. We considered the journals that are ranked 2 or above in ABS ratings. In addition, other top journals that are known to publish innovation research, such as *Strategic Management Journal*, *Organization Science*, *Management Science*, and *Journal of International Business Studies*, were also considered (Keupp et al., 2012). The entire list of journals we considered is provided in Appendix I. The period of our literature review is 1991 through 2015. The year 1991 was chosen as a cut off year because it coincides with the government policies of liberalization and economic reforms in India. China had already initiated these measures a few years earlier.

Following prior approaches to identifying relevant articles in literature reviews (Keupp et al., 2012; Rashman, Withers, & Hartley, 2009), we performed keyword searches on each of the journals and retained articles that contained different variations of the word innovation ('innova*') or technology ('technolog*') and/or any of the phrases 'R&D', 'research and development' along with the country

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names in their author-supplied keywords. We used the Scopus database for performing this keyword search. From this search, we obtained 130 articles for China and 32 articles for India.

Data Analysis

We adopted a two-tier analysis scheme for systematic evaluation. In the first part, we report the broad patterns discernible from our analysis, using trend line and frequency analysis to understand the trends in the evolution of the literature, the journals, and industrial sectors being focused. Since the count of articles is nominal, we adopt chi-square analysis to identify significant differences.

Second, we performed cluster analysis on article keywords to explore the dominant themes under discussion, to classify them, and to identify knowledge gaps in the discussion. We performed a co-word analysis on the keywords of all articles and used its results to run cluster analyses to identify clusters of related issues and topics. Co-word analysis is a content analysis technique used to reveal patterns in data by measuring the association strengths of terms representative of relevant publications produced in a field (Coulter, Monarch, & Konda, 1998). This bibliometric method is receiving increased recognition among management scholars in recent years (Furrer et al., 2008; Keupp et al., 2012; Nag et al., 2007).

We referred to the articles to cross-check on our interpretation of the keywords, and we also reduced certain keywords to their stem to consolidate different variants of the same word or words with similar meaning (Keupp et al., 2012; Rokaya, Atlam, Fuketa, Dorji, & Aoe, 2008; Tseng, Lin, & Lin, 2008). The coding scheme that we followed for joining similar terms is detailed in Appendix II. We derived a list of unique keywords for China (286) and India (84), and we calculated their absolute frequencies. We then removed those keywords that appeared only once across the articles so as to ensure that only the more important keywords entered the cluster analysis. We then carried out the cluster analysis following the methodology adopted by Keupp et al. (2012), as detailed in Appendix III. Based on the cluster analysis, we obtained a 26-cluster solution for China and a 14-cluster solution for India. These cluster solutions are presented in a separate section below.

BROAD TRENDS

A plot of the year-wise trend line of articles based on the two countries appears in Figure 1. It suggests that there has been a marked increase in the number of publications post-2000. Further, we note that in both the countries, publications reported in top management journals started at similar levels, but China has drastically overtaken India beginning in about 2000. The chi-square statistic ($\chi^2 = 59.28$, $p < 0.05$) also confirms this significant difference in the number of articles between India (32 articles) and China (130 articles).

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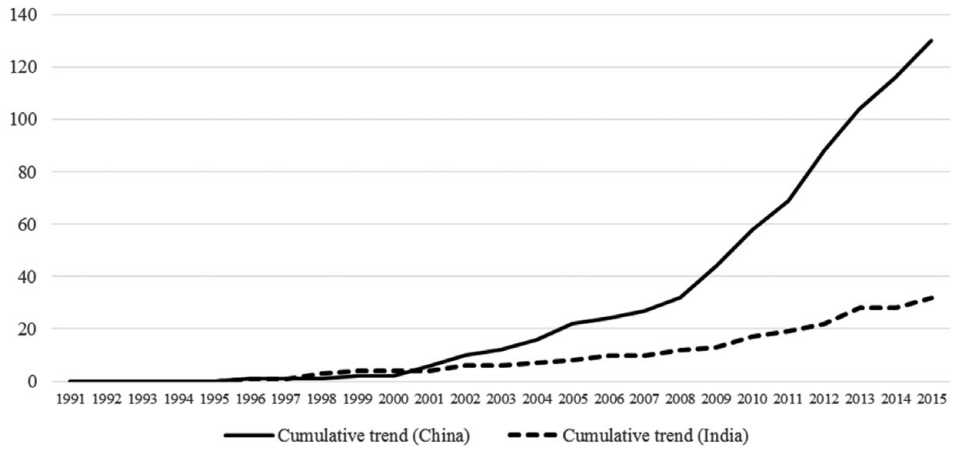

Figure 1. Year-wise cumulative trend line of articles published based on China and India

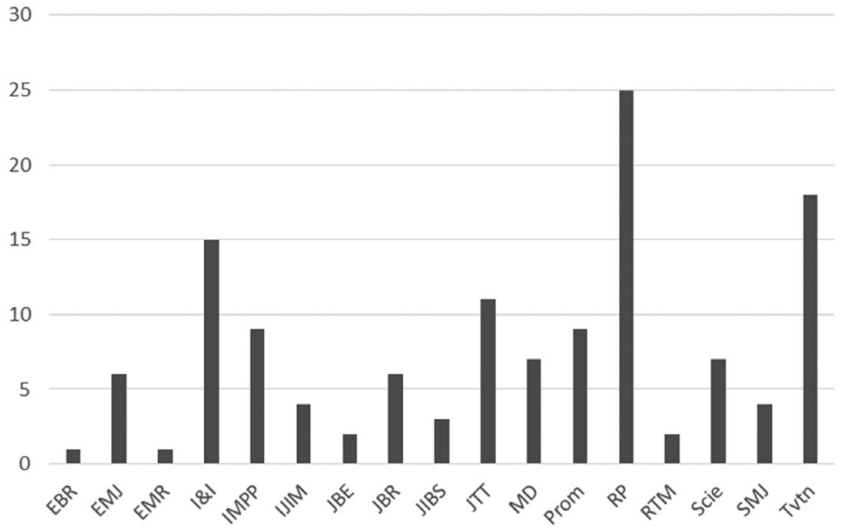

Figure 2a. Articles published by journal source[2] for China

We also looked at the trend in publication across the journals for the two countries (Figures 2a and 2b). We clearly see that more articles have appeared in innovation-based journals (all 32 for India, 100 for China) compared to other management-based journals.

We performed a frequency analysis of keywords to understand the most discussed topics on innovation in both the countries. For this, we included a cut-off (5% of the number of distinct keywords, excluding the keywords on which the search was done) to identify the top keywords for China and India. For China, they are as follows: intellectual property (26), technology diffusion/dissemination/transfer (14), and policy/economics/government (13). On the other hand, for India, the most used keywords were these: policy/economics/government (9), intellectual property (6), national/regional/sectoral innovation

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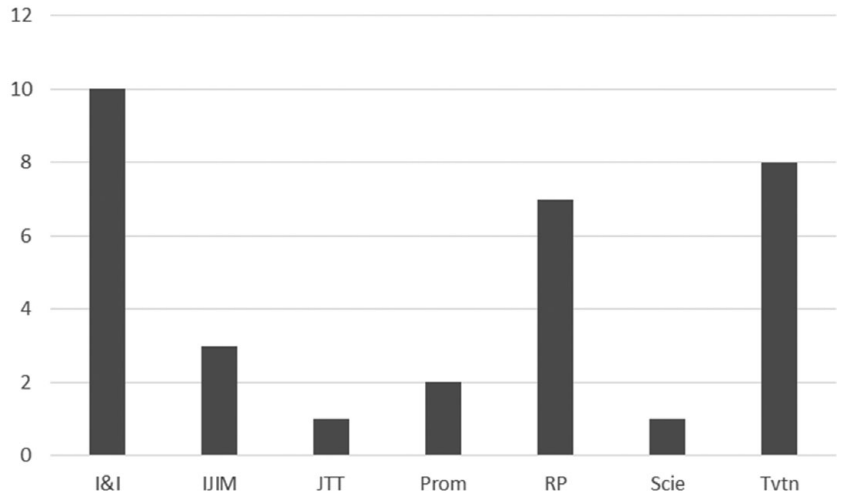

Figure 2b. Articles published by journal source for India

system (5), outsourcing/offshoring (5), and pharmaceutical industry (5). From the frequency analysis, the following are the top industries on which innovation research has focused: manufacturing industry (6) for China, and pharmaceutical industry (5) closely followed by IT/ICT/ITES (4) for India.

We make four key observations based on these broad trends. First, we note one clear discernible pattern indicating a marked increase in number of publications observed since 2000. This finding is interesting because this period occurs about two decades after China embraced policies to encourage export-oriented growth strategies, and a decade after India liberalized its economy. This suggests that economic liberalization might have had little to do with increasing the publication count. Rather, it is possible that export-led growth and the subsequent growth of several multinational companies originating in China and India might have triggered greater interest in understanding innovation in these countries. Simultaneously, another development – the dotcom boom since the 1990s and the associated growth of Indian software companies – might also have triggered this interest. Our second observation is that China clearly dominates the number of publications in the field, having published about four times as many articles compared to India, and this is probably a reflection of differences in the number of PhD degrees awarded in the two countries (Sharova, 2013). The comparatively low output from India-centric research is a matter of concern, and it calls for attention from management schools to encourage researcher interest in this field. Our third observation concerns the industrial sectors that have been studied. There is some consistency between the industries studied more frequently in a country with state of the respective industrial sector in that country (manufacturing in China, and pharmaceutical and software industries in India). Nevertheless, important strategic industries where these two countries have made significant advances, such as space science and atomic energy, are not represented. Finally,

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we find that the majority of the research from both countries have appeared in innovation management journals. However, general management journals appeal to a wider pool of scholars, have greater citation counts, and subsequently have higher impact factors, and are more likely to set directions for future research in the field. Therefore, if we assume that the amount of research reported in general management journals is an indication of conceptual development in the field, then it reflects a weakness in the field of research in both countries, although China seems to be well ahead compared to India.

MAJOR THEMES AND IMPLICATIONS

In this section, we classify the dominant themes that have been discussed and also try to explicate the knowledge gaps to offer areas for future research. These gaps in research are identified based on existing literature on the themes along with the contextual understanding of China and India. The results of cluster analysis are presented in Tables 1 (China) and 2 (India) below.

To make sense of the clusters in Tables 1 and 2 and to develop a basis for interpreting them, we organized them around broad themes, taking into account the keywords in each cluster. For this, we first examined the clusters in Table 1 and grouped them into thematically similar themes (Table 3 below). We then applied these labels to examine Table 2. We referred to the papers in those instances where we experienced ambiguity.

Table 3 suggests an interesting contrast in the 'spread' of clusters across themes in the two countries. Against this backdrop, we now examine each theme in depth, comparing and contrasting with extant literature, and highlighting issues that merit greater attention due to the specific contexts in China and India.

Theme 1. Institutions and Innovation Systems

This theme draws on research that sees technological progress as path-dependent (Kenney & Von Burg, 1999; Ruttan, 1997), predicted by inputs from basic scientific research (Fleming, 2001; Fleming & Sorenson, 2004), and hence, influenced by various institutions and innovation systems. Central issues within this theme are the governance of science and science-technology relationships (Drori, Jang, & Meyer, 2006; Fuller, 1999; Whitley & Gläser, 2008), and conditions that enable innovators to appropriate rents on innovation by creating barriers to imitation, appropriation or value capture (Teece, 1986).

The institutional view and the innovation systems approach are slightly different theoretically (Lundvall, 1999). The institutional view considers the institutional setup as given and as an exogenous variable, whereas an innovation systems approach considers the interaction between the innovation-related institutional agents. The research questions under this theme have been addressed through various perspectives such as national innovation systems (Mowery, 1998; Nelson,

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Table 1. Keyword cluster table for China

Cluster No.	*Keywords (frequency count)*
1	Absorptive capacity (4), new opportunity/new product (2)
2	Intellectual property (26), technological learning (4), technology licensing (8)
3	foreign direct investment (6), spillover (3)
4	Diffusion (2), frugal/indigenous/low-cost innovation (2), international collaboration (3), learning (3)
5	Entrepreneurship (9), exploration and exploitation (2), transition economy (5), venture capital (2)
6	IT/ICT/ITES (4), management control (2)
7	R&D investment (3), product innovation (4)
8	Performance (3), regions (4), research/academic collaboration (2)
9	Business (3), universities/research institutes (2)
10	Agricultural sector (3), evolution (2), innovation capability (3), national/regional/sectoral innovation system (7)
11	Collaboration (2), clusters (2), culture (3), knowledge diffusion/exchange/sharing/transfer (4)
12	Networks (10), technological innovations (3)
13	Asia (2), catch-up (5), emerging economies (7), India (5), Europe (2), technology diffusion/dissemination/transfer (14), science/technology parks (2)
14	Business groups (4), innovation (34), institutions (11), state ownership (3) policy/economics/government (13)
15	Cooperation (2), innovation system (6), R&D (14), science and technology (6), Taiwan (4)
16	High technology industry (4), imports (2)
17	Internationalization (7), outsourcing/offshoring (2)
18	Competition/competitive advantage (3), medicine (2), strategy (7), technological development (3)
19	Higher education reform (2), university-industry linkage (4)
20	Corporate governance (2), innovation performance (8), ownership structure/type (3), technological capabilities (2)
21	Advanced manufacturing technology (2), manufacturing (6), operations (2)
22	Emerging technology (2), SMEs (3), United Kingdom (2), United States (3)
23	Energy (3)
24	Internet (8)
25	Teamwork (2)
26	Cross-border ownership of inventions (2), developing countries (4), gravity model (2), international technology sourcing (2)

1993), regional innovation systems (Chung, 2002; Cooke, 2002), and triple helix framework (Etzkowitz & Leydesdorff, 2000; Leydesdorff & Etzkowitz, 1996).

This theme is represented in both countries by several keywords related to institutions and innovation systems (Table 3). Within this theme, the evolution of Chinese policies and institutions related to innovation and to the role of the government has been researched in several studies. For example, Liu, Simon, Sun, and Cao (2011) focus on how S&T and industrial policy-centered innovation strategy have become strengthened through a departure from a top-down approach driven by a single government agency, and also by broad-basing through financial, tax, and fiscal incentives. Gu (2009) analyzed the role of the government in the evolution of market institutions, technological and knowledge regimes.

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Table 2. Keyword cluster table for India

Cluster No.	*Keywords (frequency count)*
1	Biotechnology (2), health care (2), medicine (2), technological development (3), technology policy (2)
2	Competition/competitive advantage (3), policy/economics/government (9)
3	Capabilities (4), emerging markets (4), internationalization (3), learning (3), outsourcing/offshoring (5), path-dependency/routines (2)
4	Catch-up (3), national/regional/sectoral innovation system (5)
5	Entrepreneurship (2), technology diffusion/dissemination/transfer (3)
6	SMEs (2)
7	Energy (3)
8	Developing country (7), new opportunity/new product (3), pharmaceutical industry (5), R&D management (3)
9	Frugal/indigenous/low-cost innovation (2)
10	Clusters (2), IT/ICT/ITES (4)
11	R&D (3), technology sourcing (2)
12	China (3), Innovation (8), Intellectual property (6)
13	Institutions (2)
14	Liberalization/globalization (2), R&D expenditure (2)

Table 3. Broad themes to organize research on innovation in China and India

	Broad theme	China	India
1	Institutions and innovation systems	2, 10, 14, 15	1, 12, 13 & 14
2	Technology upgradation	1, 13	4
3	International linkages	3, 16, 17, 22, 26	3
4	Connections and innovation	11, 12	10
5	Management of innovation	6, 18, 20, 21, 25	2, 8, 11
6	Universities and innovation	8, 9, 19	
7	Entrepreneurship	5	5, 6
8	Indigenous innovation forms	4	9

Various studies have investigated the contextual background of institutions in China, such as the impact of local governments and *guanxi* (Liu, Woywode, & Xing, 2012), variations in national objectives, and industrial and political environments affecting innovation policies (Anadón, 2012), and the nature of interactions between institutions (Chang & Shih, 2004). The particularities of the Chinese institutional context also highlight the limitations that still need to be overcome to encourage an enterprising national innovation system, robust intellectual property rights regime, and developing talent for creativity and innovation (Cao, Simon, & Suttmeier, 2009). These considerations also foreground the pervasiveness of social capital in the Chinese context when compared to a market economy (Luk et al., 2008), and of the complementarities between business groups and institutions (Wang, Yi, Kafouros, & Yan, 2015).

Studies on India present a mixed picture of uniqueness and successes of Indian innovation efforts, as well as deep concerns. Among the antecedents are exogenous

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changes such as GATT and economic liberalization that have changed the profile of India's technology imports (Sikka, 1996) and TRIPs compliance that has favored innovation and export quantity but not value (Bouet, 2015). We find an absence of studies on institution-building, with the exception of one study on the challenges of venture capital development in the initial days (Pandey, 1998), and we suggest the need for more such studies to develop deeper historical and contextual understanding of innovation-related institution-building in the Indian context. Among the concerns raised about India's innovation capabilities are the lack of linkages between science and technology capabilities for development (Mouly & Sankaran, 1999), and challenges before India's innovation capacity at the national and regional level (Sharma, Nookala, & Sharma, 2012). Mytelka's (2006) study emphasizes the multiplicity of approaches to address the same concern (here bio/pharmaceutical innovation systems) and the interaction of different types of policies.

A few studies compare China and India. Vecchi, Della Piana, and Vivacqua (2015) show that China far outperforms India on several measures of innovation, but also highlight interesting differences between the two countries in policy environments that tend to favor a conservative approach among Chinese businesses, but a more resourceful and creative approach among Indian counterparts. Plechero and Chaminade (2013) analyze data on Chinese and Indian firms to present three routes to globalization of innovations from these firms; namely, global exploitation of innovation, global sourcing of technology, and global research collaboration. The research by Godinho and Ferreira (2012) compares IPR data of the two countries to show that should present trends continue, they would be able to catch up with advance economies in the near future.

In terms of the sectors studied, the presence of agriculture (and not manufacturing) is surprising for China. For India, health care and related sectors are not unexpected, although the absence of IT and related areas is surprising. It is evident that studies generally seem to suggest more vigorous efforts underway in China in building institutions and innovation systems than in the case of India. Nevertheless, the studies also report limitations both in China and India. Further, the lack of studies on the subject in India is noteworthy. Overall, therefore, we suggest greater researcher interest in the causes and consequences of absence of institutions, or weakness of existing institutions and innovation systems in both China and India, but particularly for India.

As China and India develop economically, their historical legacies, political systems, large populations, demographic profile, environmental challenges, and pressure on natural resources are some issues that foreground the need for specific institutional responses to channelize technological innovations in predetermined directions. In this context, we suggest that inputs from literature on institutional voids is a potential avenue to explore, given the copious research in strategic management on the *absence* of institutions that are taken for granted in developed economies. This institutional voids stream has essentially examined

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how organizations respond to the absence of institutions that are supposed to facilitate business (Khanna & Palepu, 2000, 2006). Indeed, it has been noted that the institutional voids afford opportunity to organizations to change institutions (Mair & Marti, 2009; Mair, Martí, & Ventresca, 2012). Further, business groups have been studied as one organizational response to cope with institutional voids (Khanna & Palepu, 2000). Yet, we note that the term 'institutional void' is absent in the list of keywords in our sample. Also, the term 'business groups' appears in the Chinese list, but not in the Indian list. In China and India, we also find that certain strategic industries like space, defense, and atomic energy have developed significant innovations like *Mangalyaan* and *Chang'e 3*. This calls for future research to understand how such innovations were made possible despite significant institutional voids. Hence, there is a strong case for examining the nature of institutional voids that influence innovations in China and India, and organizational and policy responses towards such institutional voids.

Theme 2. Technology Upgrading

Emerging economies have a strong incentive to upgrade their technological bases in order to compete with developed economies. In this regard, the role of absorptive capacity (Cohen & Levinthal, 1990) is considered crucial in the assimilation and application of the external knowledge. Empirical work on the subject has been largely restricted to commercial firms (Bertrand & Mol, 2013; Stock, Greis, & Fischer, 2001; Tsai, 2001) and has implicated the role of R&D intensity in the creation of absorptive capacity. Because private sector investment in R&D in China and India is still less than that of developed economies (Press Trust of India, 2014; Yingqi, 2015), other mechanisms to enhance absorptive capacity and catch-up merit investigation. In our sample, some interest on this theme is evident in the case of China (Clusters 1, and 13), while it appears to be under-researched in India (Cluster 4), represented by terms related to technology evolution, such as catch-up and absorptive capacity. The terms technology diffusion/dissemination/transfer, science/technology parks (China), and innovation systems (India) suggest some of the mechanisms studied.

The trajectory and evolution of technological catch-up are examined in multiple studies on China in our sample. Scholars have studied the role of technology assimilation (Srivastava & Wang, 2014), new product development performance (Wang & Li-Ying, 2014), firm diversification (Wang, Ning, & Chen, 2014) and innovation performance (Wang, Zhou, Ning, & Chen, 2015) in enabling inward technology licensing. Several moderators are implicated in these relationships, including the licensee firm's absorptive capacity and regional knowledge endowment (Wang & Li-Ying, 2014), licensee firm R&D expenditure and technological distance from licensor firm (Wang, Ning, et al., 2014), technology complexity and generality (Wang, Zhou, & Li-Ying, 2012), and external technological conditions relevant to the licensee firm (Wang, Zhou, Ning,

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& Chen, 2015). Variation in technology exchanges by geography (Wang, Pan, Ning, Li, & Chen, 2014) and by types of organizations such as importers, exporters, self-sustainers, active generalists, and isolationists (Wang, Pan, et al., 2014) suggests the need to understand the antecedents and outcomes of such patterns. The studies also indicate the impact of concurrent initiatives such as forward engineering, international mergers and acquisitions, and parallel learning (Lee, Jee, & Eun, 2011), technology trading markets, knowledge spillovers to R&D consortia, and government promotions (Mu & Lee, 2005). They also highlight the uniqueness of the Chinese approach that differentiates it from predecessors such as Taiwan and Korea (Lee et al., 2011). Research also points to the emerging favorable ecosystem for technology transfers to China from Western multinationals. These include stronger intellectual property protection regimes (De Meyer, 2001; Gross, 2013; Hsu, Wang, & Wu, 2013), university-industry linkages and technology transfers (Gross, 2013), a rapidly evolving financial support system (Gross, 2013; Hsu et al., 2013), government preferences for latest technology (De Meyer, 2001), and overcapacity in traditional turnkey manufacturing (De Meyer, 2001).

Among the wide range of variables implicated in this research, the study by Schmiele (2013) stands out because of the mechanism it investigates; namely, the role of intellectual property infringement in technological upgrading. Based partly on data from German firms operating in China, it suggests that increased international R&D activities, R&D in countries with weak IP regimes, and export intensity in host countries with little innovation are some of the factors associated with IP infringement. The study also suggests that international R&D by foreign firms increases the chances of losing competitiveness to local competitors abroad, thereby hinting at off-shore R&D as an important conduit for technological evolution of local firms.

Among the comparatively fewer studies on India, Kristinsson and Rao (2008) discuss India's unique approach to 'interactive learning' that favors learning and adaptation rather than imitation of foreign policies and institutions. Guennif and Ramani (2012) examine the success of the Indian pharmaceutical industry relative to Brazil's, although both started around the same time and from a similar base of lax intellectual property rights regimes, internal markets, and strong scientific manpower.

While the wide scope of these studies indicates vigorous researcher interest, we reiterate a point made above: namely, the need to understand the antecedents and outcomes of the patterns of technology improvement evident from studies on China. Further, we also suggest more investigations into the role of intellectual property (IP) infringement (Schmiele, 2013). Further, the joint consideration of 'catch-up' and 'intellectual property' presents a particularly interesting and vexing question. Should emerging economies such as China and India have strong or weak IP regimes in order to catch up with developed economies? Literature has suggested that strong IP regimes motivate firms to invest in innovation (Pisano, 2006; Teece, 1986). On the other hand, literature on technology denial also

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suggests that weak IP regimes might motivate firms to invest in moving up the value chain through imitation (Dosi, Marengo, & Pasquali, 2006; Kumar, 2003). It has also been suggested that process patent protection (i.e. not product patents) in India has been influential in developing its generic drugs industry (Chittoor, Ray, Aulakh, & Sarkar, 2008; Chittoor, Sarkar, Ray, & Aulakh, 2009), which is world-class in terms of cost effectiveness. Hence, the link between intellectual property regimes and catch-up needs to be studied more intensely in Chinese and Indian contexts than is suggested from our sample.

Theme 3. International Linkages

Liberalization in China has been led by foreign direct investment (Lee et al., 2011; Sun & Du, 2010). Similarly, India has also seen large inflows of foreign capital and technology since liberalization (Chakraborty & Basu, 2002; Feinberg & Majumdar, 2001). As China and India opened up, international linkages between indigenous and foreign firms have become important sources of capital and technology. Consequently, international linkages as a theme within the clusters in our study is important.

The studies indicate several types of international linkages, and also the main challenges associated with sourcing technologies. To understand this theme better, we reorganized all the keywords in these clusters into four groups. The first group represents issues related to the broad strategic directions for international linkages: international technology sourcing, outsourcing/offshoring, internal collaboration, imports, internationalization, outsourcing/offshoring, cross-border ownership of inventions, and foreign direct investment. The second group involves the type of industries/sectors studied – high technology industry, emerging technology, small and medium-size enterprises (SMEs). The locations or geographies involved in international linkages, such as developing countries, emerging markets, the United Kingdom, or the United States, constitute the third group. Finally, the fourth group is about outcomes of linkages, such as spillover, capabilities, learning, and path-dependency/routines.

Several studies on China have explored the strategies and motivations driving international linkages of foreign MNCs (multinational corporations) and Chinese firms. Studies on foreign MNCs indicate a range of strategies in R&D investments in China – knowledge exploitation versus knowledge augmentation (Liu & Chen, 2012), developing new markets versus enlarging existing ones (Chen & Reger, 2006), protection of one's own IPR versus developing new competencies (Li & Xie, 2011), owning laboratories versus engaging in cooperative joint ventures (Li & Xie, 2011), transferring hardware versus transferring innovation skills (Lan & Young, 1996), and market coverage versus protection against competitive threats (Hu, 2010). The influence of the local context is evident in the link between regional innovation systems and local networks (Liu & Chen, 2012), and in the strength of intellectual property regimes and factor markets (Li & Xie, 2011) on

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firm innovation strategy. The impact of industry is evident in knowledge spillovers from foreign MNCs and local Chinese firms (Motohashi & Yuan, 2010), while FDI driven & indigenous innovation models is found to influence the path of technological innovations (Wong & Yap, 2011).

In comparison, the number of studies investigating outflows of technology from China are fewer. Among the exceptions are the studies by Di Minin, Zhang, and Gammeltoft (2012) and Nepelski & De Prato (2014). The former study investigates Chinese companies' R&D investments in Europe and points to differences between their processes and those by developed-country multinationals. Nepelski and De Prato (2014) highlight the motivation of Chinese enterprises to acquire property rights over foreign inventions, linkages with firms in small and developing economies, and constraints from geographic distance in technology flows out of China.

In the Indian scenario, comparative case studies of Indian R&D subsidiaries of foreign firms indicate differences as well as similarities on a range of variables (Brem & Freitag, 2015). Successful identification and implementation of new business opportunities is facilitated by knowledge of the overall business context, the offshore context, and the process of internationalization, thereby emphasizing the need for cross-cultural integration and alignment of offshore operations with home country priorities (Angeli & Grimaldi, 2010). Parida, Wincent, and Kohtamäki (2013), through their comparative case study of two Swedish multinational companies, highlight the importance of 'improvisational learning' during various stages of establishing offshore R&D operations, while Bardhan and Kroll's (2006) comparative study of Russian and Indian software industry highlights the importance of industry organizations and nonmarket state institutions in explaining structural differences in outsourcing. These few studies indicate a stress on case studies to develop conceptual understanding and indicate a potentially rich field to study the role of cross-cultural management as well as the relative roles of state and non-state actors in facilitating international linkages.

There are also studies that compare Indian and foreign firms. Valuation of R&D is higher in India when compared to the US or Europe, and it is much higher for Indian firms than foreign firms invested in India, although the difference is smaller in science-based industries (Chadha & Oriani, 2010). Although average R&D levels have decreased, evidence is presented of rationalization and more efficiency of R&D spending, which rises faster with firm size and is directed toward assimilation of technology imports and toward support of exports (Kumar & Aggarwal, 2005). Both studies (Chadha & Oriani, 2010; Kumar & Aggarwal, 2005) also highlight the different profile of R&D pursued by Indian firms and subsidiaries of foreign multinational enterprises. These studies indicate a need to investigate the specific approaches adopted by Indian firms as opposed to foreign subsidiaries to improve returns on R&D investments.

As mentioned above, this theme has seen extensive and diverse interest with regard to China. However, the sparse literature around India is a matter of

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concern, and suggests a fertile field for researchers. In addition, we would suggest one potential area of inquiry that has been overlooked – the flow of technology *from* China and India to other countries. As mentioned above, barring a few exceptions in studies on China (Di Minin et al., 2012; Nepelski & De Prato, 2014), studies on this aspect are lacking. Yet, in certain sectors, such as atomic energy, space exploration and defense, both countries have had robust technology development programs for several decades (Cao, 2004; IANS, 2015; Indian National Science Academy, 2001). While these programs have largely been confined to domestic requirements, increasingly, both China and India are interested in exporting some of these technologies. Further, technologies related to commercial products coming out of China and India are becoming competitive globally. Some examples are electronics, and especially technologies related to mobile phones and consumer durables from China (Price, 2015), automobiles from China (Heilmann, 2016) and India (Hutton, 2013), and drugs and pharmaceuticals from India (Chittoor & Ray, 2007). Additionally, many multinational organizations have set up R&D facilities in these two countries to develop products and technologies for Chinese and Indian markets (Lamin & Livanis, 2013; Li & Xie, 2011), and also for exports. In this context, the concept of reverse innovation (Govindarajan, 2012; Immelt, Govindarajan, & Trimble, 2009) foregrounds instances such as General Electric's ECG machine which was first adopted in emerging economies before being exported worldwide. Therefore, we foresee the possibility of very interesting research to understand the forms of technology *outflows* from China and India, and the social, cultural, and political mechanisms that are likely to ensure the acceptance of such technologies.

Theme 4. Connections and Innovation

Research on this theme, in general, has proceeded along several directions to examine the influence of different types of connections on innovation. These include knowledge spillovers between firms (Vanderwerf, 1992), inter-firm alliances, collaborations and networks (Ahuja, 2000; Kogut, 1988; Narula & Hagedoorn, 1999), the role of users (von Hippel, 1986) and open innovation (Chesbrough, Vanhaverbeke, & West, 2006). The various aspects studied include information flows across firms (Podolny, 2001; Soh, Mahmood, & Mitchell, 2004), diffusion of practices through imitation (Westphal, Seidel, & Stewart, 2001), joint problem-solving (Midgley, Morrison, & Roberts, 1992), increased specialization and division of labor (Saxenian, 1991), the incentives for firms to collaborate (Arora & Gambardella, 1990; Lai & Chang, 2010; Zhang, Baden-Fuller, & Mangematin, 2007), and the motivation of buyers and users to innovate (Franke & Shah, 2003; Jeppesen & Frederiksen, 2006; Lerner & Tirole, 2002). Further, one perspective on this subject that has generated considerable research attention is that of social capital (Nahapiet & Ghoshal, 1998; Tsai & Ghoshal, 1998). The essential argument here is that the nature of connections between actors in a network, as well as the

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nature of networks themselves, influences important organizational outcomes such as innovations. Thus, weak and strong ties impact knowledge sharing differently (Hansen, 1999; Tiwana, 2008).

Given the extent of research that has developed around collaborations, networks and innovation, there is considerable scope to expand research on this theme in the context of China and India. In our sample, clusters 11, and 12 (China) and 10 (India) include the following keywords: clusters, collaboration, culture, IT/ICT/ITES, knowledge diffusion/exchange/sharing/transfer, networks, and technological innovations. Together, they represent the linkage between knowledge sharing and innovation, and different types of connections such as networks and collaboration. The list suggests the limited spread of research on this subject in India when compared to China.

The studies on China indicate the importance of innovation networks in providing firms with competitive advantage (Zheng, Li, & Wu, 2013). The roles of several mediators, moderators and contextual variables are also highlighted. These include the mediating influence of technological capability and relative bargaining power (Zheng et al., 2013), the nature of regional innovation systems and the extent of networks of MNC subsidiaries within such systems (Liu & Chen, 2012), and technological embeddedness and firm innovation strategies (Liu & Wu, 2011). Leung's (2013) study stands apart by examining barriers to networks, a relatively less studied aspect. Interestingly, it is found that cross-cultural differences between Chinese researchers belonging to collectivist culture and Western counterparts having a more individualistic culture do not necessarily create hindrances (Niedergassel, Kanzler, Alvidrez, & Leker, 2011), and suggest a need to study the context of such exchanges that might lower the impact of cross-cultural differences. It is necessary to account for large sub-regional differences across China in understanding the relationship between academic collaborations with industry and firms' innovative performance (Kafouros, Wang, Piperopoulos, & Zhang, 2015). Finally, a lesser number of studies have examined international linkages of university researchers. Thus, it is suggested that employing alumni from abroad doesn't necessarily result in increased intra-institutional collaborations or international linkages, but does increase publication impact factors (Li, Miao, & Yang, 2015). Increased participation in global scientific networks resulted in depressed international collaboration rates initially when China started participation in such networks, but the rates subsequently picked up with scientific advances in the country (Mehta, Herron, Motoyama, & Appelbaum, 2012).

Clusters provide firms with opportunities to benefit from spillovers. Taking this argument further, it is seen in Indian studies that firm decisions to locate in single or multiple clusters are related to cluster density, requirement for creative talent, and firms' founding in places other than origin of CEO (Dhandapani, Upadhyayula, & Karna, 2015). Madanmohan, Kumar, and Kumar's (2004) comparative study between India and Indonesia indicate that firms' ability to enhance their technological capabilities through technology imports is influenced

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by their R&D investments, availability of suitable technical talent, channels for technology transfer, government support, and supporting organizational culture. However, the study cautions that importing technology only to improve production or quality doesn't improve technological capabilities. Narayanan and Bhat (2011) examine whether advantages such as ownership of tangible and intangible assets, location, human and natural resources, and ability to internally produce technologies explain international expansion of Indian MNCs. From their study of Indian software firms, they find that in-house R&D efforts, firm size, and export intensity are important in this regard.

In light of the aforementioned studies, an important subject that remains relatively less explored in the context of China and India is whether their particular cultural context might influence the nature of connections, and how this might affect innovations. While we could identify one study on how cross-cultural differences influence international collaborations (Niedergassel et al., 2011) in China, we see considerable scope to pursue this theme further. In particular, we suggest more research into the cultural aspects driving inter-organizational connections, as previous studies have already hinted at the influence of national identities on firm HR policies (Ferner & Quintanilla, 1998), and marketing (Keillor & Hult, 1999), and of religion influencing organizational actions and outcomes in a variety of international settings (Chan-Serafin, Brief, & George, 2013; Du, 2013; Parboteeah, Walter, & Block, 2015). While India is a deeply religious country (Audretsch, Bönte, & Tamvada, 2013), religion is also an important, albeit not highlighted, facet of social life in China (Du, 2013; Du, Jian, Zeng, & Du, 2014). Further, although *'guanxi'* as a topic has been well researched (Guo & Miller, 2010; Park & Luo, 2001), as are extended family ties in China (Deng, Hofman, & Newman, 2012; Liang, Li, Yang, Lin, & Zheng, 2012) and India (Ashwin, Krishnan, & George, 2015; Singh & Gaur, 2013), their influence in either moderating or mediating the link between different types of connections and innovation outcomes is potentially an important line of research.

Theme 5. Management of Innovation

This theme connects with a long line of research on the management of innovation. Expectedly, this literature has been reviewed multiple times in the past on different aspects of technological innovation. These include product development (Brown & Eisenhardt, 1995), success and failure of innovations (van der Panne, van Beers, & Kleinknecht, 2003), innovation in the manufacturing sector (Becheikh, Landry, & Amara, 2006), and strategic management of innovation (Keupp et al., 2012). The review by Ahuja, Lampert, and Tandon (2008) is remarkable in terms of its comprehensiveness. Schumpeter's (1942) seminal work relating firm size and market structure to innovation has led to a core hypothesis that innovation increases more than proportionately with firm size, although later studies have provided inconclusive results, owing to the existence of positive and

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negative influences (Cohen & Levin, 1989; Schumpeter, 1942). Another stream links firm diversification with a host of outcomes, including type of research (Hitt, Hoskisson, & Kim, 1997; McEachern & Romeo, 1978), benefits on R&D investments (McEachern & Romeo, 1978), identification of new opportunities (Chen, 1996), ease of knowledge transfers across firm boundaries because of shared organizational codes (Grant, 1996), and reduced threats of opportunism (Williamson, 1975). The upper echelons approach (Hambrick & Mason, 1984) to study the role of manager backgrounds on innovation (Hambrick, Cho, & Chen, 1996; Smith & Tushman, 2005) is another important avenue for research.

Given the volume of research on the management of innovation spanning decades, it is not surprising that this theme has seen considerable work with respect to China (clusters 6, 8, 20, 21, 25), although the relative dearth of research interest on India (clusters 8 and 11) is equally remarkable. The keywords representing this theme are grouped as follows: (a) pharmaceutical industry, medicine, advanced manufacturing technology, manufacturing, developing country; (b) technological capabilities, competition/competitive advantage; (c) strategy, teamwork, R&D management, management control, corporate governance, ownership structure/type; (d) technological development, new opportunity/new product, innovation performance. The groups represent broadly the context/sectors studied by researchers, firm capabilities, management processes, and outcomes respectively. It is evident that the context of studies correspond largely to the important sectors that are internationally competitive in the two countries – manufacturing in China, and medicine/pharmaceuticals in India. Surprising omissions are the IT and automobile industries in India.

Studies of innovation strategies of Chinese firms during the transition period of the 1990s indicate the predominance of quality improvement initiatives and the influence of government initiatives by way of supporting high-tech manufacturing to move away from imported technology and equipment into developing indigenous R&D capabilities (Guan, Yam, Tang, & Lau, 2009). Both innovative and imitative behavior are observed, leading to the inference that not all Chinese firms are equally innovative, especially when faced with imperfect protection of intellectual property rights, and a predominance of strategic cost innovation (Zheng & Wang, 2012). Arguing that ownership structure influences the environment-strategy relationship, Jiang, Waller, and Cai's (2013) study suggests that ownership structure influences the impact of the source of innovation (i.e. internal R&D, partnerships, and university collaborations) and external contracting on innovation performance. The impact of different ownership structures, such as state-owned enterprises, private firms, joint ventures, business groups, and wholly owned foreign subsidiaries on innovation performance have been studied. The results vary, ranging from both significant and insignificant effects (Pyke, Farley, & Robb, 2002), positive influence of foreign, state and institutional ownership, negative effect of insider ownership, and no effect of concentrated ownership (Choi, Lee, & Williams, 2011). The positive influence of business groups is affirmed in two studies (Choi

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et al., 2011; Wang et al., 2015), although the first study qualifies the relationship by indicating a significant effect only in situations where business groups are related to high-level government agencies. Studies on innovation teams are almost absent. Among the exceptions, we note one by He, Ding, and Yang (2014), which reports the impact of cognitive and affective conflict, and conflict management styles on team innovation outcomes.

Studies of Indian pharmaceutical companies suggest their ambidextrous capabilities to undertake exploration and exploitative R&D in response to changing IPR regime as a consequence to TRIPS agreement, and thereby respond to increased competitive pressures from MNCs (Brem & Freitag, 2015). Upadhyay, Sikka, and Abrol (2009) examine various forms of government technology financing and their role in strengthening industry-R&D laboratories, while Sikka (1998) argues for stronger linkages between corporate R&D, national laboratories, and technical institutes in light of the performance of R&D laboratories of Indian companies. It is also seen that for Indian pharmaceutical companies, quality of technical personnel directly influences market sales, and research intensive firms tend to be younger and more aggressive in learning (Ramani, 2002). Narayanan and Bhat's (2009) study of the basic chemical industry suggests that the source of technology, namely in-house R&D, technology imports through machinery etc., and purchases of codified technology, are predicted by a range of variables such as firm size, age, level of firm integration, foreign ownership, and profitability. The need for cross-national studies of team work, and for Western companies to be sensitive to the Indian context, are highlighted in Brem and Freitag (2015), in which they found differences in key aspects of R&D team and project management approaches across German and Indian teams of multinational companies operating R&D centers in India.

Despite the wide presence of work on this theme on China, and to a lesser extent on India, we suggest that there is scope to investigate the impact of the nature of the firm on innovation in Chinese and Indian contexts. In particular, the role of state-owned enterprises on innovation performance, although examined in two studies in our sample (Choi et al., 2011; Pyke et al., 2002), point to the need for more studies. Also, the presence of large state owned enterprises in China and India, and large family business groups in India (Li, Sutherland, Ning, & Wang, 2014; Nair et al., 2015; Singh & Gaur, 2013) are likely to confound the effects of firm size, scope, governance and upper echelons on innovation and are directions for future research. Large state owned enterprises operate in different conditions (such as monopolies or state protection) that are often not strongly linked to market forces (Wang, Wong, & Xia, 2008), a key assumption in Schumpeter's (1942) work. Yet, they are also often able to command large resources. Similarly, family-owned business groups may enjoy many of the benefits that have been identified in research on firm diversification and innovation (Ashwin et al., 2015; Singh & Gaur, 2013). However, the characteristics of their top management, namely the

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extent of their professional training, and governance structures, may influence the diversification-innovation relationship which needs future exploration.

Theme 6. Universities and Innovation

In recent decades, the direct involvement of universities in research commercialization through different routes such as faculty-driven technology start-ups, collaborative ventures with industry, science parks, business incubation, etc. (Agrawal, 2001; Hendry & Brown, 2006; Miller, Richard, & Arora, 2011) has been underscored. Literature also notes that this development is accompanied by a different mode of doing scientific research, in which government, private industry, and universities are intertwined with each other in, what has been termed, as the 'Triple Helix' framework (Etzkowitz, 2011; Etzkowitz & Leydesdorff, 2000; Etzkowitz, Webster, Gebhardt, & Terra, 2000). Therefore, research to understand the nature and extent of university-industry interfaces for technology transfer and research commercialization is important, especially in the context of China and India, which aspire to be technological powerhouses.

In this context, we note from Tables 1 and 2 that research on this subject is still in its infancy in China, while the subject is unrepresented in any cluster in India. The limited research in China over clusters 8, 9, and 19 include the keywords universities/research institutes, research/academic collaboration, university-industry linkage, higher education reform, business, performance, and regions. This list suggests that this research has largely focused at broad-level issues such as higher education reform, and impact of university-industry linkages on regions. In this, the research finds resonance with studies on similar lines in other countries (Bramwell & Wolfe, 2008; Doutriaux, 2003; Huggins, 2008).

Papers under this theme generally indicate the uneven progress of university-to-industry technology transfers in China. The studies suggest that such transfers haven't maintained momentum after an initial impetus during the 1980s and 1990s (Wu & Zhou, 2011). There are also discussions around faculty preference for scholarly work (Wu, 2010), and challenges faced by university spin-offs initially (Kroll & Liefner, 2008). A recent paper (Fisch, Block, & Sandner, 2016) notes that university patents have increased rapidly in quantity without corresponding improvement in quality, and highlights the effect of subsidies to promote research versus reducing patent application costs. However, many of the studies also highlight the continuous development of the ecosystem for university technology transfers. A study of Tsinghua University Science Park highlights the efficacy of its strategies in developing and transferring technologies (Zou & Zhao, 2014). Other studies suggest the institutional evolution of universities from rigid hierarchical forms to flexible and market-based mechanisms (Wu, 2010; Wu & Zhou, 2011), and the influence of government restrictions on entrepreneurial spin-off performance (Kroll & Liefner, 2008).

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Yet it is also evident from the spread of keywords that even in Chinese studies, several promising lines of inquiry remain unexplored. One important theme that is missing is the *nature* of university-industry interfaces, and how this impacts the effectiveness of technology transfers. It is likely that the interfacing mechanism will be contingent upon various contextual variables, such as the nature of technological knowledge being transferred (Morandi, 2013; Niedergassel & Leker, 2011; Pries & Guild, 2011), and technological competence of local industry (Gatignon, Tushman, Smith, & Anderson, 2002; Tatikonda & Stock, 2003). Another important facet that needs to be studied is the role of universities' internal contexts on university led innovations. These include the impact of university policies (Goldfarb & Henrekson, 2003), structural arrangements (Caldera & Debande, 2010; Chang, Yang, & Chen, 2009), and organizational identity (Chatterjee & Sankaran, 2015; Lam, 2010). Finally, research on universities also needs to investigate their role in developing technological capabilities (cf. Liefner & Schiller, 2008), and 'translating' findings from basic research into applications that can be understood by industry practitioners (Woolf, 2008). Hence, there is a clear link between university research and absorptive capacity and catch-up that needs to be fleshed out in the context of China and India.

Theme 7. Entrepreneurship

Since Schumpeter's early work (Schumpeter, 1934, 2000), the innovator is closely identified with the entrepreneur. Entrepreneurship deals with the identification, evaluation, and exploitation of new opportunities (Shane & Venkataraman, 2000; Venkataraman, 1997). Given its importance as an engine for economic growth (Hessels & van Stel, 2011), there is copious research to study various individual, firm, and institutional level variables on opportunity identification and resource mobilization for new ventures (Bhagavatula, Elfring, van Tilburg, & van de Bunt, 2010; Davidsson & Wiklund, 2001; De Clercq, Danis, & Dakhli, 2010). It is observed that entrepreneurship and innovation are complementary, and a combination of the two is essential for organizational success over its entire life cycle and not just at the starting stage (Zhao, 2005). Given that entrepreneurship is especially relevant for emerging economies like China and India, innovation through entrepreneurial ventures assumes special relevance owing to the impetus it offers for job growth and economic development (Monsen, Mahagaonkar, & Dienes, 2012; Thurik, Carree, Van Stel, & Audretsch, 2008).

In this context, our sample suggests that research on the link between entrepreneurship and innovation is severely constricted in China and India. From Tables 1 and 2, we note that entrepreneurship and innovation in new ventures has had very limited attention in China and India. In the case of China, the keyword entrepreneurship co-occurs with exploration and exploitation, transition economy and venture capital, while in the case of India, it co-occurs with technology diffusion/dissemination/transfer. This suggests that the limited discussion that

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has happened in China has been around the role of learning and financing of innovation in entrepreneurial ventures, while in the case of India it has largely been around knowledge transfer.

The studies on entrepreneurship in China reflect concerns with several topics. At the policy level, Huang, Audretsch, and Hweitt (2012) examine the impact of technology transfer policies aimed at reducing regional disparities by catalysing economic development, while White, Gao, and Zhang (2005) look at China's system of new venture capital funding and its evolution from government dominated centralized system of the 1980s to the emergence of venture capital funds later. Two studies examine the impact of international connections. The study by Saxenian (2001) examined the development of technology ventures resulting from home bound engineers from the USA, while Yu and Si (2012) investigated the relationship between R&D intensity, international initial public offering, and firm performance of entrepreneurial firms. One important aspect of entrepreneurship studies is reflected in two papers (Goxe, 2012; Kriz, 2010) that discuss the role of China's national culture and value systems on entrepreneurship.

For India, Subrahmanya (2013) found that innovation frequency and internal technical competence were associated with higher external technical support, while sales from innovation related products tend to be higher when firms are able to obtain external support and complement it with internal technical competence and are entrepreneurial. The study also found that sales increase of the SMEs was related to firm origin, age, and nature of innovations. Kumar and Subrahmanya (2010) investigate the impact of MNC assistance to SMEs on their innovation and economic performance. They found that, while product and purchase process related assistance were predominant, the relationship nevertheless enhanced technological innovation and economic performance.

We point to three general directions to future research in this field: the individual entrepreneur, large firms, and innovation-led entrepreneurship, and new streams in entrepreneurship research. The first draws on studies in our sample that hint at the role of national culture on entrepreneurship (Goxe, 2012; Kriz, 2010). It has been pointed out that individual resources in innovation generation and in subsequent venture creation (Baum, Locke, & Smith, 2001; Davidsson & Honig, 2003; Miller, Grimes, Mcmullen, & Vogus, 2012), and innovation orientation of individuals (Wiklund, Patzelt, & Shepherd, 2009) are important in linking entrepreneurship and innovation. However, it has also been suggested that the education systems in China and India, with their stress on cognitive development, and deeply rooted social preference for higher education (Witt & Redding, 2013), are less suitable for entrepreneurship orientation (Raichaudhuri, 2005). Yet, evidence also suggests a surge of entrepreneurship in China and India (Sahasranamam & Sud, 2016), and understanding this surge is an interesting angle for future research.

Further, there is a need to understand how innovations within large Chinese and Indian organizations are commercialized as new businesses (Subrahmanya, 2013). In this regard, internal corporate venturing (Burgelman, 1983), corporate

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entrepreneurship (Morris, Kuratko, & Covin, 2010), and spin-offs (Iturriaga & Cruz, 2008) have commanded considerable attention from researchers. However, innovation and new product development processes followed in entrepreneurial firms are potentially different from those seen in large firms (Bhave, 1994; Ray & Ray, 2011). As discussed earlier, in Chinese and Indian contexts, most large firms are either state-owned or family-owned enterprises that tend to be conservative. To what extent this affects technology-led entrepreneurship, and how innovations are commercialized as new businesses, are potentially interesting subjects for future research.

Finally, India has a large presence of social enterprises championing the cause of people living in poverty (Agrawal & Sahasranamam, 2016; Datta & Gailey, 2012; Intellicap, 2012; Sahasranamam & Ball, 2016). Hence, it is necessary to explore the process of innovation and entrepreneurship in such enterprises.

Theme 8. Indigenous Innovation Forms

Only one cluster each in China and India can be identified as representing this theme. Cluster 4 for China contains the keywords diffusion, frugal/indigenous/low-cost innovation, international collaboration, and learning. For India, cluster 9 has only frugal/indigenous/low-cost innovation. Surprisingly and regrettably sparse, this theme nevertheless represents potentially an extremely rich and fertile ground for theory development that may break fresh ground in innovation literature.

Among studies on China, Lazonick (2004) discuss patterns of indigenous innovations by Chinese enterprises. Xie, Gao, Jiang, and Fey (2015) discuss the distinctiveness of indigenous innovations, as emphasized in Chinese government initiatives, and classify them into three patterns – original, integrative, and re-innovation, and examine the connections between business-institutional social ties and learning intent. For India, Lim, Han, and Ito's (2013) case study of the Tata Nano small car suggest the importance of various strategic decisions to overcome what they call the 'deficiency problem', and the potential for local firms to develop innovation capabilities by creating products for underserved markets in which firms in advanced countries have little experience. McMahon and Thorsteinsdóttir's (2013) comparative study of regenerative medicine in Brazil, China, and India indicates the operation of processes hitherto unexamined in innovation literature. In particular, the study reveals the importance of non-firm actors, and the need to study a different set of dynamics through which innovations occur in these contexts.

We suggest three themes that require deeper researcher interest: emerging economy innovation paradigm, sustainability and green technologies, and traditional knowledge-based innovations. First, it has been pointed out that much of the innovation literature is based on ideas that mainly apply to western and affluent contexts (Ramachandran, Pant, & Pani, 2012; Viswanathan & Sridharan, 2012) that are aligned with global business interests (Nakata & Weidner, 2012).

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Therefore, it is worthwhile to discuss to what extent innovation research in China and India is engaged in discovering locally relevant themes for research, and discovering indigenous methods for innovation and developing technologies. There is sufficient literature to suggest that it is essential to develop products and technologies for emerging markets accounting for their specific contexts, which are not necessarily cheaper versions of products developed for affluent markets (Ernst, Kahle, Dubiel, Prabhu, & Subramaniam, 2015; George, McGahan, & Prabhu, 2012; Prahalad & Mashelkar, 2010). Similarly, work on 'grassroots' innovations (National Innovation Foundation – India, 2013) suggests that motivations for innovation might not be material for many inventors. Hence, the process to develop such products and technologies is likely to be quite different from other innovations and may require new capabilities and technologies (Prahalad & Mashelkar, 2010). While China is fast growing beyond the conditions available in many emerging economies, these certainly prevail strongly in India. Anecdotal evidence suggests interesting and fresh approaches to these innovations and provides cases for interesting research. The limited research captured in our sample, namely frugal/indigenous/low-cost innovation, is predominantly concerned with this stream, and suggest the scope for more vigorous research.

Second, a surprisingly conspicuous omission in innovation research on China and India has to do with sustainability and green technologies. Both the countries together account for more than 30% of global greenhouse emissions (Mohan, 2015). As the two economies expand rapidly, and the stress on natural resources aggravate, the demand for sustainable technologies is bound to increase. As Nidumolu, Prahalad, and Rangaswami (2009) noted, sustainability can be a catalyst for innovation. Given that these problems are immediate in China and India, we note the absence of keywords such as sustainability, ecology, and green, and a need for an active research program to understand and inform policy on the management of innovation on sustainable and green technologies as a fruitful research area.

Third, several nations, including China and India, have had long 'pre-scientific' traditions that were different from Western science (Basalla, 1967). This traditional knowledge can be understood as that available with non-Western societies and aboriginal communities, and often concerned with environmental, health, natural resource usage, hunting, agriculture, but may also include more abstract and symbolic knowledge such as science, engineering, mathematics, philosophy, etc. (Hansen & VanFleet, 2003). Today there is thriving scholarship around the links between traditional knowledge and ecological sustainability (Green & Raygorodetsky, 2010), development, especially among poor communities in non-Western societies (Briggs, 2005), and medicines based on traditional knowledge. The last subject is much debated (Reyes-García, 2010), and an active research interest has spawned the discipline of ethno pharmacology (Etkin & Elisabetsky, 2005; Reyes-García, 2010). China and India, with rich indigenous medicinal traditions spanning millennia and with a vast repository of documented knowledge,

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can contribute significant research in this subject (Chaturvedi, Kalam, Ladikas, Lifeng, & Srinivas, 2014). Yet, in our sample, keywords connected with traditional science and technologies are surprisingly omitted, perhaps reflecting a deeply rooted worldview on scholarship drawn on Western notions of management research. We see tremendous potential for research in China and India in unearthing traditional approaches to innovation, and thereby propose boldly new (or old?) and different approaches to innovation.

DISCUSSION

Most attempts to review the research on the management of technological innovations have been restricted to Western contexts (Ahuja et al., 2008; Keupp et al., 2012). Our research is among the earliest attempts to systematically and comprehensively review innovation management research in two of the largest and fastest-growing emerging economies in the world – China and India. This review makes several contributions.

Contributions

First, this review foregrounds salient trends in innovation management research in China and India. We note that while the number of publications is increasing in both countries, they are still far behind developed countries. While there are certain themes such as 'institutions and innovation systems' that have attracted maximum research interest in both the countries, as evident from Table 3, there are significant cross-country differences as well. A note of concern is research out of India, which seems to be far behind in terms of number of publications, as well as heavily biased toward policy (rather than management) issues. Therefore, we urge management scholars in India to take a cue from their colleagues in China, and undertake more vigorous research in the field.

A second contribution of our work is to highlight a significant gap in extant studies in largely ignoring the potentially very rich avenue of research rooted in indigenous traditions of China and India. We note the concerns of scholars who have pointed to the limited flow of novel management knowledge from emerging economies to the global field (Frenkel, 2008; Kipping et al., 2008). We connect this concern with our observation that since the number of publications based out of both countries is still quite low in general management journals when compared to innovation journals, the stress appears to be more on concept application and testing rather than conceptual development on innovation management in China and India. It reflects a world view in which researchers' attention is guided by conceptual developments advanced in Western universities. Research based in contexts like India's from perspectives such as Bottom-of-Pyramid (Prahalad, 2005) and subsistence markets (Viswanathan, Echambadi, Venugopal, & Sridharan, 2014) has motivated new concept development such as grassroots innovation

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(National Innovation Foundation – India, 2013), reverse innovation (Govindarajan, 2012), *jugaad* innovation (Radjou, Prabhu, & Ahuja, 2012) and global service delivery model (Kumar & Puranam, 2012). However, these streams primarily draw on only a subset of the characteristics of emerging economies, namely, resource constraints, weak infrastructure, competition from unbranded products, and poor formal governance systems (Ernst et al., 2015; Viswanathan & Sridharan, 2012). As our review reveals, we are yet to seize on opportunities that are unique to China and India, such as indigenous intellectual bases, national cultures, religious traditions, and distinct national identities and ambitions (Ashwin et al., 2015; Du, 2013; Lin, 2013). We feel that there is considerable scope for work on these subjects, and call for a research agenda that is truly rooted in the indigenous ethos of China and India.

Third, while we followed suggestions of scholars to strengthen the methodological rigor of literature reviews (Keupp et al., 2012; Thorpe, Holt, Macpherson, & Pittaway, 2005; Tranfield et al., 2003) and thereby adopted a methodologically rigorous bibliometric approach, we also advance the methodology significantly in two ways. Bibliometric reviews have generally used extant theoretical frameworks, often developed on the basis of studies in developed economies, to interpret the results of mathematical analysis (Keupp et al., 2012). However, this may not be sufficient in situations such as the present study, where it is difficult to argue that such frameworks would do justice to the context of emerging economies while simultaneously starting with a position that they are different from developed economies.[1] Hence, we adopted an inductive approach to aggregate the results of our cluster analysis, resulting in the eight themes that formed the basis of our interpretation. We suggest that this approach may prove useful in situations where it is difficult to justify the adoption of extant frameworks to organize literature on certain subjects. Further, we also compensated for the potential limitations of quantitative bibliometric analysis emanating from limited attention offered to individual articles by providing references to pioneering work carried out in each of the themes in order to aid further investigation.

Future Research Directions and Limitations of the Study

Based on existing literature on the eight themes combined with the contextual understanding of China and India, we identified several future research directions across them. These have been highlighted in the earlier sections, and Table 4 summarizes some of the key future research questions to be explored. In addition, future research could also make comparisons between China and India to understand the commonalities and differences in approaches towards innovation management. Considering that Chinese scholars have made greater progress across the eight themes, management scholars from India could potentially do replication studies based on the innovation research from China. While discussing each of the eight themes, we have highlighted the relevance of studying each

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Table 4. Some future research questions to be explored across the eight themes

	Broad theme	*China*	*India*
1	Institutions and innovation systems	• What is the role of state ownership and its' characteristics on innovation? How do they help in bridging innovation specific institutional voids? • What is the role of political and non-market strategies on innovation?	• How do Indian firms overcome the innovation-related institutional voids? • How has certain strategic industries like space technology been able to come up with multiple innovations despite institutional voids?
2	Technology upgradation	• How have state-owned enterprises in industries such as electronics managed to catch up with global MNCs? • In a largely government-dictated intellectual property regime, what encourages investments towards technology upgradation? What is the role of government policy changes on technology upgradation strategies?	• How does public R&D investment aid in technology upgradation and improvement in quality of human talent? • What is the role of incremental improvement in intellectual property rights on technology upgradation and knowledge sourcing strategies?
3	International linkages	• How does technology transfer from China to other countries happen in industries like electronics and other consumer durables? • How does the international linkage with global MNCs as an outsourcing hardware development partner influence innovation? • How does inward and outward foreign investments aid in innovation?	• What is the role of international connections on technology spillovers? • How does technology transfer from India to other countries happen in industries like pharmaceuticals and space technology? • What processes do Indian firms take to legitimize their innovation in international markets? • What are the differences in approaches to innovation management between Indian firms and foreign subsidiaries in India?
4	Connections and innovation	• What is the role of *guanxi* on development of innovation networks within and across firms? • What is the influence of political connections on innovation activities? • What is the effect of technology clusters and science parks on innovation?	• What is the role of religious communities and traditions on innovation? • How does external knowledge sourcing partnerships of Indian firms like licensing, and JVs affect innovation? • What is the influence of family and business group ties on innovation process and outcomes?

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Table 4. Continued.

	Broad theme	China	India
5	Management of innovation	• What is the influence of political bureaucracy on management of innovation? • What are the differences in approaches to innovation management between state-owned firms and private firms?	• What is the role of governance structure and upper echelons on innovation management? • How does professional training influence management of innovation?
6	Universities and innovation	• How did Chinese universities manage to increase academic research rapidly in a short span of time? • What is the role of partnerships between universities and science parks in promotion of innovation?	• How do Indian universities balance the demands of research, commercialization and teaching? • What is the role of technology business incubators in university on innovation development?
7	Entrepreneurship	• What is the role of private property protection and state regulations in encouraging innovation-led entrepreneurship? • What factors influenced the entrepreneurship promotion in certain clusters of China like Shanghai and Shenzhen?	• What modifications in the education system are needed to encourage entrepreneurship and innovation? • What are the reasons behind certain cities of India like Bangalore and Mumbai becoming entrepreneurship hubs? • How social enterprises in India are developing innovation in resource constrained environments?
8	Indigenous innovation forms	• How is green technology aiding China in battling pollution? • What is the role of traditional knowledge and *Confucianism* on innovation?	• Is there an India-specific innovation paradigm? How did indigenous innovations like *jugaad*, and *grassroots innovation* take shape and grow? • What is the role of government's push towards green technologies on innovation in that sector? • How is the traditional knowledge of Indians in Ayurveda and medicines aiding innovation in the pharmaceutical industry?

knowledge gap. We believe that future research carried out across the eight themes would develop valuable insights to inform management practitioners and influence policy making.

Finally, we would like to point out a few limitations of our study. Our data was dependent on the journals we selected. While we did try to ensure that this

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selection process was not arbitrary, we do recognize that important bodies of work might have been left out since our selection methodology was inherently biased toward journals that are popular among Western scholars. We certainly recognize that we left out journals that are more national in nature, and journals in local languages, which might be important in China. In this sense, it is possible that our data set might have under-represented the research in the two countries. This limits us in our identification of research gaps as well. Going further, it is important to design investigations that connect these trends more specifically with institutional environments. While we did recognize this possibility in places (for example, in connecting with macro-economic trends related to the dot-com boom), there is scope to study these relationships further. A recent study, for instance, looked at the historical reasons to explain the challenges facing innovation in China (Augier, Guo, & Rowen, 2016).

CONCLUSION

In conclusion, because both China and India are pitched as the next global economic powerhouses, and innovation is a key driver facilitating this economic growth journey (Acs & Szerb, 2007; Galindo & Méndez-Picazo, 2013; Galindo & Méndez, 2014), it is imperative to develop new theories, concepts, and models for management of technological innovation grounded in these economies. We urge renewed vigor and fresh approaches in innovation management research in China and India.

NOTES

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[1] We thank one of our anonymous reviewers for providing this insight.

[2] Full names of abbreviated journal sources provided in Appendix I.

APPENDIX I

Journals Considered for the Review

General management journals	*Innovation journals*
Academy of Management Journal	Journal of Product Innovation Management
Academy of Management Review	Research Policy
Administrative Science Quarterly	R&D Management
Journal of Management	Technovation
British Journal of Management	Creativity and Innovation Management
Journal of Management Studies	Industry and Innovation
Academy of Management Perspectives	Innovation: Management, Policy and Practice

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General management journals	*Innovation journals*
European Management Review	International Journal of Innovation Management
International Journal of Management Reviews	Journal of Engineering and Technology Management
Journal of Business Research	Journal of Technology Transfer
Journal of Management Inquiry	Prometheus
Business Horizons	Research Technology Management
Canadian Journal of Administrative Sciences	Science & Technology Studies
Competition and Change	Science, Technology and Human Values
European Business Review	Scientometrics
European Management Journal	Social Studies of Science
International Studies of Management and Organization	Structural Change and Economic Dynamics
Journal of General Management	***Other journals***
Management Decision	Strategic Management Journal
Journal of Intellectual Capital	Journal of International Business Studies
Journal of Revenue and Pricing Management	Organization Science
Scandinavian Journal of Management	Management Science

APPENDIX II

Coding Scheme Adopted for Keyword Analysis

Broader keyword category	*Example of keywords classified under the category*
Intellectual property	Foreign patenting, patents, patent analysis, patent citations, patent quality, patent quantity, trademarks, university patenting, IPR, IPR protection, TRIPS compliance
Manufacturing	Manufacturing firms, manufacturing in China, manufacturing industries, manufacturing technology
Agricultural sector	Agricultural hi-tech enterprises, agriculture, agricultural sector, vegetable sector
Research/academic collaboration	Academic collaborations, research collaboration
National/regional/ sectoral innovation system	China innovation system, national innovation system, national innovative capacity, regional innovation system, sectoral innovation, sectoral innovation system, sectoral systems of innovation
Competition/ competitive advantage	Competition, competitive advantage, competitiveness, comparative advantage
Policy/economics/ government	Economic development, economic policy, economic reforms, economic transition, government, local government, policy, public policy, roles of policy, economics
Liberalization/ globalization	Liberalization, globalization
Frugal/indigenous/low-cost innovation	Frugal innovation, indigenous innovation, low cost innovation

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Broader keyword category	*Example of keywords classified under the category*
IT/ICT/ITES	Information and communication technology, IT adoption, Indian ITES industry, information technology, IT industry, software
Knowledge diffusion/ exchange/ sharing/ transfer	Knowledge diffusion, knowledge exchange, knowledge sharing, knowledge transfer
New opportunity/new product	New product development, new opportunity identification
Outsourcing/ offshoring	Offshore R&D, offshore R&D networks, offshoring of high-value activities, outsourcing, captive offshore
Foreign direct investment	FDI, foreign direct investment, outward foreign direct investment, outward FDI
Networks	Social network ties, actor-network theory, networks, ethnic ties
Strategy	Corporate strategy, strategic approach, strategic capabilities, strategic transition, strategic upgrading, innovation strategy, strategy
Technology diffusion/ dissemination/ transfer	Technology diffusion, technology exchange, technology transfer, technology dissemination
Science/technology parks	University science park, science parks, technology parks
Internet	Web scraping, China internet, websites, internet
Energy	Energy innovation, wind energy industry
Learning	Learning human resources, learning intent, organizational learning, interactive learning
Universities/research institutes	Public applied research universities, public research institutes
Clusters	Cluster density, multi cluster presence, clusters
Institutions	Institutional-based view, societies and institutions, institutions

APPENDIX III

Cluster Analysis Methodology

Using an Excel function, we produced a keyword x keyword (79 x 79 for China and 34 x 34 for India) matrix with the individual keywords in the rows and the columns and the frequency of their co-occurrence in the respective cell. These absolute frequency values were then transformed into a normalized measure of association between the keywords using the cosine formula (Peters & van Raan, 1993: 48):

$$C_{ij} = \frac{c_{ij}}{\sqrt{c_i c_j}}$$

where c_i is the frequency of a word in row i, c_j is the frequency of a word in column j, and c_{ij} is the number of co-occurrences of these two words. C_{ij} is limited between 0 and 1, and functions as the similarity measure for the cluster analysis. We used STATA software package for performing the cluster analysis. STATA performs cluster analysis on the dissimilarity matrix and hence we exported values of $1\text{-}C_{ij}$ to it.

We performed the cluster analysis using Ward's linkage method, which is considered to be consistent with the cosine measure of the strength of co-word association (Leydesdorff, 1989). The number of clusters was chosen on the basis of the Duda–Hart Je(2)/Je(1) index, which is recognized as one of the best rules to determine the number of clusters (Milligan & Cooper, 1985). Along with the Duda–Hart index we get a pseudo-T^2 value, where smaller pseudo-T^2 values indicate more distinct clustering (Duda, Hart, & Stork, 2001). So, to choose distinct cluster solution, we compared the pseudo-T^2 values for the solutions consisting of 2–30 clusters separately for China and India.

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