From regional innovation systems to global innovation hubs: Evidence of a Quadruple Helix from an emerging economy

Abstract

Despite the growing importance of regional innovation systems as agglomerations of firms and actors that possess technical, leadership and managerial endowments for innovation and R&D activities, their impact on the evolution of global innovation hubs is still unclear. We address this gap by investigating the multiple influences of macro-, meso- and micro-level factors in the formation of global innovation hubs, using a comparative qualitative case study design with four MNEs operating in the Indian IT, pharma and healthcare sectors. We confirm the presence of 'Communities of Practice' as a fourth strand in our conceptualization of a Quadruple Helix in the emerging markets context. We also discover the critical role played by the interactions among communities of practice members and meso-level investments in organizational capabilities, learning and relationship quality. Finally, we highlight the importance of managing trust and power dynamics among members of communities of practice in a global innovation hub.

Keywords: R&D teams; global innovation hubs; agglomeration; India; quadruple helix; communities of practice

1. Introduction

Past research recognizes helix formation as a mechanism to spur entrepreneurial activity, innovation and growth across different regions, through the notion of interactions and collective cooperation between each of the helix strands. The literature shows evidence that helix formations are largely classified as triple (Binz & Truffer, 2017; Burgos-Mascarell, Ribeiro-Soriano, & Martínez-López, 2016; Etzkowitz & Leydesdorff, 2000; Etzkowitz & Zhou, 2017; Lazzeretti & Capone, 2016), quadruple (Brunetta, Marchegiani, & Peruffo, 2019; Hasche, Höglund & Linton, 2019; Schütz, Heidingsfelder, & Schraudner, 2019) or even quintuple in nature (Carayannis, Barth, & Campbell, 2012). The key strands typically conceptualized in a helix formations include: *government*, *business*, *academia* (for triple), *open society* (for quadruple) and *culture* (for quintuple). However, despite such growing interest on the impact of key helix strands on the innovativeness and growth of regions, many research gaps still remain.

First, at a macro policy level, there is no clear understanding of how helices interact with each other to contribute to the emergence of global innovation hubs (GIHs) in certain regions compared with others. Second, there is little evidence of how a temporal interaction between these helices influence the dynamics of innovation at a firm level, in terms of the structures, processes, practices that are needed for effective interactions between the key stakeholders in GIHs (Audretsch, 2015; McAdam & Debackere, 2018). Temporal understanding is critical as the interactions between different stakeholders assume a dynamic nature, especially as there are changes in people and policy and their interests at different levels and times, thereby affecting the outcomes of players in a system. This would suggest that the spheres of influence of each strand of a helix may expand or contract at different times (Kriz, Bankins, & Molloy, 2018; Patnaik et al., 2020). Finally, building on the gaps identified in the literature on micro-foundations theory (Foss, 2011; Foss & Lindenberg, 2013) there are calls in the

literature on helix formation for further exploration of individual level, human-centered processes, such as trust, power and network centrality of key actors in a system as key constructs that help explain the effectiveness of quadruple helices (Cunningham, Menter, & O'Kane, 2018; Kriz et al., 2018; Scuotto et al., 2020). To the best of our knowledge, no investigation has been undertaken in relation to the above concerning GIHs, and hence we aim to contribute by filling this gap, through our research.

From a policy perspective, understanding the above gaps is critical to the literature on helix formation, as the proliferation of GIHs has intensified in several regions, leading to attracting foreign direct investment in these GIHs, which would lead to increases in regional employment and economic activity. From a theoretical perspective GIHs rely extensively on external input from societal and open innovation channels for supporting their innovations. Thus, our focus is on micro-level factors how these factors interact with different firms in its broader innovation ecosystem to determine the strength and success of innovation projects (Cunnigham et al., 2018; Scuotto et al., 2020). Thus, there is a lack of research in examining the micro-foundational and meso-level factors, such as the role of the evolving nature of power and trust dynamics between different stakeholders in a helix and GIHs and the organizational capabilities that firms in a GIH develop for overcoming any adverse impacts from the interactions between them and a quadruple helix. We argue that these interactions create the fourth strand in our conceptualization of a Quadruple Helix in GIHs, namely *Communities of Practice* (CoP), which these GIHs foster to improve the micro- and meso-level interactions between them and other stakeholders in a regional innovation ecosystem.

We posit that CoP is a critical strand that enables interactions between the other stakeholders in a regional innovation system and GIHs, and do so in line with scholars who have been arguing in favor of this, through their recent work (e.g., Binz & Truffer, 2017; Etzkowitz & Zhou, 2017; McKinsey, 2011; Padilla-Perez, Vang, & Chaminade, 2009;

Patnaik et al., 2020; Pereira, Temouri, Patnaik, & Mellahi, 2020; Pereira, Patnaik &Temouri, 2020). The complex interactions of meso- and micro-level dynamics in a GIH, calls for a nuanced understanding of the interactions between stakeholders for supporting and encouraging R&D investment and activities at a global, national and regional level (Awate, Ajith, & Ajwani-Ramchandani, 2018). While there is evidence of macro-level interactions in several emerging market contexts, wherein the government, through its intermediaries and policy arms, engages favorably with the industry, to attract external foreign direct investment in R&D (Malik & Nilakant, 2015), there is a limited understanding of the meso- and micro-level factors supporting the emergence of a GIH. To this end, it is important to unbundle the complex micro-foundational dynamics that unfold between macro-, meso- and micro-level factors in the creation of successful GIHs from an emerging market perspective.

To understand the complex and multiple levels of influences at play, we employ different theoretical lenses. At a macro-level, we rely on the regional innovation systems and helix formation literature (Asheim & Gertler, 2005; Carayannis et al. 2012; Chung, 2002; Kriz et al. 2018; Nelson, 1993). At a meso-level, we rely on theories of strategic choices that multinational enterprises (MNEs) exercise in developing their learning and organizational capabilities (Croom, 2001; De Meyer, 1993; Malik et al., 2012; Pereira et al., 2019b; Sinkula, Baker, & Noordewier, 1997). Finally, at the individual and group level, we rely on concepts of relationship quality, trust (Colquitt et al., 2012; Mooradian, Renzl, & Matzler, 2006; Mrinalini, Nath, & Sandhya, 2006) and power dynamics (Malik, Ngo & Kingshott, 2018) between individuals, parent-subsidiary dyads and other stakeholder groups to achieve the desired innovation outcomes in a GIH.

We delve deeper in our analysis by exploring characteristics of a region and unbundling the complex interactions between key stakeholders (Patnaik et al., 2020; Pereira et al., 2019 a, c; Pereira et al., 2020). Therefore, we argue that by understanding the ‘local codes’ of a

region (Ashiem, 1999) and other organizational and relational aspects (Malik et al., 2018), MNEs are able to successfully implement their innovation agendas (Pereira & Temouri, 2017). Based on the above rationale, this study seeks to answer the following principal question in an emerging market context: *How does collaboration in a regional Quadruple Helix formation influence the emergence of GIH?*

By addressing the above question, this paper offers three distinct contributions to the literature on regional and global innovation systems. *First*, we contribute by identifying a "new" strand of helix, which we refer to as COP. We argue that this is a key pillar in our conceptualization, as the fourth strand of a Quadruple helix, as it critically supports the GIHs operating in a regional innovation ecosystem. *Second*, we contribute by presenting a temporal and multi-level analysis of the micro- and meso-level factors interacting with different stakeholders in shaping the growth of GIHs, which has not been explored previously. Finally, our *third* contribution lies in shedding light on specific micro- and meso-level factors operating in a GIH and how these serve as mechanisms in strengthening the interactions between the key strands of a Quadruple Helix.

The rest of the paper is organized as follows. We begin with a critical reviews of the literature on regional and global innovation systems. Next, we describe our research methodology, including the Indian GIHs focusing on three main industries, namely the Indian IT (information technology), healthcare and pharmaceuticals industries, as the research setting for this study. We then offer a temporal and cross-case analyses of the case studies in our sample, highlighting the traditional influences in a triple helix regional innovation system for an emergence of industry-specific innovation hubs, followed by the inclusion of a fourth strand from the Indian GIH context – the CoP. We conclude this paper with a discussion of our findings and implications for policy and practice along with the limitations of our study and some useful directions for future research.

2. Literature review and background

There are different incentives for MNE subsidiaries, emerging markets MNEs and third-party service providers, who form part of the GIH network and are expected to search for and deliver complementarities between different parties (Un & Rodríguez, 2018). We argue that this complementarity of accessing different knowledge bases is critical for GIHs to be successful. Furthermore, at times, these complementarities occur outside of the client-third-party provider or the parent-subsidiary dyad (Goerzen, 2018) in the form of strategic partnerships such as strategic inter-cluster alliances. Firms engage in boundary spanning activities for seeking appropriate links for accessing and integrating relevant pools of knowledge for firms' strategic and operational advantages through a range of inter-cluster alliances (Pereira et al., 2019b).

2.1. Regional and global innovation systems

There is a growing interest in achieving sustained competitive advantage and growth by adopting a coordinated national and a regional innovation systems approach (Asheim & Gertler, 2005; Chung, 2002; Nelson, 1993; Porter, 1990). In this context, recent examples of sustained performance by regional 'high growth firms' have also been portrayed (Pereira & Temouri, 2017). Some of the earlier works on national innovation system can be traced to the seminal work of Lundvall (2016) who built on the foundations of learning economy, theory of economic hope and micro-foundations of innovation processes in proposing a theory of national innovation systems. Chung (2002), for example, tracking the evolution of a national innovation system in South Korea, argues for the importance of creating a regional innovation system first, before a successful national system of innovation can emerge. The need for an active and interventionist role played by the government in different geographical regions for ensuring growth and sustained competitive advantage (Porter, 1990), is similar to

the strategic choices exercised by leaders at a firm-level (Asheim & Gertler, 2005; Kriz et al, 2016; Tellis, 2012). This line of thinking often adopts a deterministic view, such that regions are purposive entities, who can plan and control their outcomes in fashions similar to business entities (Kriz et al., 2016) and that regions are agglomeration of firms and actors possessing technical, leadership and managerial endowments.

Past research has identified a Triple (Etzkowitz & Leydesdorff, 2000) or Quadruple Helix (Carayannis & Campbell, 2019) in shaping a region's innovation system, wherein, the term helix or helices refer to the 'interwoven and cross-connected and cross-interconnected sectors' (Carayannis & Campbell, 2019: p. 3). Carayannis and Campbell (2009, 2011) track the evolution from a Triple through to a Quadruple and then to a Quintuple Helix for regional innovation systems. The authors note that Triple Helix innovation focuses on collaboration between three sets of stakeholders: the university-industry-government, whereas, the Quadruple Helix, building on the core ideas of a Triple Helix, blends in a 'media-based and culture-based public' and 'civil society' as its fourth strand to support innovative activities.

More recently, focusing on the challenge of global warming in an innovative way, scholars have added the need to focus on 'the environment' and to utilize human knowledge and sharing of such knowledge, to form the Quintuple Helix, such that it "supports here the formation of a win-win situation between ecology, knowledge and innovation, creating synergies between economy, society, and democracy." (Carayaanis et al., 2012; p. 1). In an Australian context, Kriz et al. (2018) have argued for the role of "community" as the fourth sphere in the formation of a "quadruple helix". There are two key modes of knowledge production for achieving innovation. In Mode 1, universities are viewed as creators of new knowledge, setting the foundation for future innovative activity to occur, which, in Mode 2, requires a transdisciplinary approach to combining, recombining, and problem solving and embedding this in the form of applications for societal gain (Carayannis & Campbell, 2019).

The above two modes form the basis for supporting the Triple Helix collaboration between government, academia and industry. While there are numerous typologies of the Quadruple Helix, in essence, the Quadruple Helix extends the collaboration and cooperation evident in the Triple Helix to seek different ways to advance knowledge production and innovation. This paper concurs with Carayannis and Campbell's (2009) Mode 3 of learning, which is a pluralist approach to integrating different sources of knowledge production and innovation, in order to facilitate mutual cross-learning opportunities. Such an approach, allows the democratic co-existence of multiple sources and paradigms of knowledge production and innovation at different levels. The industry helix strand comprises of domestic firms as well as MNEs operating in a given industry. To this end, in any regional innovation system, we argue that global MNEs are part of a global ecosystem of innovation, and can benefit from the interactions at the interface of global, regional, national and strategic micro-level actors of both domestic firms and MNEs that are interacting within a larger system of knowledge production and innovation.

Owing to the extensive research undertaken, we now have a much more nuanced understanding of the variants of regional and national innovation systems. Asheim and Gertler (2005), for example, identified the following archetypes. For example, the *territorially embedded regional innovation systems* from Italy's Emilia-Romagna region very much depicts a bottom-up, network-based support approach for innovating in industry sectors such as design, fashion, manufacturing food and agro products. Also from Europe, the second dominant type of system is the *regionally networked innovation system* that is typical in the state of Baden-Wurttemberg in Germany, where a number of automotive and mechanical engineering firms have created a network of providers that have formed a synergistic and mutually supporting regional innovation system. Another variant to the theme is the *regionalized national innovation system,* for example, from the clustering of science and

software technology parks and high-end R&D laboratories in the US IT sector as well as in the biotech industries. These systems co-exist with a range of supporting institutions that are typical to the Triple Helix of collaboration.

2.2. Regional innovation systems and GIH in emerging markets

In a survey of 1000 MNEs, about two-thirds of the MNEs and the entire population of top 100 global innovating MNEs had established an innovation and R&D base in an emerging market (McKinsey, 2011). While the different helix forms are evident in developed nations and indeed some aspects of these approaches have increasing relevance to India, the application of the above archetypes to an emerging market context or indeed to another region is fraught with challenges (Kriz et al., 2016). In emerging market contexts such as India, where diversity and institutional voids persist (Elango, Patnaik, & Weiland, 2016; Manikandan & Ramachandran, 2014), MNEs need to think of alternate designs, wherein new and non-standard forms of organizing can lead to serendipitously favorable innovation outcomes. Although MNEs have had success in offering their products and services to emerging markets, there has been some pushback from emerging markets, mainly due to a lack of context-relevant and affordable products.

The emergence of GIHs has facilitated reverse diffusion of innovation, highlighting the importance of contextual factors in boosting the innovative activity of GIHs (Cappelli, Singh, Singh, & Useem, 2010; Govindrajan & Trimble, 2012; Kumar & Puranam, 2012; Radjou, Prabhu, & Ahuja, 2012). However, issues of managerial and leadership talent and knowledge sharing in MNEs remains a key issue (McKinsey, 2011). There is evidence that this line of thinking has evolved from frugal innovation theory, which highlights the importance of context-sensitivity (Ramdorai & Herstatt, 2015; Tiwari & Herstatt, 2012). Given the vast market potential that emerging market economies such as the BRICS (Brazil, Russia, India, China and South Africa) offer, it is not surprising to see a resurgence of interest among

MNEs to establish GIHs in India, and this includes several high-growth industry sectors (McKinsey, 2011; Tiwari & Herstatt, 2012).

While the former logic focuses on offering adaptations of advanced nation products to emerging markets, we envisage that the emergence of GIH puts the focus on seeking new and contextually sensitive products and services for an under or unserved market. It seems logical then, for MNEs, to develop innovative products and services where they are needed most. Hence, the emergence of GIHs in a range of emerging market economies, including India, has witnessed large growth in the last decade or so. The interface between regions and MNEs would suggest that MNEs need to develop a contextual understanding of the 'local codes' in relation to a MNEs strategic goals (Ashiem, 1999). Therefore, regional (and global) innovation hubs should not only focus on innovation using a relational proximity logic, but must also focus on contexts that share a high degree of institutional and demographic similarity. This requires a disaggregated understanding of the drivers of innovation in GIHs, in the first instance, before finding markets that serve other emerging market regions that share an institutional and demographic similarity. A key question in the minds of MNEs for committing their R&D and innovation bases to regions in India is about the ability of India's GIHs to export the innovations developed by them to other or similar emerging markets such as Brazil, Russia, China and South Africa (Govindarajan & Ramamurti, 2011)?

2.3. Meso-level influences of learning and capabilities

The literature on regional innovation systems further highlights the importance of investing in organizational learning mechanisms, such as training and development (Malik et al., 2018) and knowledge sharing and integration between the internal and wider external stakeholders (Lam, 2007; De Meyer, 1993; Isaksen & Karlsen, 2011), especially in the case of local codes of practice (Ashiem, 1999). Knowledge, in terms of what works in a particular context, is critical to take into account, when it comes to the design and implementation of

innovative products and services. To accomplish this, firms in the GIHs need to learn and effectively sense the latent and expressed needs of the local market, and then disseminate these to the product development teams, utilizing and invoking their market-based organizational learning capabilities (Malik et al., 2012; Sinkula et al., 1997). Furthermore, knowing which capabilities to invest in and to what degree, requires a systematic identification, collection, analysis and evaluation of the key metrics, received from different internal and external stakeholders, in arriving at a prudent decision (Malik et al., 2012).

2.4. Micro-level influences of trust and power

At a micro-level, interactions between employees in internal teams as well as external product development teams, requires strong relational capital, through their networks (Malik et al., 2018), accompanied by high levels of interpersonal trust between employees and managers (Mooradian et al. 2006). Firms that are unable to manage interpersonal trust and maintain power dynamics between employees, can have negative influences on the endurance of internal and external stakeholder relationships (Bruneel, Spithoven, & Clarysse, 2017; Zaheer & Zaheer, 2006). Technical and process innovations often require subject matter expertise within team members. This creates power-equations, where some have greater power over others when it comes to sharing their expertise and knowledge on a particular subject matter. By implication then, employees who possess the power of expertise and knowledge (French & Raven, 1959), can bring about significant positive influences on others in the innovation network. Some scholars have even argued and equated power as the functional equivalent to trust (Bachmann, 2001; Patnaik et al, 2020). In relation to innovation in regional and global innovation systems, expert power has the potential to reduce issues such as information asymmetry as well as reduce the adverse effects of dispositional power in such complex multi-party stakeholder relationships.

3. Methodology

This study employs a comparative qualitative case study design, wherein four MNEs operating in the Indian IT (x1), pharma (x1) and healthcare (x2) GIHs were purposively included in the sample to capture the dynamics of how R&D teams in India's GIHs interact with the wider CoP to support the strategic innovation goals of MNEs (Eisenhardt, 1989; Yin, 2003). Primary data from interviews and secondary data available from industry reports and organizational documents were collected and analyzed. Twenty-three in-depth interviews were conducted taking about 45 to 90 minutes. Data from these interviews were transcribed verbatim and analyzed using a combination of automated concept and theme extraction and subsequent manual theoretical coding. Table 1 shows all the interviewees' details.

< Insert table 1 about here >

Case study 1 is about a healthcare MNE that specializes in innovative medical equipment and personal care products, and employs more than 3000 engineers tasked with designing and developing a new generation of products. Case study 2 is about another healthcare MNE with many new medical diagnostic products, such as non-invasive sugar, urine and blood testing diagnostic products. Case study 3 involves an IT MNE, which produces highly specialized and niche set of microprocessors for high-end graphic users. Case study 4 is about a global pharmaceutical and biotechnology products MNE, which is a leading generic and bulk drugs manufacturer with many popular drugs and formulations against its name.

We utilized a sophisticated specialist content analysis software Leximancer-4.5, that allows for unhindered and programmed mining of seed concepts using non-linear dynamics, supported by machine learning logic and statistical analysis (Smith & Humphreys, 2006) to explore our dataset. Leximancer is currently well accepted in premier management and innovation journals (Malik et al., 2018; Malik, Pereira, & Tarba, 2019; Malik, Froese, &

Sharma, 2020). The application aids in first completing frequency counts and thereafter helps identify the relational co-occurrence of text in two-sentence blocks, thereby helping in increasing the accuracy in a content analysis context.

Following the Leximancer 4.5 analysis at a within-case level, the automated concepts and themes were manually explored using a theoretical coding approach. However, to get a holistic understanding of the entire dataset, all interview data was analyzed collectively for a cross-case analysis. Such an approach allowed analysis of themes and concepts at a cross-case level (Corley & Gioia, 2004; Gioia, Corley, & Hamilton, 2013). The interview transcripts totaled 123,702 words and were analyzed together using Leximancer 4.5. Following the automated output of the concepts and themes at 100% concept and 33% theme visibility, a manual exploration was conducted, for each of the 52 concepts and 12 themes, wherein, each theme (circles) and concepts (dots within a circle) is depicted in the thematic map created by the software (Figure 1), which were analyzed for their relational aspects (Smith & Humphreys, 2006). The size and proximity of a theme depicts the relationship the theme has with other themes. Themes in dark red or brown colors are core themes, e.g., themes of Business Need, People and Collaboration. The relationship of the core themes with other themes, e.g., lighter green color themes of Product, Process, Firm, Probability, Business Models and Activity were also analyzed. The purple color theme of Training is further away from the dataset depicting a lesser relational co-occurrence with the dataset.

< Insert figure 1 about here >

4. Case study analysis and results

4.1. Temporal analysis of the evolution of India's GIHs

In line with the identified gaps noted earlier, and based on our review and analysis, a temporal evolution of India's GIHs in three industry sectors: IT, pharmaceuticals and

healthcare, we found a different trajectory for each industry sector in the establishment of their GIHs due to the diversity and industry-specific institutional voids. The GIH evolution tended to vary due to differences in political and economic ideologies and regional endowments in human capital between Indian state territories. These differences are noted in research on IT and engineering industries, wherein, certain geographical regions in India have taken a lead over others (Heeks, 1998; Malik & Nilakant, 2015). For example, Heeks (1998) highlighted the uneven structure, service-product mix and the ownership composition of MNEs and firms operating in the Indian IT GIH. These differences allowed inter-firm collaboration opportunities as well as cross-pollination and knowledge spillovers leading to diffusion of knowledge and best practices between the Indian firms, higher education institutions, government strategic research institutes and global MNEs resulting in new knowledge creation as well as gaining information-in-expectation for further growth and expansion by Indian firms (Banerjee, 2004) These sectoral differences that were analyzed over a period of time provided new insights about the dynamic coordination of information and knowledge exchange that occurred due to firm heterogeneity leading to the creation of new knowledge and value between firms, which consequently spurred growth and expansion of IT GIHs in India (Malik& Nilakant, 2015). Similar patterns were evidenced in the structure and composition of the healthcare and pharmaceutical industries, where there was evidence of a different nature of cooperation between vendors, again, due to the structural and ownership diversity between Indian firms, higher educational institutions, government-supported industry-specific technology parks and MNEs operating in the sector.

In the Indian context, MNEs have to balance the diversity of a new context and its knowledge production system presents, along with their ethnocentric, linear and dominant modes of knowledge production and relatively fixed ideas of how innovation processes must occur. The differences between linear and ethnocentric growth approaches employed by

MNEs from the US, UK and Europe can be quite challenging for implementing innovations in India. Due to a highly unpredictable nature of growth, selection and rejection of activities in the Indian context, we argue that a temporary or project-based approach to regional innovation systems in India's GIHs is appropriate. It is under such a setting, that key players in the Indian innovation ecosystem have to rely on CoP, or groups that have common interests for progressing their diverse innovation agendas.

We argue that more than geographical proximity, it is organizational, relational and occupational proximity that is critical in knowledge generation, identification and appropriation of the flow of tacit knowledge (Allen, 2002; Amin & Cohendet, 2000), in the context of India's GIHs. Such an approach relies on Mode 3 of learning (Carayannis & Campbell, 2009). For example, these GIHs actively draw upon both sets of hard and soft tacit knowledge and rely on a transdisciplinary application of multidisciplinary knowledge for developing innovative solutions, with a further reliance on the fourth strand – the CoP , which we portray as our Quadruple Helix. Our preliminary framework for analyzing GIHs in India captures and provides evidence of the four strands of the Quadruple Helix (Figure 2).

< Insert figure 2 about here >

The emergence of MNEs' innovation and R&D centers in India has witnessed a sustained growth in a number of industry sectors, such that in 2011, India was the eighth largest attractor of R&D investments by MNEs (Gupta & Gupta, 2014). Some estimates suggest India hosted close to 1100 MNE R&D centers in 2013. The incentives offered by the Government as part of its liberalization program led to the establishment of several tax-free software and IT export-processing zones, involving high-technology satellite communication systems to enable cross-border sharing of information (Heeks, 1998; Malik & Nilakant, 2015). This suggests an active collaboration between the industry and government – the first two strands of our Quadruple Helix. Whilst this attracted maximum investment and

participation by MNEs from the US, it was closely followed by MNEs from UK, Germany, France and Switzerland (Mrinalini, Nath, & Sandhya, 2013). Here, we find evidence of government support and regulation in influencing context-specific innovations.

> *…to develop a solution and show our visibility and show that it makes business sense …so that is how we kind of do it. Second part would be that you know, the way the government actually came up with regulations to prevent the misuse of what of ultrasound [devices]…. They have a very strict way of basically going in… Can we come with a solution here…? We can simply pad the whole thing and show that, you know [how] to simplify it so that accessibility [and therefore, misuse] can be reduced. [**Case 1**]*

> *So, if you take grant money, and there is a resurgence in Government money available for translation, translational research, you take that money, you make a product, you go through the clinical trials, you prove its efficacy and then you spend the money. [**Case 2**]*

Access to high-skilled technical talent, from large and developed urban cities, such as Bengaluru, Hyderabad, Chennai, Mumbai/Pune and National Capital Region/New Delhi, has thus attracted the highest R&D investments. Among different industry sectors, the maximum R&D centers were in IT and software development (50%), followed by Aerospace (13%), pharmaceuticals and biotechnology (10%), automobiles (9%) and the rest was distributed between machinery and equipment, services and chemicals (Gupta & Gupta, 2014). Since their establishment, almost 706 MNEs, employing 250,000 workers have successfully filed and obtained more than 1100 patents. The research and development productivity in terms of scientific publications of top 21 MNEs alone involved more than 3000 peer-reviewed publications, recording close to 7000 citations (Gupta & Gupta, 2014). Therefore in line with this argument, we found strong evidence of collaboration between industry and academia.

> *…from a technical perspective, we do a lot of work with IIT [Indian Institute of Technology]. So currently, for example, we have about three life projects with them.* [***Case 2***]

> *Yes, it happens. I would say on balance, because the company was formed in the US and it has extremely close ties to academic institutions like Stanford and MIT and it is deeply engaged with the professors there.* [***Case 3***]

The high degree of international collaboration (46%), as well as collaboration with

scientists from premier Indian institutes, such as the Indian Institutes of Technologies (IITs) and other top-tier regional engineering colleges (Gupta & Gupta, 2014) is a prominent feature and reinforces the academia-industry collaboration strand of the Quadruple Helix, both domestically and internationally. In addition to collaboration and sharing for creation of new knowledge, industry collaboration was also noted at numerous Centre(s) for engineering excellence, housed at academic institutions and industry partners for co-sharing of the technological resources and infrastructure for testing and conducting scientific experiments and research. Examples of these include formal collaborations between industry and academia such as IBM Research Institute and IIT Delhi, Honeywell International and Indian Institute of Science Bengaluru (IISB), Phillips Electronics and IISB, GE's John Welch Technology Centre and IISB- to name a few. Prominent MNE partners include: General Motors, Yahoo Labs, Intel, HP, ABB, Cisco, Motorola, Samsung and Accenture. Industry and other stakeholders in the GIHs, who are also collaborating for supporting innovation.

> *Typically, in consumer industry …because engineers want a product in a way the product is there, but the functionality, ID may not be for it, so that is always a problem. Doctors want it this way, because it is more clinically useable. So the way we design a product is, on a system level, we start sketching on a paper and the usability perspective sits with me …. He [Doctor] looks at it and we come from a usability perspective. …we still don't have a prototype; we just have the sketches. …. What do you think? …this is how we will realize the [final] design?* [***Case 1***]

> *So these are basic DNA is that we look out for each other's companies. And fortunately or unfortunately these are silos in this industry. An R&D guy never gets into manufacturing…. you see, the pharmaceutical industry in general …they fit at a different level of innovation intensity. What you will perceive, say for example, you start with a discovery program, with a more or less pre-defined objective because primarily we are working in an industry where the organization rightfully is expecting a product at the end of the day.* [***Case 4***]

Similar to IT and software firms, a number of pharma, biotechnology and healthcare MNEs have also established their presence in the Indian R&D and innovation ecosystem (PWC, 2010). Recent research highlights the growth of India as a base for pharmaceutical industry's clinical trials (Fernandes et al., 2019). All major global pharma firms have a

manufacturing base in India as well as, India has the largest number of Food and Drug Administration (FDA) US's approved contract manufacturing centers, as compared with any country, after the US. This would suggest an emerging capability of the Indian pharma sector (PWC, 2010).

Further, this industry report states that the top 10 Indian pharma firms invest in excess of US$ 500 million on R&D. There is, thus, significant evidence of collaboration between academic institutions, government research institutes and Indian pharma firms and MNEs for co-developing new drugs and or generics for the developed and emerging markets. India holds more than 20% of the global market for producing generic drugs and accounts for about 35% of global Abbreviated New Drug Applications (ANDA) issued by the global apex body in the US, the FDA (PWC, 2010). Due to the relatively weak institutional make-up of firms in the pharma and healthcare sector, firms in the sector had forged a number of strategic partnerships. For example, include partnerships between Indian Pharma MNEs and global pharma MNEs such as, between Glaxo SmithKline and Dr. Reddy's Laboratories and Pfizer and Aurobindo, to name a few. Furthermore, a number of large Indian MNEs have acquired small to mid-sized pharma MNEs in a number of countries to extend their technical knowledge and patent competency gaps and gain market access. Notably in each GIH, the government and academia collaboration with the industry was rife, which gave the initial impetus in the formation of India's GIHs.

As per the research gap noted earlier, by bringing together in this analysis and our conceptual model, the four helix strands in the context of GIHs in India, we highlight how CoP interacts with the well-established triple helix strands. Subsequently, it was more to do with the interactions between the meso- and micro-level aspects, such as the focus on CoP, for further enabling the success of India's GIHs. The interdependencies between different stakeholder groups at a meso- and micro-level, thus, supported the emergence of the fourth

strand in our conceptualization of a Quadruple Helix – CoP, as follows:

> *…every time people are travelling for something …we ensure that they are also making hospital visits, they are meeting the end-users of our products. We constantly keep calling people here to come and meet…* [***Case 1***]

> *It's really empowering the people, and giving them a space where they feel it's okay for me to come with all kind of ideas and I have a platform where I can discuss this and I can pursue it and it's all right in this organization.* **[*Case 1*]**

> *You cannot innovate in a controlled environment, it has to be open, it has to be empowerment-oriented and trust based. So if you don't trust your employees to go work there, and come back errors it won't happen.* [***Case 3***]

The above developments have, thus, positioned India in becoming a GIH for a number of pharma and healthcare device manufacturing and IT/software services. This suggests that there was an initial shift for the Indian GIHs moving from a weak institutional infrastructure offering only cost arbitrages, as evidenced in contract manufacturing/ service provision through competence building, to a center for developing a context-specific arbitrage. Thereafter, profound collaborations and a progressive upgrading of India's innovation ecosystem, which initially relied on cost arbitrage, has now seen a move towards competence and context-specific advantages.

< Insert table 2 about here >

As Table 2 shows, each stakeholder group in India's Quadruple Helix shifted their influence in the last three decades, in support of the evolution of the IT, pharma and healthcare industry's GIH. Albeit, this was initially through offering low-end, routine work (merely transactional work) to a move towards its current offerings involving a full spectrum of services (including transformational work). The following section presents a cross-case analysis of all the case organizations, aided by Leximancer 4.5 and robust triangulated manual theoretical coding. The coding schema (automated (first-order) and manual theoretical codes (second-order themes and aggregate dimensions) and its relationship with

the four helices is presented in Table 3 below.

<<Insert Table 3 about here>>

Based on our automated exploration and analysis of the cross-cases (Figure 1), having already analyzed the temporal evolution of GIHs, we now provide further elaboration and analysis of the role of *CoP in GIHs*, *Power and Trust Dynamics*, *Organizational Capabilities* and a focus on *Supranational Regions*. The above interrelationships and conceptualization of a Quadruple Helix in India's GIHs is presented in Figure 3. In Figure 3, we show the interwoven, interrelated and cross-interconnected nature of overlaps that exists between the helices. We also show that the size of each of the four helices may change with time, due to the changing nature of stakeholder power and trust dynamics, emerging organisational capabilities and the ability of the GIH to serve one or more supranational regions.

< Insert Figure 3 about here >

4.2. Communities of practice (CoP)

The attention to micro-level strategic alignment between different stakeholder needs, have been confirmed through the emergence of a CoP – at local, regional and global levels. The alignment of MNEs' business needs by working closely with the multiple sets of stakeholders was a common focus, as evident from the following quotes:

> ***…****You work internally with multiple stakeholders, globally, with multiple teams, the ability to work in teams… so that was where all the team members were contributing in terms of developing that, [and] building that technical expertise. …from engineering …there is mechanical team, …electrical teams, there is a modification specialist and cross functional teams of supply chain, regulatory verification, so those teams were established…. And then, our marketing team was also tied in to this* ***[Case 1]***
>
> *So the process of actually arriving at that proposal is what we call us, you know, again like what I mentioned at the innovation topics and for each topic there's what you call the long-term research strategy objectives that are released are again driven by global level* ***[Case 1]***
>
> *…from a technical perspective, we do a lot of work with IIT. So currently for example,*

*we have about three live projects with them. This [diagnostic product] was an output of IIT Mumbai, the XXX [another diagnostic product] is also with IIT Mumbai. Our next to next product is also with IIT Mumbai. So what we do is we apply for grants together with academia. And a lot of the high risk research happens at IIT Mumbai. But we essentially are with them from day zero. [**Case 2**]*

*So that collaboration is kind of important, in which we need to involve all parties. And sometimes even the third parties which are contributing into the complete solution that the OEM has in mind, they might get called into those workshops also, so we're, we will need to then collaborate with them as well. [**Case 3**]*

4.3. Organizational Capabilities

Since all our case-study firms were operating in an Indian contextual environment, there was evidence of extensive learning routines, which were beginning to form for developing products for the Indian and other emerging markets. The learning codes of the Indian setting becomes a critical part in defining the key table stakes in the product development process. Key areas and questions the firms faced were- how to allocate tasks; how to engage with the CoP; when to leverage resources and with which parties and at what time is highly contextual learning that these MNEs had to develop and grasp to remain effective- are few examples. Some of these activities were driven top-down, invoking the MNE's global strategic mandate, whereas in other instances, it was driven by the identified market needs and trends through a firm's market-based organizational learning capabilities and other regulatory and quality management metrics, that these firms were able to implement a number of effective innovation strategies. The following quotes throws further light on the above arguments.

*…it's normally the strategic plan. We have a grid for the next five years of the molecules that we will be working on based on our technical, IP and market analysis. Then, we, on an annual basis, reprioritize the products based on developments in each product project that we go for…as the scenario changes…as another company's innovation IP might be launched or rejected and accordingly we then change our priority-_so the resources get reallocated in R&D, formulations and project management group and other functional folks to strengthen their campaign. [**Case 4**]*

It is also understood that in healthcare and pharma products, a number of regulatory influences also shape the development of organizational capabilities and learning

routines, and the collaborations between different stakeholders occur at multiple levels for sharing skill complementarities, as is evident in the quotes below.

> *So, that was determined that there would be three range of products in this segment and markets, with our products and our positioning of the products…, when we looked at our products, in what we call this a value segment that is minimalist [approach], as we were all discussing, there are certain minimal things that we always try to provide. So like safety, we never sacrifice safety or compliance, we never sacrifice. So, those kind of things we cannot compromise on. [**Case 1**]*

> *So we help them formulate the problem, provide data to the problem with some market research from the channels that we have. We give them product design insights. Sometimes also instrumentation expertise, because the labs, the lab that we work in IIT Mumbai is focused on chemistry, not really that much of instrumentation. Instrumentation design and market insight. We help them raise money in terms of plans, they build the product…[**Case 2**]*

Further, strategic positioning for a niche area of drug innovation is the key in an already regulated landscape, as portrayed by the following quote.

> *Eco-friendly drugs. So this kind of innovation, then the third degree of innovation types is, how do you convert this active drug into a finished dosage form, which many human beings consume. The consumption may be by a variety of methods: orally, injectable and things like that. But again, that is like converting a drug into a finished dosage form by formulation-based knowledge. So that is another big group innovation. When it comes to even higher degree of innovation or where there's, I use the term innovation intensity is higher. It is a discovery. Where it is primarily for personal care, objective of finding a new drug which will bring substantial therapeutic advantages which were not seen in the earlier products. [**Case 4**]*

Also, in new areas where there are gaps in the Indian institutional system for key technical competencies in the Indian labor market, alternate learning paths for developing these technical capabilities had to be sought. For example, these include using the competencies from its headquarters, as is evident from the quote below.

> *…so currently we have XXX business, which is kind of a totally …global setup, right. Basically, what we could say is that we're designing an arm-based SOC [system-on-chip] with the target markets being tablets and platforms and, you know, there are bunch of activities that you need to do, which kind of globally separates it out. But we do have a lots of people who [are] kind of moving out there and work on that and come back and stuff …. Compared to other companies, I would say we are far beyond [in competencies] because the level in which we work as an organization considering that we're pretty small with respect of the other organization you see more or less [an] end-to-end, we end*

*of up working from an India perspective also. [**Case 3**]*

4.4. Trust and power dynamics

Given the institutional voids that persisted in the Indian context, negotiating the political and business imperatives between local and global CoP was seen as a challenging and iterative process, involving trust and power play between product development teams and stakeholders for developing context-specific innovative products, as is evident from the following quote.

> ***…****sitting in the USA designing… the next generation prototype we all look at this problem. This is actually very specific …we can appreciate why the government [in India] wants to do…. actually banned portable ultra sound. And one of the biggest …benefit of ultrasound is that, "Okay, this lady is actually in an obstructive labor. She will die if you don't do." But you wanted to know whether it's obstructive labor or not. So you have to make sure that ultrasound does that, but government said that a lot of people are [mis]using portable ultrasound …doing fetal gender and abortions. So government banned …. no portable ultrasound can go outside the building. …But until we kind of look at this problem and talk to doctors and look for solutions, you know, what is the technology trend could actually bring in here and how we are going to develop business around it, to address that is how we look at it. [**Case 1**]*

The product development team also had to work closely with doctors, technicians and a wide range of small and medium-sized medical clinic owners, who would be the end-users of the new product. There was, thus, a need to operate in conditions that are not akin to, or as sterile as, what one would expect in advanced nations. Therefore, we found that it was critical to foster trust between users and producers of the innovation. Such interactions with the wider CoP have yielded invaluable sensitivities in the context of environmental challenges, such as heat, dust and climatic conditions that contribute to the ruggedness of the product's final design and functionality features. The development of these relational capabilities between stakeholders evolved over a period of time, as is evident from the following quote.

> *…from a technical perspective, we do a lot of work with IIT. So, currently for example, we have about three live projects with them. This product was an output of IIT Mumbai; the glucometer is also with IIT Mumbai. Our next to next product is also with IIT*

*Mumbai. So what we do is we apply for grants together with academia. And a lot of the high risk research happens at IIT Mumbai. But we essentially are with them from day zero. So we help them formulate the problem, provide data to the problem with some market research from the channels that we have. We give them product design insights. Sometimes also instrumentation expertise, because the labs, the lab that we work in IIT Mumbai focuses on chemistry, not really that much of instrumentation. Instrumentation design and market insight is here. We help them raise money in terms of plans, they build the product… [**Case 2**]*

It is very hard to define precisely the wide range of CoP that provided invaluable insights in developing context-specific solutions. The development processes gradually evolved and required building of trust, mitigating power relationships, integrating expert knowledge, resources and technical capabilities from the CoP in design and development of innovative products, as is evident from the following quote:

*That is probably the most non-linear part… We really cannot articulate how that happens. Serendipitously, so we have a lot of friends who are doctors. We are doctors ourselves, of course we don't practice but we go to them we talk to them, what are you facing, what issues you are facing. But it's not really a structured… So this is actually very much not in line with what most Western universities do. [**Case 2**]*

Given the high frequency of collaborative activities and co-creation and co-development of semiconductor products across borders, several key micro-level values were inculcated by the following MNE. These includes areas such as trust, integrity and challenging peers. Individuals' trust in a team or group and their need to be challenged and remain excited was central to innovative product design (see quote below):

*Yeah, you have to have deeper knowledge and you have to be able to speak from experience, right? A lot of times, basically you may not have a chance to really try things you have to kind of speak from experience and that's how you earn the trust and if whatever you said turns out to be true, then you are suddenly more expected… and sometimes we have situations where customers ask for people by name also that, "I want so and so person to come to the workshop," because of the past experience. [**Case 3**]*

Thus, employees and managers have to be mindful of these dynamics and understand the value of expert power over dispositional power (see quotes below).

*I think that's where the manager plays a role, really. So he has to kind of try to mentor them as you challenge them. [**Case 3**]*

*Yeah, not being given the challenge is what may cause frustration right, not anything else…. throw them in an area slightly outside their comfort zone [and see them flourish]. **[Case 3]***

The senior leadership team had established a wide CoP involving groups of experienced technical leaders from around the world, including the parent company's headquarters, to support emerging leaders in India. This support was extended, till such time that the Indian location in Bengaluru could take ownership of one or more technical competency areas (see quote below).

*...then there are other teams where it's not... where it's globally distributed, where Bengaluru happens to be just a geographical location, there are things [activities] where the competency is completely owned by Bengaluru. [**Case 3**]*

This dynamic interdependence between stakeholders from academia, government, industry and other external partners such as FDA and other approval boards, requires significant coordination and cooperation between the various stakeholders. The slow development and regulatory processes and the relative power imbalance between this MNE and global pharma majors led to a different focus for the firm to operate in a niche space, as is evident from the following quote.

*...I would say as compared to intellectual property or strategic plan group as their work is much restricted in those two instances as they have to follow the required SOPs for the product. .... FDA's guidelines let's go up with them as it is. Your innovation should not compromise on quality. We are not the Pfizer or Glaxo who have the gravitas and their connections to challenge or even suggest any betterments to FDA standards. We are viewed as an insignificant company from India so knowing this we focus on **[Case 4]***

4.5. Focus on supranational regions

The context-specific needs of India and BRICS markets, which are cost sensitive share the same problems of institutional voids and a very similar demographic make-up of their ecosystem. This aspect was a critical consideration in the design of new products in most GIHs in India. They are seen and portrayed as leaders of reverse

diffusion as well as developing new products for emerging markets. While this points to significant collaboration and critical interactions between members of the CoP, the focus on developing context-specific and relevant products for emerging markets, relative to the products designed for advanced nation was also evident:

> *They [West] are building bigger, better devices…for example, urine analysis machines, you'll have a machine that does 50,000 samples…100,000 samples. You'll have a machine that 300,000 tests. And the fundamental difference is throughput. How many tests can you do? So companies start off with 100 tests. And then they make 300 tests, larger companies make 800 tests /day/lab. Now, there are probably 0.5% of labs, which do more than 100 tests per lab [in emerging markets]. [**Case 2**]*

> *…when we looked at it, [it] was focused on the BRICS markets, or because there were the Global Millennial goals of improving infant mortality rate. So, we wanted to contribute on to that and that is where we looked at. And instead of going for every high-end product that goes into the US, we looked into the emerging world first. So this product is positioned for the emerging markets, like India and BRICS. [**Case 1**]*

For some of the high-end product line, India and other emerging markets, still lag behind as the institutional and technological ecosystem is not fully developed (see quote below):

> *So, Asia-Pacific at Intel is around 35 to 40 per cent of their total revenue. Sixty per cent of that will be coming out of China and when I look at – so we are around what, four and a half to five billion dollars, it would probably be doing around 100 million out of India…. Intel is a US$ 55 billion company or thereabouts, the Indian operation is barely around a billion dollars also and they have been doing sales and marketing [in India] for the last 20 years….*

5. Discussion and implications

5.1. Theoretical contributions

Based on our analysis of the four case studies, our findings point to the distinctive relationship and collective interaction between the four strands of our Quadruple Helix conceptualization: i.e., between academia, government, industry and CoP, from India's GIHs thereby influencing change and innovations in the Indian GIHs. Our findings highlight several important theoretical contributions. First, we introduce the fourth helix strand – CoP, which draws upon the strengths of each strand in a Quadruple Helix to help integrate GIH

firms' common and specialist knowledge for achieving a range of innovative activities (Kriz et al., 2016; Malik et al., 2019). Our research findings points to the importance of diverse group of stakeholders coming together to shape the conceptualization of CoPs through diverse sets of interactions (Walshok, Shapiro, & Owens, 2013). CoP constitutes of leaders, managers, employees and select group of collaborators, who are both internal and external to the MNE in India's GIH. The CoP members can be from within the local region, where the GIH is located, such as third party service providers or subsidiary operations of MNEs, or regional (e.g., Asia-Pacific) or in a supranational area. Specifically, examples of these external CoP members include representatives that are local and global users, customers, clients, academic institutions, and suppliers, who were empowered to contribute to the innovation processes and outcomes of GIHs (Von Hippel, 2005). Such a broader conceptualization of CoPs is critical for the successful operation of a GIH.

Second, given the diversity in CoPs, we find that MNEs may exercise strategic choices in deploying and allocating resources and technical and managerial capabilities. The MNEs also have to integrate local and global tacit knowledge from the CoPs, especially, the leaders and managers when it comes to managing the duality of local-global, indigenous and context-specific codes versus global standards. The constant pressure to balance this duality may lead to the temporal evolution and change in the mindsets of leaders of the MNEs to move from a cost-arbitrage position through to a competence arbitrage to a context-specific knowhow and arbitrage position. Such an approach requires significant levels of trust as well as skills in managing the power dynamics inherent in numerous human-centered factors (Kriz et al., 2016; Marcovich & Shinn, 2011; Miller et al., 2016). All these ideas help us advance the current theoretical knowledge of the underlying process by which all the strands within the Quadruple Helix may cooperate and collaborate with each other.

Third, we found constant negotiation and renegotiation of cooperation and collaboration

among the different members of the CoP for positioning India as a GIH in all the above three industry sectors. While this facilitated the rise in R&D investment and innovative activity through government incentives and sharing the Indian University's technical and physical infrastructures, subsequent growth came from the subsidiaries and through other strategic partnerships (Miller et al., 2016). This confirms our assertion of the critical role played by CoPs as a fourth and critical strand in the formation of India's Quadruple Helix for its GIHs, which allows us to further advance the current definition and scope of Quadruple helices by providing new theoretical insights into the process by which these are formed.

Finally, in all GIHs, the role of market signaling for delivering credible and innovative solutions was created through the capabilities these MNEs developed, such as quality management and market-based organizational learning capabilities (Malik et al., 2012) and other technical and managerial capabilities for negotiating power and trust (Patnaik et al., 2020) between the CoPs and the leaders in each sphere of the helix. The emergence of GIHs was also facilitated by deliberate strategic choice decisions to design and produce innovative products for emerging markets, such as in the BRICS. In doing so, the role of relational proximity was achieved through close collaboration relationships between local, regional and global level partnerships of a much wider CoP. This complex coordination meant the caliber of leadership and managerial talent was such that the leaders were capable of managing the duality of simultaneously moving between regimes of asset exploitation and subsequently asset augmentation in their R&D centers in India's GIHs (Malik et al., 2018). These findings help us extend current conceptual knowledge about the process by which GIHs are formed.

5.2. Managerial implications

Our results also have some useful managerial implications. First, we clarify and highlight the key mechanisms enabling the negotiation of the dual objectives of asset exploration and

exploitation by the senior leaders in the parent firm and/or with client firms, which may help them develop a shared understanding through extensive intra-organizational communication of innovation activity. For example, our results underline the importance of cross-functional team-based designs for greater collaboration depth and diversity needed to design products for new markets (Miller et al., 2016). Similarly, we show that knowledge creation and renewal are likely to occur through careful interactions with members of the CoP (Cooke & Memedovic, 2003). We also found ample evidence that the managerial and leadership practices had to support the coordination of projects/processes using key performance measures and incentive approaches (Walshok et al., 2013).

Second, the pressure on governments to remain competitive and innovative has led them to realize the power of strategic partnerships between industry, academia and CoPs. As evidenced from our case study analysis, when it comes to a practice viewpoint, fostering micro-level interactions between the CoPs and the Triple Helix of academia, government and industry is critical to the emergence of regional and GIHs. The above also highlights the need for setting a baseline of effective relational and contractual governance between key stakeholders in an MNE's value chain. The trust and power dynamics between all members of the CoP should be managed effectively by focusing on collaborative approaches and actively searching for complementarities among partners. A multi-level coordination policy platform is critical for enabling cooperation and collaboration between the key stakeholders in the Quadruple Helix. It is also vital that policy makers remain sensitive to the needs of the context for which the innovations are designed. Adopting a bottom-up and human-centered approach, along with tangible and intangible incentives will help gain commitment of CoP members, including an MNE's value chain.

6. Limitations and future research

Our paper has a few limitations that future research may address. First, we developed our Quadruple Helix model based on three industry sectors in India, hence, future research may validate and extend our model using data collected from other emerging markets because each context may offers unique temporal and resource-based advantages that actors and CoPs may be able to leverage. Second, following the principle of equifinality, future research may explore new mechanisms that could replace CoP, and include mechanisms that may be relevant in different contexts in shaping a new Quadruple Helix. Third, future research may also adopt a longitudinal design, tracking the evolving temporal dynamics in other R&D and innovation contexts such as in equipment manufacturing settings or social innovation hubs, and rural and primary industries, as there are a number of economies that rely extensively on their primary sector that have generally done very well.

Fourth, future research may also explore how each strand of a helix shapes the 'starting points' for interactions with a range of micro-level factors (Kriz et al., 2018: p.16). As certain regions can be agglomerations of actors that operate at a firm level, future research can profile the strength of regions and its stakeholders, to successfully assess the readiness a region has for creating sites for GIHs. Such research can also identify, from the key mechanisms and profiles, favorable and unfavorable power and trust dynamics between a parent MNE and its subsidiary or between the service provider and MNE client and how they affect the creation of GIHs. Finally, the concept of resilience of a region is also important, especially when a region is faced with changed stakeholder dynamics, natural or man-made disasters. In such times, learning from failures or crises may offer invaluable knowledge critical in the shaping a new or a renewed global, national or regional system of innovation.

References

Allen, J. (2002). Power/economic knowledge: symbolic and spatial formations. In R. Bryson, P. W. Daniels, N. Henry and J. Pollard (eds) *Knowledge, Space, Economy* (pp. 26-44). London: Routledge.

Amin, A., & Cohendet, P. (2000). Organizational learning and governance through embedded practices. *Journal of Management and Governance*, *4*(1-2), 93-116.

Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: regional innovation systems. In *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Audretsch, D. B. (2015). *Everything in Its Place: Entrepreneurship and the Strategic Management of Cities, Regions, and States.* Oxford, Oxford University Press.

Awate, S., Ajith, V., & Ajwani-Ramchandani, R. (2018). Catch-up as a survival strategy in the solar power industry. *Journal of International Management*, *24*(2), 179-194.

Bachmann, R. (2001). Trust, power and control in trans-organizational relations, *Organization Studies*, (22) 2, 337-365.

Banerjee, P. (2004). *The Indian software industry: Business strategy and dynamic co-ordination*. Springer.

Binz, C., & Truffer, B. (2017). Global innovation systems—A conceptual framework for innovation dynamics in transnational contexts. *Research Policy*, *46*(7), 1284-1298.

Bruneel, J., Spithoven, A., & Clarysse, B. (2017). Interorganizational trust and technology complexity: evidence for new technology based firms, *Journal of Small Business Management*, *55*(S1), 256-274.

Brunetta, F., Marchegiani, L., & Peruffo, E. (2019). When birds of a feather don't flock together: Diversity and innovation outcomes in international R&D collaborations. *Journal of Business Research*, *114*, 436-445.

Burgos-Mascarell, A., Ribeiro-Soriano, D., & Martínez-López, M. (2016). Dystopia

deconstructed: applying the triple helix model to a failed utopia. *Journal of Business Research*, *69*(5), 1845-1850.

Cappelli, P., Singh, H., Singh, J., & Useem, M. (2010). The India way: Lessons for the US. *Academy of Management Perspectives*, *24*(2), 6-24.

Carayannis, E. G., & Campbell, D. F. J. (2009). "Mode 3" and "Quadruple Helix": Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management, 46*(3-4), 201–234.

Carayannis, E. G., Barth, T. D., & Campbell, D. F. (2012). The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, *1*(1), 1-12.

Carayannis, E. G., & Campbell, D. F. (2019). *Smart quintuple helix innovation systems: How social ecology and environmental protection are driving innovation, sustainable development and economic growth*. Cham: Springer.

Chung, S. (2002). Building a national innovation system through regional innovation systems. *Technovation*, *22*(8), 485-491.

Croom, S. R. (2001). The dyadic capabilities concept: examining the processes of key supplier involvement in collaborative product development. *European Journal of Purchasing & Supply Management*, *7*(1), 29-37.

Colquitt, J. A., LePine, J. A., Piccolo, R. F., Zapata, C. P., & Rich, B. L. (2012). Explaining the justice–performance relationship: Trust as exchange deepener or trust as uncertainty reducer? *Journal of Applied Psychology*, *97*(1), 1-15.

Cooke, P., & Memedovic, O. (2003) *Strategies for Regional Innovation Systems: Learning Transfer and Applications,* Vienna, Austria: United National Industrial Development Organization.

Corley, K. G., & Gioia, D. A. (2004). Identity ambiguity and change in the wake of a

corporate spin-off. *Administrative Science Quarterly*, 49, 173-208.

Cunningham, J. A., Menter, M., & O'Kane, C. (2018). Value creation in the quadruple helix: A micro level conceptual model of principal investigators as value creators. *R&D Management*, *48*(1), 136-147.

De Meyer, A. (1993). Internationalizing R&D improves a firm's technical learning. *Research Technology Management*, *36*(4), 42-49.

Elango, B., Patnaik, C., & Wieland, J. R. (2016). Do business group characteristics matter? An exploration on the drivers of performance variation. *Journal of Business Research*, *69*(9), 3205-3212.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy, 29*(2), 109–123.

Etzkowitz, H., & Zhou, C. (2017). *The triple helix: University–industry–government innovation and entrepreneurship*. UK: Routledge.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532–550.

Fernandes, S. D., Anoop, N. V., Castelino, L. J., & Charyulu, R. N. (2019). A national approach to pharmacovigilance: The case of India as a growing hub of global clinical trials. *Research in Social and Administrative Pharmacy*, *15*(1), 109-113.

Foss, N. J. (2011). Invited editorial: Why micro-foundations for resource-based theory are needed and what they may look like. *Journal of Management*, *37*(5), 1413-1428.

Foss, N. J., & Lindenberg, S. (2013). Microfoundations for strategy: A goal-framing perspective on the drivers of value creation. *Academy of Management Perspectives, 27*(2), 85-102.

French, J. R. P., Jr., and Raven, B. H. (1959). The bases of social power, In D. Cartwright

(Ed.), *Studies in Social Power* (pp. 150–167). Ann Arbor, MI: Institute for Social Research.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, *16*(1), 15-31.

Goerzen, A. (2018). Small firm boundary-spanning via bridging ties: Achieving international connectivity via cross-border inter-cluster alliances. *Journal of International Management*, *24*(2), 153-164.

Govindarajan, V., & Ramamurti, R. (2011). Reverse innovation, emerging markets, and global strategy. *Global Strategy Journal*, *1*(3-4), 191-205.

Gupta, R., & Gupta, B. M. (2014). Foreign MNC R&D centers in India: A study of their publications, 2003-12. *DESIDOC Journal of Library & Information Technology*, *34*(4), 287-292.

Hasche, N., Höglund, L., & Linton, G. (2019). Quadruple helix as a network of relationships: creating value within a Swedish regional innovation system. *Journal of Small Business & Entrepreneurship*, Available online: https://doi.org/10.1080/08276331.2019.1643134

Heeks, R. (1998). The uneven profile of Indian software exports. *Development Informatics Working Paper*, (3), Manchester, UK: Institute for Development Policy and Management.

Isaksen, A., & Karlsen, J. (2011). Organizational learning, supportive innovation systems and implications for policy formulation. *Journal of the knowledge economy*, *2*(4), 453-462.

Kriz, A., Molloy, C., Kriz, A., & Sonntag, S. (2016). All Australian regions are not born equal: Understanding the regional innovation management sandpit. *Technology Innovation Management Review*, *6*(6), 11-23.

Kriz, A., Bankins, S., & Molloy, C. (2018). Readying a region: temporally exploring the

development of an Australian regional quadruple helix. *R&D Management*, *48*(1), 25-43.

Kumar, N., & Puranam, P. (2012). *India inside: The emerging innovation challenge to the West*. Harvard Business Press.

Lam, A. (2007). Multinationals and transnational social space for learning: knowledge creation and transfer through global R&D networks. *The Economic Geography of Innovation*, 157-189.

Lazzeretti, L., & Capone, F. (2016). How proximity matters in innovation networks dynamics along the cluster evolution. A study of the high technology applied to cultural goods. *Journal of Business Research, 69*(12), 5855-5865.

Lundvall, B. Å. (2016). National systems of innovation: towards a theory of innovation and interactive learning. *The Learning Economy and the Economics of Hope*, UK: Anthem Press.

McAdam, M., & Debackere, K. (2018). Beyond 'triple helix' toward 'quadruple helix' models in regional innovation systems: Implications for theory and practice. *R&D Management*, *48*(1), 3-6.

McKinsey. (2011). *R&D strategies in emerging economies: McKinsey Global Survey Results*. http://www.mckinsey.com/insights/operations/r_and_38d_strategies_in_emerging_economies_mckinsey_global_survey_results

Malik, A., Froese, F. J., & Sharma, P. (2020). Role of HRM in knowledge integration: Towards a conceptual framework. *Journal of Business Research, 109*, 524-535.

Malik, A., & Nilakant, V. (2015). Context and evolution of the Indian IT industry. *Business models and people management in the Indian IT industry: From people to profits*, 15-34. UK: Routledge.

Malik, A., Ngo, L. V., & Kingshott, R. P. (2018). Power, resource dependencies and capabilities in intercultural B2B relationships. *Journal of Services Marketing*, *32*(5), 629-

642.

Malik, A., Pereira, V., & Tarba, S. (2019). The role of HRM practices in product development: Contextual ambidexterity in a US MNC's subsidiary in India. *The International Journal of Human Resource Management*, *30*(4), 536-564.

Malik, A., Sinha, A., & Blumenfeld, S. (2012). Role of quality management capabilities in developing market-based organisational learning capabilities: Case study evidence from four Indian business process outsourcing firms. *Industrial Marketing Management*, *41*(4), 639-648.

Manikandan, K. S. and Ramachandran, J. (2014). Beyond institutional voids: Business groups, incomplete markets, and organizational form, *Strategic Management Journal*, *36* (14), 598-617

Miller, K., McAdam, R., Moffett, S., Alexander, A., & Puthusserry, P. (2016) Knowledge transfer in university quadruple helix ecosystems: an absorptive capacity perspective. *R&D Management*, *46*, 383–399.

Mrinalini, N., Nath, P., & Sandhya, G.D. (2013). Foreign direct investments in R&D in India. *Current Science*, *105*(6), 767-73.

Mooradian, T., Renzl, B., & Matzler, K. (2006). Who trusts? Personality, trust and knowledge sharing. *Management Learning, 37*(4), 523-540.

Nelson, R. R. (Ed.). (1993). *National innovation systems: a comparative analysis*. Oxford University Press, Oxford, UK.

PWC. (2010). *Global pharma looks to India: Prospects for growth*. London: PWC.

Padilla-Perez, R., Vang, J., & Chaminade, C. (2009). Regional innovation systems in developing countries: Integrating micro and meso-level capabilities. In *Handbook of Innovation Systems and Developing Countries: Building domestic capabilities in a global*

setting, (pp. 140-182).

Patnaik, S., Pereira, V., Temouri, Y., Malik, A., & Roohanifar, M. (2020). The dance of power and trust-exploring micro-foundational dimensions in the development of global health partnership. *Technological Forecasting and Social Change*, *156*, 120036. Available online: https://doi.org/10.1016/j.techfore.2020.120036

Pereira, V., Corradini, C., Temouri, Y., & Mellahi, K. (2019a) Investigating Institutional, Economic and Social Determinants of European Regions for Firm-growth through Employment Generation, *British Journal of Management*, *31*(1), 162-183.

Pereira, V., Mellahi, K., Temouri, Y., Patnaik, S., & Roohanifar, M (2019b). Investigating Dynamic Capabilities, Agility and Knowledge Management within EMNEs: Longitudinal Evidence from Europe. *Journal of Knowledge Management*, *23*(9), 1708-1728.

Pereira, V., Munjal, S., & Nandakumar, M. K. (2016). Reverse dependency: A longitudinal case study investigation into headquarter-subsidiary relationship in the context of an emerging economy. *International Studies of Management & Organization*, *46*(1), 50-62.

Pereira, V., Patnaik, S., and Temouri, Y. (2020). Getting Our Act Together for COVID-19 Drug Development. *Issues in Science and Technology*. (May 21, 2020). Link-https://issues.org/covid-19-drug-development-infectious-disease-partnerships/.

Pereira, V., and Temouri, Y. (2017). Impact of Institutions on Emerging European High-Growth Firms. *Management Decision*, *56*(1), 175-187.

Pereira, V., Temouri, Y., & Patel, C. (2019c) Exploring the Role and Importance of Human Capital in Resilient High Performing Organisations: Evidence from Business Clusters, *Applied Psychology: An International Review*, Available online: https://doi.org/10.1111/apps.12204

Pereira, V., Temouri, Y., Patnaik, S., & Mellahi, K. (2020). Managing and preparing for emerging infectious diseases: Avoiding a catastrophe. *Academy of Management*

Perspectives. Available online: https://doi.org/10.5465/amp.2019.0023

Porter, M. (1990). The Competitive Advantage of Nations, Free Press, New York.

Radjou, N., Prabhu, J., & Ahuja, S. (2012). *Jugaad innovation: Think frugal, be flexible, generate breakthrough growth*. Jossey-Bass, San Francisco, CA.

Ramdorai, A., & Herstatt, C. (2015). Frugal innovation in healthcare. *India Studies in Business and Economics*, Springer, Cham, Switzerland.

Scuotto, V., Beatrice, O., Valentina, C., Nicotra, M., Di Gioia, L., & Briamonte, M. F. (2020). Uncovering the micro-foundations of knowledge sharing in open innovation partnerships: An intention-based perspective of technology transfer. *Technological Forecasting and Social Change*, *152*, 119906. Available online: https://doi.org/10.1016/j.techfore.2019.119906

Schütz, F., Heidingsfelder, M. L., & Schraudner, M. (2019). Co-shaping the Future in Quadruple Helix Innovation Systems: Uncovering Public Preferences toward Participatory Research and Innovation. *She Ji: The Journal of Design, Economics, and Innovation*, *5*(2), 128-146.

Sinkula, J. M., Baker, & W. E., Noordeweir, T. (1997). A framework for market-based organizational learning: Linking values, knowledge, and behaviour. *Journal of the Academy of Marketing Science, 25,* 305–318.

Smith, A., and Humphreys, M. (2006). Evaluation of unsupervised semantic mapping of natural language with Leximancer concept mapping. *Behavior Research Methods, 38*, 262–279.

Tellis, G. J. (2012). *Unrelenting Innovation: How to Create a Culture for Market Dominance.* New York: John Wiley & Sons.

Tiwari, R., & Herstatt, C. (2012). Frugal innovation: A global networks' perspective. *Die Unternehmung*, *66*(3), 245-274.

Un, C. A., & Rodríguez, A. (2018). Local and global knowledge complementarity: R&D collaborations and innovation of foreign and domestic firms. *Journal of International Management*, *24*(2), 137-152.

Von Hippel, E. (2005). *Democratizing innovation*. Cambridge, MA: MIT Press.

Walshok, M., Shapiro, J., & Owens, N. (2013) *Unravelling the Cultural and Social Dynamics of Regional Innovation Systems*. San Diego, CA: University of California.

Yin, R. K. (2003). Case study research: design and methods (ed.). *Thousand Oaks*.

Zaheer, S., & Zaheer, A. (2006). Trust across borders, *Journal of International Business Studies*, 37, 21-29.

Table 1. Interviewee Details

Interviewee	Case 1	Case 2	Case 3	Case 4	Total
HR Manager/ L&D Manager	3	-	1	2	**6**
Business Development	1	1	-	1	**3**
Product/project Heads	2	1	3	2	**8**
Innovation /R&D Head	1	1	2	2	**6**
Total	**7**	**3**	**6**	**7**	**23**

Table 2. Temporal Influences of Each Helix in influencing Evolution of GIHs

Key focus	Stages	Academia	Government	Industry	CoP
Cost arbitrage	Stage 1	M-H	H	M-L	L
Competence arbitrage	Stage 2	M-H	M	H	H
Context-specific (regional) arbitrage	Stage 3	H	L	H	H

Legend: H=High, M=Medium, L=Low, M-L=Medium to Low, M-H=Medium to High, CoP= Communities of Practice

Table 3: Cross-Case Codes: First-order, Second-order, Aggregate Dimensions and Quadruple Helix Linkages

S. No.	First Order Concepts	Second-order Themes	Aggregate Dimensions	Helices
1	Important, ideas, problem, sales, working, people, experience, level, team and organisation	Ideas, Collaboration, People	Trust and Power Dynamics	CoP Industry Academia Government
2	Use, quality, market, product, different, business, India, sense	New Products, Process and Business models	Supranational Regions	CoP Industry Academia Government
3	Use, quality, market, things, happen, down, area, terms and training	New Drugs and product development, Firm, training and activities	Organizational Capabilities	CoP Industry Academia Government
4	Technology, time, research, doing, development, probably, manufacturing	Probability, Process Change, Business Need	Temporal Changes	CoP Industry Academia Government

Figure 1. Cross-case analysis of concepts and themes

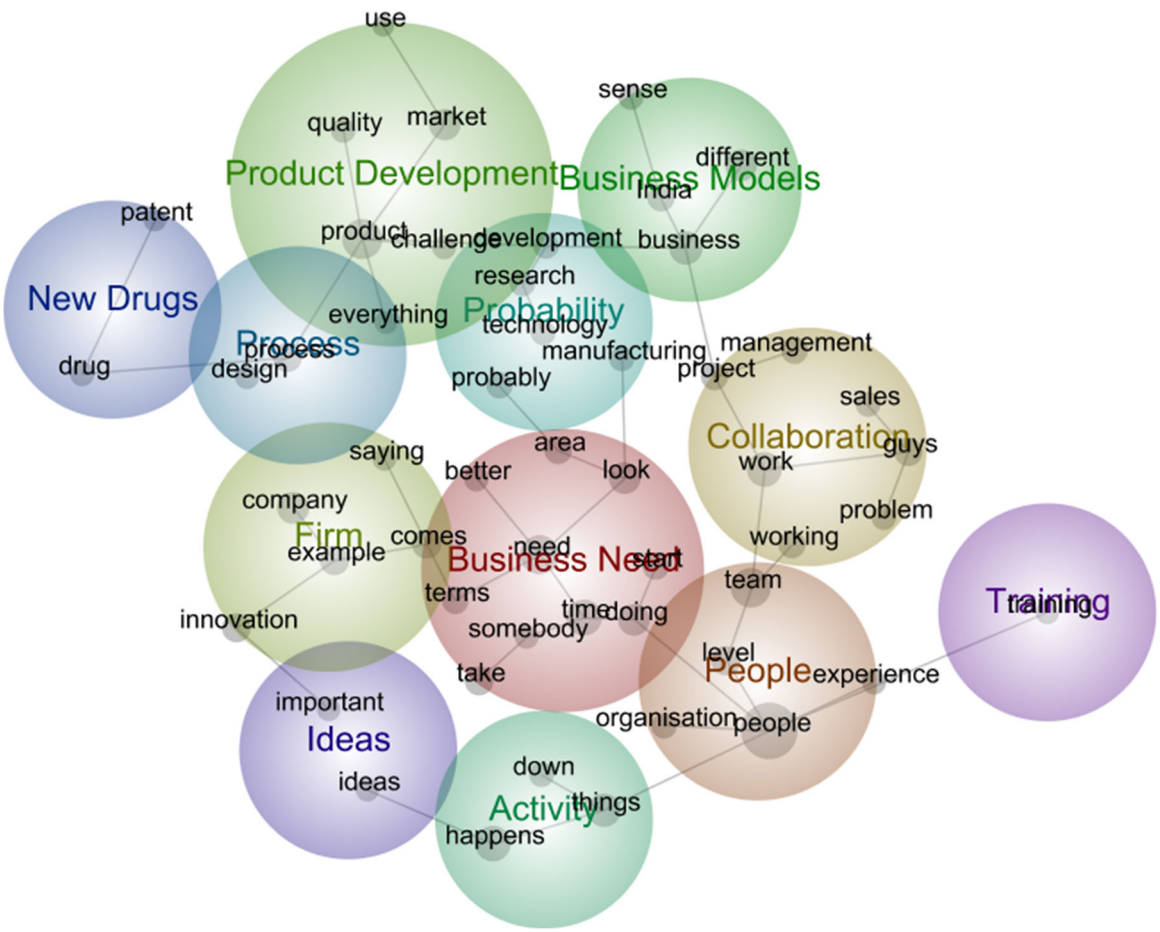

Figure 2. Quadruple Helix in India's GIHs

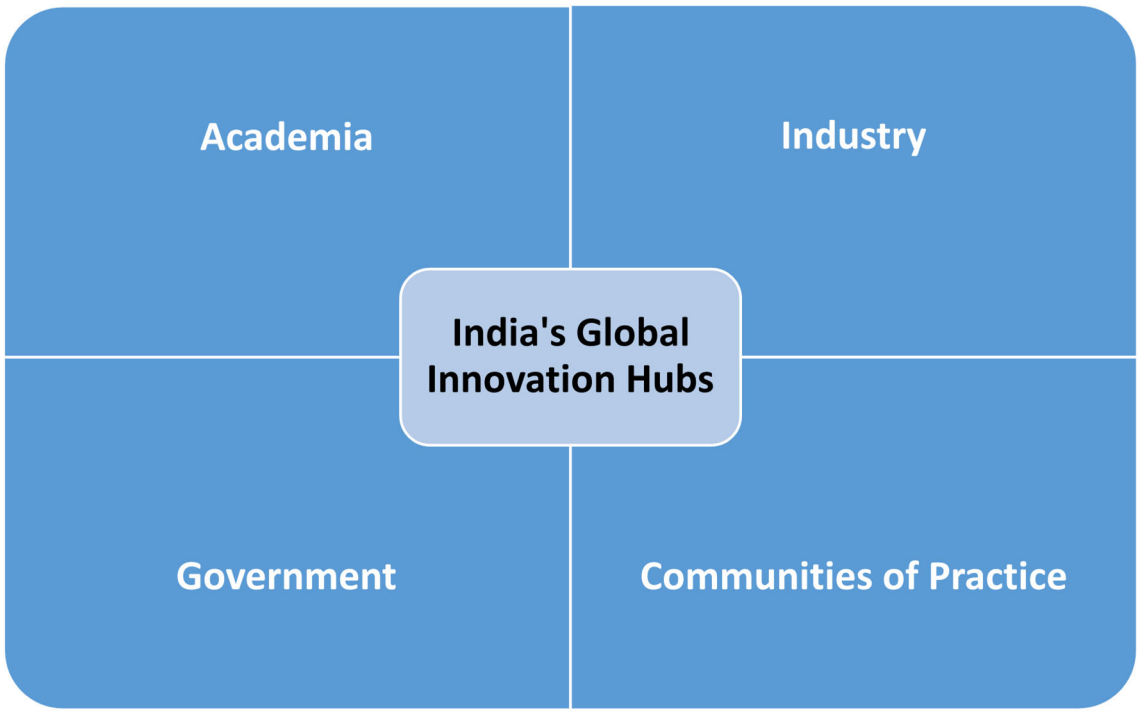

Figure 3. The Quadruple Helix in GIH: Micro-, Meso-Influences and Temporal Change