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Internationalisation of R&D: New insights into multinational enterprises' R&D strategies in emerging markets**

Multinational enterprises' research and development (R&D) activities are increasingly internationalised and organised into new types of network, as part of their global innovation networks. In this article, we investigate the dynamics and strategies of R&D reorganisation through an in-depth case study of a global firm from the most globalised industry in terms of R&D, biotechnology. The article investigates dynamics of internationalisation of R&D in global networks by looking at: 1) the strategic drivers of location, either as a large potential market or as a pool of competencies; and 2) the evolution of the company and its R&D activities into emerging market locations: India, China and Brazil. Together, these two dimensions constitute the drivers of R&D internationalisation and contribute to the construction of global innovation networks through knowledge augmenting and exploiting strategies. The article shows how multinational enterprises can use a combination of augmenting and exploiting strategies in emerging markets and hence demonstrates that international R&D activities not always evolve in a sequential and ordered trajectory.

Key words: **internationalisation of R&D, biotech industry, emerging markets, home-base exploiting, home-base augmenting, strategic drivers, evolutionary approach**
(JEL: D21, L65, L66, O31, O32)

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** Acknowledgements: This research was kindly sponsored by the European Commission FP7 in the project INGINEUS and the Sino-Danish Center for Research and Education (SDC) to whom the authors are very grateful.

Article received: July 10, 2014
Revised version accepted after double blind review: June 17, 2015.

management revue, 26(2), 101-122 DOI 10.1688/mrev-2015-02-Haakonsson
ISSN (print) 0935-9915, ISSN (internet) 1861-9908

1. Introduction

Due to the rapid internationalisation and disintegration of value chains, it has become imperative for firms at the forefront of technology development to reorganise and restructure innovation activities on a global scale. This article aims to provide a greater understanding of the complex and dynamic process of internationalisation of research and development (R&D) taking place in multinational enterprises (MNEs). The international business and management literature has been relatively silent about the actual internationalisation of R&D in MNEs, although this process has intensified immensely during the last decade (OECD, 2008, 2013). Burgeoning evidence shows that a momentous integration of knowledge activities from new locations beyond the Triad (US, Europe and Japan) is currently taking place. MNEs are extending R&D activities to host locations in emerging markets as part of their global innovation networks. This process has interested many but remains poorly understood. In light of this, a specific aim of this article is to explore R&D strategies and the drivers being deployed in emerging markets as part of firms' efforts to integrate R&D activities undertaken abroad. The article draws on an in-depth case study of Novozymes, a leading European MNE from a highly globalised sector (biotech) with eight R&D sites spanning eight countries. By specifically focussing on the R&D activities in the emerging markets of China, India and Brazil, the article delves into Novozymes's current reorganisation of innovation.

The article draws attention to two gaps in the international business literature in the understanding of R&D strategies of MNEs. Firstly, while the extant literature has enriched our knowledge of the general trends in international R&D (Gammeltoft, 2006; Ernst, 2006; Patel & Pavitt, 1992; UNCTAD, 2005; Cooke, 2013) and on its various typologies (Ronstadt, 1978; Håkanson & Nobel, 1993; Archibugi & Iammarino, 1999; Pearce, 1999), the MNE R&D strategies abroad were presented in narrow typologies (archetypes). For instance, according to these typologies, the establishment of foreign subsidiaries is connected to *either* home-base augmenting (HBA) strategies (hereafter augmenting) *or* home-base exploiting (HBE) strategies (hereafter exploiting) (Kuemmerle, 1999). According to Kuemmerle (1997, p. 61), who coined this dichotomy: "All foreign R&D sites fall into one of two categories and each type has different needs." Whether the two strategies can co-occur and eventually even shift frequently remains unclear. Given the speed of globalisation today, it seems likely that an MNE may use a combination of these strategies at its multiple locations and that its foreign subsidiaries may pursue these two strategies simultaneously. As a result, the exploitation/augmentation dichotomy, though convenient, may have resulted in an oversimplification of the R&D internationalisation that MNEs practise. Hence, we suggest that a more nuanced view of the static classification is relevant.

Secondly, while prior research has drawn on many perspectives, such as product life cycle (Vernon, 1966), incremental commitment (Johanson & Vahlne, 1977), sequential expansion (Kogut, 1983) and organisational learning (Kogut & Zander, 1993), to explain international strategies, the focus has mainly been on MNE entry strategies in foreign *markets*. Albeit, the few studies that draw on economic geography (Mudambi, 2008; Buckley & Ghauri, 2004; Haakonsson, Jensen, & Mudambi, 2013), the evolu-

tion of global innovation networks in general and internationalisation of R&D strategies in particular have received limited attention (Herstad, Aslesen, & Ebersberger, 2014). As also pointed out by Blomkvist, Kappen, and Zander, (2010), evolutionary paths and potential limits to the development of technological capabilities at the foreign subsidiary level have not been fully explored. Studies focussed on internationalisation of innovation such as R&D have traced an ordered or sequential evolutionary pattern. Proponents of this model identified that initial R&D investments in foreign subsidiaries are for market adaptation or to provide production support, and to act as a global scanner sending signals about changing demands back to the headquarters (HQ). The foreign subsidiary expands into higher capabilities such as to develop new and improved products for the local or even global markets. Over time, the R&D carried out in the foreign subsidiary will potentially contribute to the MNE's overall competitiveness (Bartlett & Ghoshal, 1989; D'Agostino & Santangelo, 2012; Archibugi & Michie, 1995; Zanfei, 2000; Luo, 2002).

Meanwhile, some authors clarify that evolutionary models are insufficient to describe MNE strategies. For instance, Granstrand, Hikanson, and Sjiilander (1993) criticised the "models of gradual expansion to geographically or culturally neighbouring countries, models of sequential internationalisation of in turn marketing, production, and R&D functions, or models of centralised generation of technology, followed by transfer to subsidiaries and adaptation" (Granstrand et al., 1993, p. 424). Our approach advances this argument by demonstrating that international R&D activities do not always evolve in a sequential and ordered trajectory. In the sections that follow, we illustrate through an analysis of Novozymes these two points that we believe have been overlooked in the literature. An in-depth case-study design combining insights from multiple locations within a single MNE enables us to achieve this. Our focus is on the evolution of Novozymes's R&D facilities in three emerging markets, which allows us to explore the complexity and dynamics of R&D strategies. Our results elicit why it is imperative to reconsider the static categorisation of exploitation and augmentation strategies, as well as the gradual evolution from one stage to other. The remaining parts of the article are organised as follows: Section 2 sets the context of the research, presenting the biotechnology industry as a backdrop and also how global R&D is organised in Novozymes. Section 3 discusses relevant literature to provide a grounding for the conceptual framework put forward in this article. This framework is specifically developed by drawing on past literature and used to provide more clarity on the new insights gained from the empirical research. Section 4 deals with the research methodology while the empirical findings are presented in Section 5 together with a comparative analysis of the evolution of R&D units in China, India and Brazil. Sections 6 and 7 discuss the evolution and the conclusions, respectively.

2. Internationalisation of R&D in a biotech multinational

Spanning a range of scientific disciplines and building on natural biological phenomena, innovation in the biotech industry is inherently global. The biotech industry is the most globalised and networked in R&D and innovation, which is also mirrored in the investment patterns of the industry. Overall, 40% of foreign direct investment (FDI) in the biotech industry is for R&D, more than any other industry (in pharmaceuticals

it is 21% and in software 5%) (FT fDi Intelligence, 2014). The biotech industry relies on global R&D integration. The nature and use of biotech have developed so that international networks create competitiveness, which makes it imperative for organisations to engage in global techno-scientific collaborations and hence innovation networks (Haakonsson, 2012, 2013). Consequently, no single company or geographical region has capabilities and competitiveness that are independent of its global network.

Novozymes, a world-leading enzyme producer, is a typical firm in the biotech industry, engaging in innovation across the globe and across value chains. Hence, it is not surprising that due to the reorganisation of innovation, Novozymes faces new challenges. This is illustrated by Novozymes's current R&D priority projects. Novozymes is an important player in the development of second- and third-generation biofuel, which requires a strong network upstream in the chain of innovation activities for exploring, developing and testing new forms of biofuel. Meanwhile, it also requires a strong downstream network for integrating Novozymes's products into the production of biofuel and into the development of international standards for biofuel. A similar process took place when detergents were developed for energy-saving laundering in cold water, which integrated researchers across four continents.

Novozymes is an MNE with globally dispersed competencies orchestrated through eight integrated specialised R&D centres that together constitute the core of Novozymes's global innovation network (Gerybadze & Reger, 1999). However, three elements show that Novozymes is an extreme case with a highly internationalised R&D strategy, which is excellent for explorative research. Firstly, Novozymes originates from Denmark, a small open economy, and hence faces a strong need to internationalise. Secondly, it is a producer of ingredients and enzymes for many global firms who are increasingly operating globally. These firms require that their key technology suppliers, such as Novozymes, adjust products to local tastes and raw materials. Finally, Novozymes specialises in biotech, an industry that, as mentioned, has the highest share of R&D-related investment in total FDI. With core capabilities in biotech solutions, primarily in enzymes, microorganisms and biopharmaceutical ingredients, Novozymes commands 47% of the global enzyme market spread across 120 countries. Enzymes account for 92% of its total sales and a considerable proportion of its total R&D expenditure. Table 1 shows that its leading markets are Europe

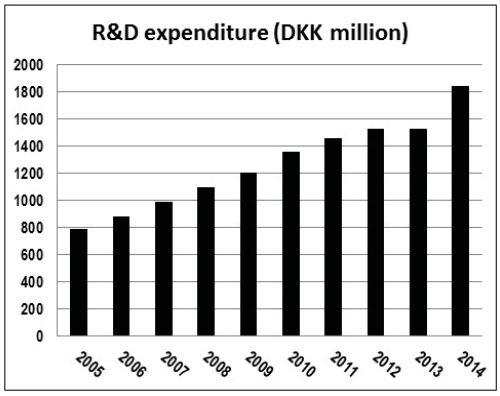
Table 1: Novozymes's Geographical Distribution of Revenue and Assets (2014)

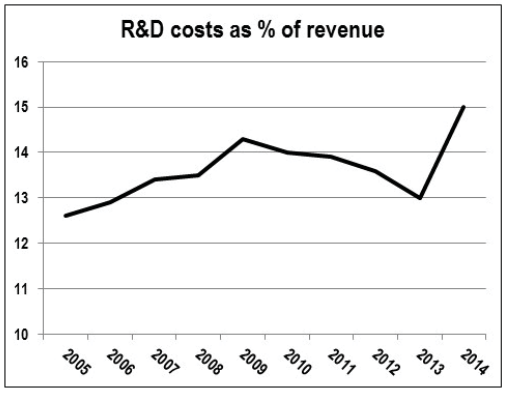
Location	Revenue		Assets	
	DKK million	% of total	DKK million	% of total
Denmark	173	1	4,969	47
Rest of Europe	4,533	36	81	1
North America	4,286	35	3,262	31
Asia Pacific	2,176	18	1,840	18
Latin America	1.300	10	300	3
Total	**12,459**	**100**	**10,452**	**100**

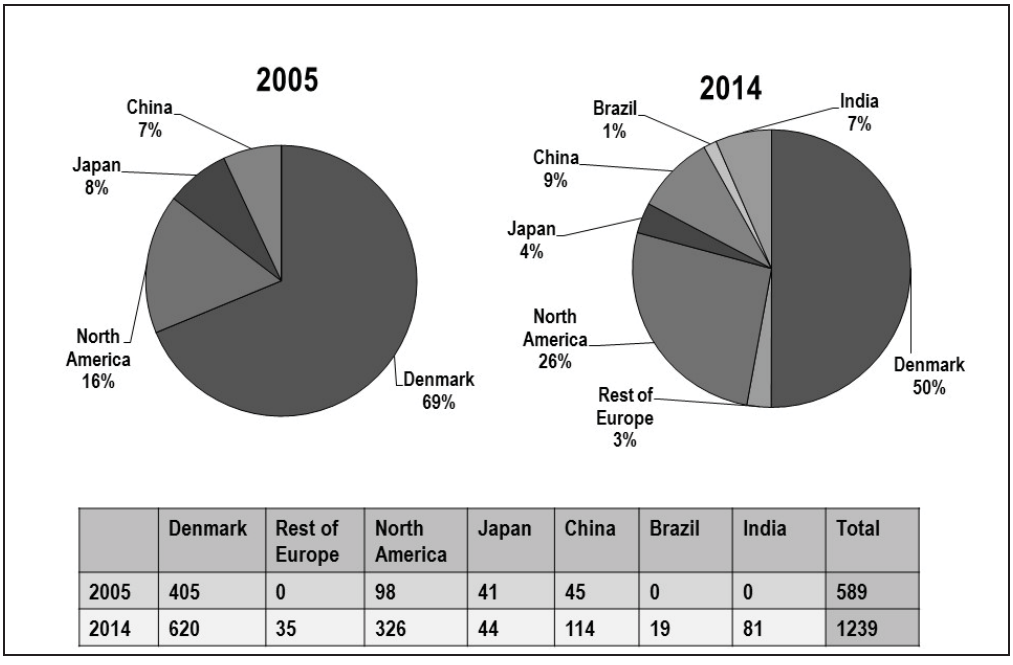
Source: Novozymes Annual Report 2014

(36%) and North America (35%). The revenue generated in Denmark (1%) is minimal compared to that in Asia Pacific (18%), which is also mirrored in the distribution of assets in Asia.

Figure 1: R&D Expenditure (2005-2014) and Distribution of R&D employees in Novozymes (2005 & 2014)







	Denmark	Rest of Europe	North America	Japan	China	Brazil	India	Total
2005	405	0	98	41	45	0	0	589
2014	620	35	326	44	114	19	81	1239

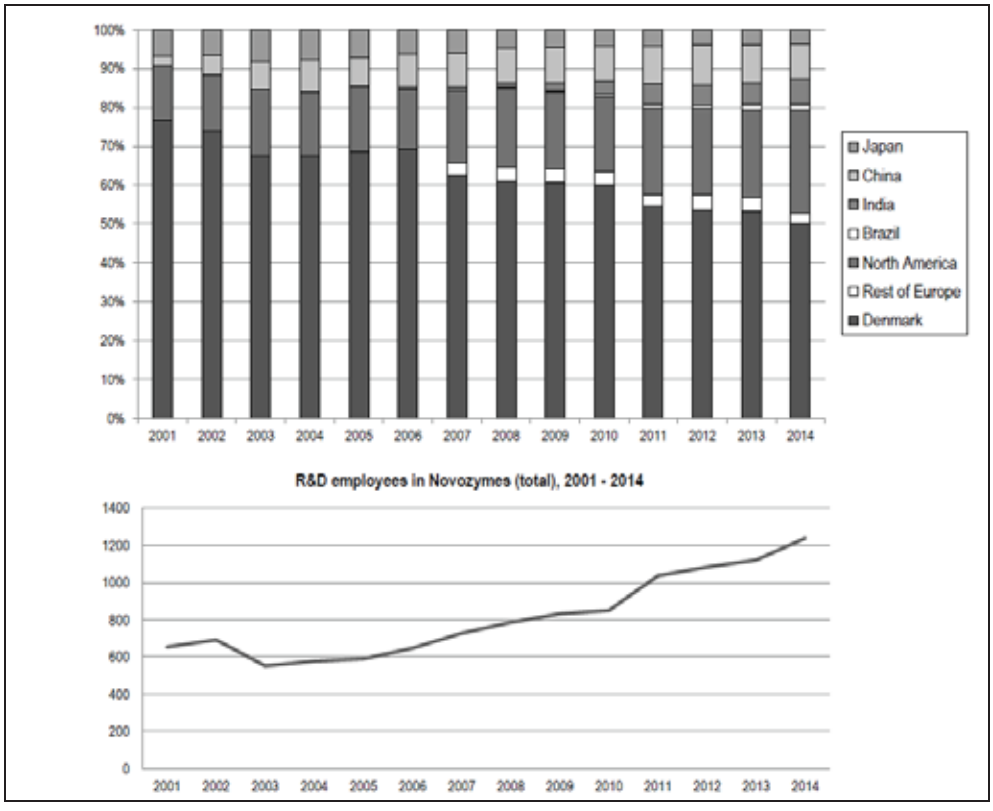
Source: Adapted from www.novozymes.com; Annual Reports and company data.

Novozymes's corporate mission is to be a provider of technology for a bio-based society. This impeccably reflects the need for constant political engagement at every level in each of its locations to ensure that new enzymes are approved and protected in different markets. Approximately 22% of the global workforce of Novozymes is involved in R&D. R&D expenditure as a share of total revenue is 13–15% (Figure 1).

The company holds more than 7,000 patents. The corporate R&D organisation consists of eight global sites (Denmark, UK, Japan, China, India, Brazil and two in the US) with "each site representing a certain set of skills and competencies" (Vice President, HQ). Figure 1 also shows the internationalisation dynamics of the R&D organisation. In total, these sites employ more than 1,200 dedicated R&D staff. The foreign R&D sites are either add-ons to existing offshore production facilities or acquisitions of complementary technological strengths in key markets (India and the UK).

Figure 2 shows the changes in the geographical distribution of R&D employees between the world regions over time, reflecting the changing geography of R&D in Novozymes. This distribution confirms the evolution of Novozymes into an MNE with highly internationalised R&D between 2001 and 2014. This period of 14 years allows us to examine the dynamic nature of the global R&D strategies of Novozymes. Although the distribution of R&D employees has changed, the number of employees did not decrease at any site.

Figure 2: Internationalisation of R&D in Novozymes: Distribution of R&D personnel in world regions and R&D investment (2001–2014)



Source: Adapted from www.novozymes.com; Annual Reports and company data.

The geographic reach of R&D activity, as demonstrated by the distribution of full-time R&D employees (Figure 2), shows that it is a dynamic and international technol-

ogy-based company. Biotech MNEs are patent-intensive firms, since patents play a major role in developing competitiveness. The geographic spread of Novozymes's patent activity indicates that emerging markets also contribute to the overall *output* of innovation (Table 2). The number of international patents shows the internationalisation of R&D by capturing the collaborative R&D activities that have taken place.

Table 2: Number of patent registrations filed with R&D locations outside Europe

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Brazil				1			4		1	2
India						2	1	1	2	1
China	5	2	4	6	7	14	10	27	13	1
Japan	4	2	2	5	5	7	9	9	7	2
US	45	21	36	32	59	38	43	44	27	21

Source: Derived from the European Patent Office database by the Authors

* Includes all patent applications by Novozymes A/S, Novozymes North America, Inc. and Novozymes Inc.

In Table 2, international patent activity is illustrated by the number of patent applications made by Novozymes over the decade from 2005 to 2014. The patent applications are primarily made at the HQ location, Denmark, as this is also where the office for intellectual property is located. The table shows the number of patents where at least one of the inventors was located outside Denmark. The US is the main R&D location outside Denmark. However, within the past decade, emerging market locations are slowly becoming hosts for R&D activity outputs. The importance of China is on the rise, showing that R&D activities undertaken in these locations are contributing with new processes, products and services. In summary, the input into international R&D activities in terms of the distribution of R&D employees and the distribution of R&D output in terms of patents filed illustrate a changed strategy for R&D beyond the Triad.

3. MNE R&D internationalisation from an evolutionary perspective

Scholars have widely documented locational drivers of MNE internationalisation, which was initially confined to the Triad (Cantwell, 1995; Patel & Pavitt, 1992; Verspagen & Schoenmakers, 2004). Dunning (2009) established that the different drivers of FDI in MNEs resulted in various types of engagement in the host economies. Dunning noted that compared to an asset-exploiting FDI, an asset-seeking FDI led to more embeddedness in the host location and to a further deepening of value chains. Other scholars have linked this to the impact of institutional and legal frameworks in the host location (Peng, Wang, & Jiang, 2008; Hoskisson, Eden, Lau, & Wright, 2000; Kyläheiko, Jantunen, Puumalainen, Saarenketo, & Tuppura, 2011) or focussed on country-specific technological advantages (Feinberg & Majumdar, 2001; Shan & Song, 1997; Kogut, 1990) as implied in the framework for national systems of innovation (Freeman, 1988, 1995).

More recently researchers have looked into how large knowledge-intensive companies have extended R&D activities to emerging markets, showing that India and China (and more recently also Brazil) have become attractive destinations for R&D-related FDI due to: 1) market dynamics, 2) requirements from host institutions on the demand side and 3) the availability of new knowledge capabilities on the supply side (Ernst, 2002, 2006; Gerybadze & Merk, 2014; Liu, Chaminade, & Asheim, 2013; Narula, 2003; Santos-Paulino, Squicciarini, & Fan, 2014). The predominant focus remains on the market entry and locational dynamics impacting such MNE decisions (Schuster & Holtbrügge, 2012). Meanwhile, Demirbag, and Glaister (2010) note that there has been very limited focus on the evolution of R&D activities in the emerging markets and that most scholars have been looking into HBE strategies, which implies there is limited scope for HBA strategies in such contexts (Luo, 2002). The rationale is that in comparison to the national systems of innovation in advanced economies, emerging markets have more diversity and institutional instability (Wright, Filatotchev, Hoskisson, & Peng, 2005) and less sophisticated supporting institutions (Meyer, 2004; Narula & Dunning, 2000).

Others have looked at the process from the firm level. According to London & Hart (2004), MNEs' emerging market strategies differ from strategies in well-established markets, which results in new types of network, e.g. relationships with non-traditional partners, co-inventing custom solutions and building local capacity. Furthermore, evidence shows that MNEs' past experience of overseas R&D projects abroad is also a critical factor (Demirbag & Glaister, 2010; Luo, 2002). For MNEs to extend their knowledge activities into emerging markets, corresponding changes are required in organisational capabilities (Hoskisson et al., 2000; Malik & Kotabe, 2009). Few studies have focussed on the evolution of R&D strategies and how internationalisation of R&D leads to new types of global innovation networks (Rugman & Verbeke, 2001; Luo, 2002; Hobday & Rush, 2007; Iammarino, Padilla-Péres, & Tunzelmann, 2008). Consequently, Meyer (2004) argued that theories and research methodologies should be developed to enable new insights into the current dynamics of globalisation (Cantwell & Zhang, 2011).

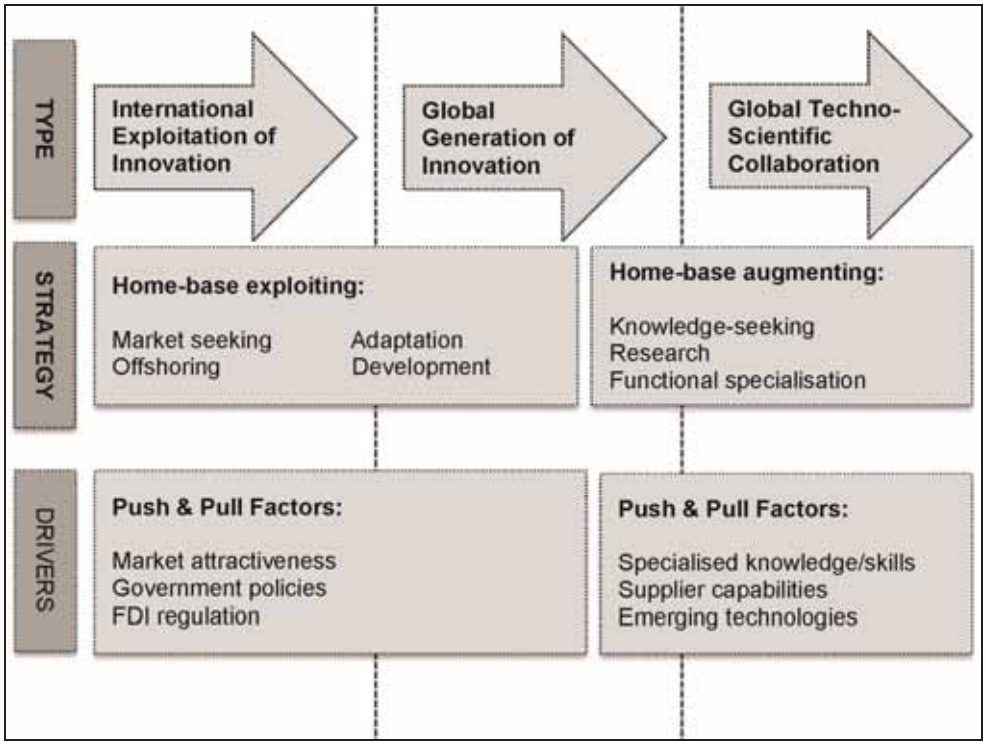
Current approaches to R&D internationalisation stem from the firm-level strategic management of R&D. Here, the terminologies HBE and HBA relate to the competitive push and pull factors companies experience, which in turn drive their strategies (Kuemmerle, 1999). Exploiting strategies dominate when MNEs face a limited home market for their increasing R&D costs while augmenting strategies relate to MNEs' need to tap into new knowledge that is not readily available in their home country.

Likewise, Archibugi, and Michie (1995) developed a more descriptive and dynamic taxonomy with three main categories, which are understood to emerge in successive stages (Archibugi & Iammarino, 1999). The first category, *international exploitation of innovation*, implies the marketing of nationally generated innovation beyond the MNE's home market, i.e. through exports, licensing and offshoring production. The second category, *global generation of innovation*, entails the MNE re-organising activities beyond the home economy and (re)locating R&D and other innovative activities within the home country and in host countries. This could, for example, be intra-firm offshoring

of R&D to adjust products to local conditions, tastes or due to certain host country government regulation. The third category, *global techno-scientific collaboration*, is where MNEs, research institutions and universities collaborate in joint scientific projects across countries. This stage involves strategies to access new technological knowledge and cutting-edge R&D, such as second-generation biofuels and genomics. Within this approach lies a perception of the evolution of internationalisation of R&D from the first category towards the third category, as the MNEs construct and engage in innovation networks globally.

Building on these two typologies, relating to the strategies behind the internationalisation of R&D and the progress of such engagement, the conceptual framework of this article is presented in Figure 3. In addition to the typologies of international R&D strategies, this article distinguishes between internal and external drivers (supply-led and demand-led) influencing such strategies, that is the push and pull factors. Following this, the *international exploitation of innovation* mainly involves exploitation strategies. At the other end of the spectrum, *global techno-scientific collaboration* mainly involves augmenting strategies. The intermediate strategy is *global generation of innovation.* This type of R&D internationalisation potentially involves both exploiting and augmenting strategies.

Figure 3: Conceptual framework for internationalisation of R&D



In terms of drivers, the framework distinguishes between push factors, which force MNEs to internationalise activities, i.e. the need for larger markets to recover the costs of R&D (exploitation), and pull factors, i.e. the need to access specialised knowledge not available at home (augmentation) or something in between, such as accessing cheaper human resources in low-cost locations (exploitation and/or augmentation). The framework also challenges the perception in the literature that innovative activities are often cumulative, path-dependent processes (Dosi, 1982), which make it easier for firms to pursue R&D along the existing trajectories of internationalisation. In fact, MNEs may engage in all three types of R&D internationalisation in parallel, rather than successively, through a combination of exploitation and augmenting strategies. The potentially different engagement of MNEs in different host locations depends upon a set of factors as they relate to the firm, its experiences and the host/home location, as is understood in evolutionary economics (Lewin, Long, & Carroll, 1999; Dicken, 2007; Coe, Dicken, & Hess, 2008). Moreover, an MNE's engagement in the host economy derives from a sequence of incidences, the order of which is likely to vary according to idiosyncratic locational drivers, although they eventually lead to similar innovation network constructs.

4. Research methodology

This article is based on a case study of Novozymes. A case methodology relies on multiple sources of evidence bringing together rich data, resulting in an apex of understanding and validation of research through triangulation (Yin, 2003). A case study is most appropriate for our empirical study as it aims to explore and unravel the complexity and dynamism of the MNE's foreign R&D strategies at different host locations. We employed a research design enabling us to integrate illuminating insights from four locations: Novozymes's HQ in Denmark as well as foreign subsidiaries engaged in R&D in three emerging market locations (India, China and Brazil). This research design was useful for identifying similarities and dissimilarities (in how R&D strategies evolved) across the emerging market R&D sites within one MNE. The establishment of R&D sites, engagement in the host location and extent of integration of the foreign R&D site in Novozymes's global innovation network differ across India, China and Brazil. Compared to India and China, the R&D site in Brazil is fairly new (from 2011) and hence has not been consolidated and integrated into the global innovation network.

The empirical data were gathered between July 2009 and March 2015. A total of 16 individual semi-structured face-to-face interviews, along with 48 hours of focus-group discussions and observations, were conducted across the HQ and the R&D sites in Denmark, China, India and Brazil. Nine of the interviews were conducted in the HQ: five with senior R&D managers, one with the vice president and three with high-level employees dealing with internationalisation in the strategic management department. Furthermore, interviews with employees responsible for heading R&D and managing global R&D projects were conducted at two emerging market subsidiaries: four in China (Beijing) and two in India (Bangalore). Insights for Brazil were gathered from interviewing a manager currently working in the HQ but who earlier had responsible for setting up the R&D unit in Brazil. Each interview lasted for 2–3 hours, and

was recorded with Novozymes's and the interviewees' permission. Along with the interview and workshop data, field notes from all encounters with Novozymes were collected in a logbook. Following the interviews, transcripts were sent to the interviewees at Novozymes for clearance.

Besides the interviews, we engaged with the Chinese R&D subsidiary for a 48-hour observation exercise. The 48-hour exercise involved presentations, group discussions and informal focus-group discussions on how innovation is being geographically dispersed and networked in practice. The workshop took place in a hotel in Beijing where all attendants stayed for the full 48 hours. Spending two days with company representatives gave us an opportunity to get unique qualitative data and have long discussions on the implications of internationalised R&D. A template structured into six themes served as an interview guideline for exploring the following: important drivers of global R&D activities; type of activity and the evolution of the internationalisation of research, development, technology and markets; global R&D structure and organisation of globally dispersed innovation activities; mechanisms for global integration, coordination and control of dispersed R&D; and strategies to enhance learning and knowledge integration and sharing.

The research design enabled an excellent synthesises of various perspectives (HQ and subsidiaries). To support our findings and for triangulation, secondary data sources, such as annual reports and patent data from the European Patent Office, were collected to verify historical data on technological progress and to illustrate foreign techno-scientific collaborations. In addition to this, Novozymes allowed access to disaggregated data on the geographical distribution of R&D otherwise not avaliable. Finally, a review of field notes, recorded interviews and secondary data was made by the same two researchers who had initially carried out the interviews. These steps in the data collection were part of the triangulation procedure used to guarantee the reliability and validity of the research.

5. Novozymes's R&D internationalisation: Increasing R&D activities in emerging markets

5.1 Head Q perspective

Novozymes engages in two types of R&D: basic research and technology development of core technologies and of application technologies. A highly specialised set of capabilities is a prerequisite for basic technology development, hence these are performed only in locations that are able to provide them (Patel & Pavitt, 1992). For Novozymes, the cutting-edge R&D activities in basic research take place in the HQ, the facilities at the Research Triangle Park in North Carolina (US) for biofuel and bio-agriculture and the UK (which specialises in bio-pharma). High-level coordination between the HQ and these subsidiaries is important and likewise the coordination between Novozymes's research centres and the surrounding research communities the company taps into. One example is the Danish Technical University, where Novozymes has funded a research centre on biosustainability. Similarly, in the US, the location allows for collaborations with Duke University, North Carolina State University and the University of North Carolina.

For basic technology development, the drivers of location in the internationalisation of R&D are based on the anticipated need for being present in important global hubs for biotech. For the application technologies that are also coordinated globally from the HQ, collaboration and coordination take place mainly with customers and often across sites. Application relates to how an invention is applied to various industries such as the food, textile, rubber and energy industries, and the local markets. Hence, the drivers of internationalisation of application processes are much more market based. The R&D sites in China and Brazil were initiated on these drivers. This is mirrored in the two core strategic drivers for offshoring R&D, as emphasised in the interviews. The drivers behind the internationalisation of basic research had an HBA nature: "The location of every one of the R&D centres is based on two main factors: 1) whether the location offers a strong research environment and/or 2) whether it offers significant sales potential" (Vice President, HQ). "Since, not all good research takes place in Bagsværd [HQ location] there is a strong incentive to establish overseas strategic links with academic researchers and technology intensive firms globally" (Innovation Manager, HQ).

For application technology, an international R&D set-up is also necessary, although for other reasons, as given by the Head of Global Innovation: "Since the use of enzymes and the end-products these go into differ across markets, a substantial part of research has to take place in proximity to the markets," and by an innovation manager: "In China, the use of enzymes differs from other places, there are many innovations regarding applying products to the market, which would not be possible to perform in Denmark. Lots of research needs to take place close to the market. In servicing a Chinese market and the Chinese customers it is an advantage to do research on these products locally." It becomes apparent the latter suggests an exploiting (HBE) strategy.

Novozymes's HQ has over the past decades developed organisational capabilities for coordinating internationalisation of innovation. This is a key priority in managing and coordinating the intra-firm networks of globally distributed R&D units. The tools for coordinating international R&D include: an inter-unit software database; an electronic lab notebook in which employees can follow the more than 250 ongoing R&D projects around the world; joint databases; and Skype-like communication systems. Besides the communication platforms, there is a vivid exchange of R&D personnel across the sites to make the R&D organisation truly global. For example, one of the interviewees, a Dane, has worked in R&D units in China, Denmark and the US, and was recently involved in R&D in Brazil. Innovation is also increasingly integrated into the corporate culture as employees can allocate 10% of their working time to their own projects. These projects are monitored by the Radical Innovation Catalysts team, which is "responsible for getting business projects qualified" (www.novozymes.com).

As is clear from the geographical distribution of R&D, Novozymes was early in enhancing its international R&D organisation into a global innovation network for constantly generating competitive advantages. All R&D projects are today organised internationally. In fact, the innovation process is designed so that only 20% of most project teams are located near the project leader. This was formulated in the interviews: "It is easier to talk with people in Beijing if we have researchers placed there"

(R&D Manager, HQ); and "You look more serious if you have local R&D" (Vice President, HQ). Interviews emphasised the importance of a local presence for developing products for new markets as well as the need for a strong organisation: "We are not moving R&D out from Denmark […] but sitting in Denmark thinking about what would work for preserving juice from fruits in India may not be the most brilliant thing to do" (Innovation Manager, HQ). Discussing new collaborations in Africa, it was stated that South African "bread is different and has a different look, which is important to acknowledge when developing our products" (Business Development Manager, HQ).

Novozymes's R&D global organisation consists of eight sites (in Denmark, UK, US, Japan, China, India and Brazil) with "each site representing a certain set of skills and competencies" (Vice President, HQ); there is a clear strategy behind each site and its role in the global R&D strategy. Although the sites may appear to be scattered across the globe, they are very much consolidated in the organisation. Furthermore, the company is aware that each site added to the innovation network, brings about more coordination. As was shown in Figure 1 and according to the interviewees, offshoring R&D to emerging markets, i.e. India, China and Brazil, has increased dramatically up till today. The company has experienced a steady increase in the number of R&D employees located in non-traditional locations. Novozymes experienced that "it is easier to attract non-Danish world-class researchers to the sites abroad than to Denmark" (HQ and Beijing). Among other things, this is due to cultural, language and other barriers, of which the critical one is the Danish tax level. As a result, offshore R&D centres are currently experiencing higher growth. Nevertheless, cutting-edge R&D activities are still performed in Denmark.

5.2 Subsidiary perspectives from emerging markets

Along with the increase in the share of foreign R&D, a qualitative shift is evident in the type of R&D carried out by Novozymes internationally. This is reflected in the higher roles and tasks assigned to R&D centres abroad, which then increase their importance in the firms' innovation network. Novozymes faces many institutional challenges in emerging markets compared to developed nations. However, the nature and extent of challenges differ across sites, as does the consequences for the company's strategies for internationalisation of R&D. Over the past two decades, Novozymes has established R&D centres in three emerging markets: China (since 1997, expanded in 2005), India (since 2007) and Brazil (since 2011).

R&D in China: Decades of evolution from exploitation to augmenting strategies

Novozymes's entry into the Chinese market was the setting up of an office in Hong Kong in 1972. This was followed with the establishment of a Beijing office in 1982 and production facilities in Hongda (1994) and Tianjin (1995). In 1994, Novozymes obtained business licences to set up two wholly owned foreign enterprises. "The motivation at that point was the growth of the Chinese market. We had to be there" (Vice President, HQ). The exploitation strategies of the 1990s were followed by the establishment of an R&D facility in Beijing in 1997, a decision that was strongly influenced by institutional frameworks and the regulation of foreign firms in China. This

happened relatively early compared to other foreign biotech companies operating in China at that time. However, by then Novozymes already had substantial production and market activities in China.

The opportunities in the local adaptation of products and technology, and the local content requirement policy, both created strong incentives to establish R&D locally. The R&D centre in Beijing was extensively expanded in 2005, after which it was granted a mandate to be Novozymes's global research centre of excellence for textiles and detergents. Thereafter, the R&D centre began establishing technological collaborations with local research institutions and Chinese state-owned enterprises, and was involved in setting up a large biofuel facility in 2012. According to the company, these links were possible only due to the company's long history in China. In summary, from being a site of development and adaptation technology, the China R&D centre advanced into being an integral part of Novozymes's global R&D operations from 2005 onwards. The strategy behind the Beijing R&D centre evolved from HBE to HBA and the drivers behind the engagement changed from pure market to also include technology and network: "As of today, 80% of the research carried out in China is for the global R&D operations" (R&D Manager, Beijing).

The upgrading and upscaling happened simultaneously with the evolution of the institutional framework, e.g. the investment policies in the 1990s and more recent policies regarding renewable energy and in particular the enactment of the Renewable Energy Law in 2006. Nevertheless, demand-led factors played a crucial role in enabling the subsidiary to gain higher mandates and greater HQ attention (Ambos & Birkinshaw, 2010). The initial engagement was set out as an exploitation strategy, i.e. to become a key player in the booming Chinese economy. Subsequent to the growth achieved over 15 years (12% annually), Novozymes became a strong player in the Chinese enzyme market, currently commanding approximately 40% of the local market. In that sense, the higher level of local sales and the demands on the products in a booming market provided a greater incentive to undertake process improvements, as well as to differentiate output to bolster margins (Cantwell & Mudambi, 2005). Over time, Novozymes has engaged with the Chinese national system of innovation through collaborations with universities, research organisations and companies in China. Hence, internationalisation of R&D evolved from international exploitation of innovation to global generation of innovation and recently into techno-scientific collaboration for some of the projects carried out in China.

R&D in India: Quick entry and evolution from augmenting to exploitation strategies

Novozymes began operations in India in 1983 with just two employees. Being a nascent market, the initial engagement in India was manifested in small marketing and sales offices for 25 years and intermittent sourcing from local firms. Products were imported or production was outsourced to local companies. Despite this, an R&D strategy in India was developed envisioning a booming economy. However, this was done much later than in China. "Although the enzyme market is still limited in India, the company feels strongly that this is the new place to engage in the creation of an enzyme market" (Business Development Manager, HQ). The first investment in R&D in India happened in 2006 through the establishment of an office with six researchers.

This R&D unit was hosted within the Institute of Bioinformatics and Applied Biotechnology in Bangalore as the investment was grounded in a strategy to forge strong research links locally in this Indian research hub for biotechnology.

An augmenting strategy was pursued from the beginning. In 2007, Novozymes acquired the enzyme and protein divisions of the Indian firm Biocon, a leading Bangalore-based biotech firm. Besides being a serious competitor in the emerging Indian enzymes market, Biocon had highly specialised knowledge in complementary products, which Novozymes could leverage. Biocon's enzyme division with its 150 employees, production facilities, sales and markets, as well as an established and well-networked R&D centre, offered an excellent means for Novozymes to become embedded in the local research environment. The Indian R&D centre currently has 50 researchers employed in three departments: Protein Engineering (specialising in protein synthesis), Strain & Process Development, and Application Technology (dealing mainly with wines and juices). Certain specialised product developments, such as that in wines and juices, are now undertaken solely in Bangalore but with a global mandate. Likewise, the protein-optimising expertise is centralised in India and serves Novozymes's global R&D operations. In other words, the R&D unit in India immediately became a global centre of excellence for research into wines and juices and surface-grown enzymes.

In summary, Novozymes's initial strategy in India was to benefit from existing local knowledge and networks in specific technologies through brown-field investment, and with time to exploit presumed market opportunities. Novozymes has continuously adapted its R&D strategies in India in the wake of various external opportunities and difficulties, and thereby benefited from a dynamic local environment. The initial strategy and the Biocon takeover clearly show that the internationalisation of R&D into India originally was grounded in HBA strategies. However, recent strategies are aimed at creating and developing the market infrastructure for enzymes in India in the long term, hence evolving into more HBE.

R&D in Brazil: New horizons and old models

The most recent establishment of an R&D centre in emerging markets is the 2011 investment in Brazil. Novozymes has been in the Brazilian market since 1974; its production facilities were established in 1989. The main driver to set up the R&D centre in Brazil in 2011 was to secure localised support for the existing bio-energy business in the country. So far, the R&D site in Brazil has not yet been integrated into the global innovation network of Novozymes as it still focusses on the application of products to the Brazilian market. Hence, so far the R&D centre in Brazil is the result of a pure exploitation strategy; however, according to a former employee at the site, the site is slowly building the capabilities needed for getting a global mandate. One area where Brazil is very attractive is bioethanol production, which requires enzymes. This is due to the early and consolidated market for biofuels. However, the market for biofuel in Brazil uses first-generation technologies based on sugar cane. The R&D centres specialising in second-generation biofuel are the US site and to some extent China. During the interviews in the HQ, the potential for future R&D investments in Brazil was mentioned several times as the strategic management sees that there is a

potential asset in being close to the large bio-diversity of the country. However, so far the R&D unit is only catering for the application of Novozymes's products to the local market. The strategy for setting up R&D in Brazil so far remains exploiting (HBE).

6. Comparing R&D Strategies in Emerging Markets

The emerging market locations have evolved into important locations for the internationalisation of R&D for Novozymes, not only because these are large and growing markets (China and Brazil), but also because the internationalisation of R&D into these locations contributes positively to the global innovation network of Novozymes (India and China). The patent data mentioned in the background section also demonstrate the advanced capabilities and techno-scientific collaboration in the emerging markets (Table 2). Novozymes has techno-scientific collaborations with large Chinese state-owned enterprises that have led to at least three joint inventions on "Methods for producing a fermentation product from lignocellulose-containing material", "Detoxifying and recycling of washing solution used in pre-treatment of lignocellulose-containing materials" and "Fermentation of a lignocellulose-containing material" (filed by Novozymes and two large Chinese state-owned enterprises, Sinopec and COFCO). In India, all patents have been filed through an international collaboration, e.g. in collaboration with Novozymes France on new methods for wine filtration and with Novozymes Demark on new "Methods for juice production" and "Variants of a polypeptide with lipolytic activity and improved stability".

6.1 Challenges and opportunities

Starting up and establishing a market in *China* were not without challenges. One main challenge was the language and substantial early investments were required to upgrade skills and to retain staff. Currently, the cost incentive for offshoring R&D to China is limited: "Costs are really not the issue. In China, salaries have increased a lot recently also because there is a shortage of English-speaking researchers" (Financial Affairs Officer, Beijing). Meanwhile, Chinese research institutes have started engaging in research on second-generation biofuel. Subsequent to launching the national policy prohibiting the use of food materials and agrarian land solely for energy, China is developing capabilities in generating fuel from waste. This implies the increasing presence of key partners for developing biofuel production and infrastructure in China with whom it is appropriate to link up to maintain a core position in this technology.

In *India*, Novozymes experienced that it was easier to communicate and recruit qualified people for their global R&D activities, hence the company faced fewer barriers than in China. The deliberate strategy to be part of a network consisting of local academic institutions made recruiting, engaging in dialogues and interacting in common projects and research funding easier. The Indian Institute of Technology and Indian Institute of Science are prestigious research institutes, which perform world-class research: "It is easier to tap into these resources if you have local presence" (HR & Project Manager, India). Bangalore also offers specialist capabilities in IT for supporting the pharmaceutical industry and for developing solutions for the biotech industry. In *Brazil*, it remains a challenge to establish the necessary capabilities for application technology focussing on the local market. So far, the activities carried out in Brazil are

for local customers and if basic research is needed, the R&D unit draws on the specialised global R&D sites.

6.2 Evolution

This Novozymes case study portrays a non-conventional mode of evolution of R&D strategies. Novozymes's current strategies in emerging markets can hardly be categorised as exploiting strategies alone. In India and China, R&D sites have obtained a full global mandate and project responsibility for specialised tasks, having accumulated advanced capabilities that complement Novozymes's core technologies. These two emerging market R&D sites have not simply transcended the HBE strategies, but are actually engaged in both HBA and HBE strategies at both locations. Meanwhile, Brazil is still at an early stage based on HBE strategies. R&D sites in India, Brazil and China have evolved very differently but the internationalisation of R&D strategies displays a convergence of strategies in the recent years. Table 3 draws comparisons across India, Brazil and China on four aspects: Novozymes R&D strategies, specifies drivers, evolution and integration.

Table 3: Comparison of international R&D strategies in India, China and Brazil

	India	China	Brazil
Drivers for establishing R&D	Pull: Advanced local capabilities Push: Lack of specialised skills and knowledge for process technology at home	Pull: Substantial market opportunity Push: Saturated markets at home could not match the dynamic host market	Pull: Substantial market opportunity Push: Access to developed infrastructure for biofuel
R&D strategy	Augmentation => Exploitation	Exploitation => Augmentation	Exploitation
Evolution	Global techno-scientific collaborations ↓ Global generation of innovation ↓ International exploitation of innovation	International exploitation of innovation ↓ Global generation of innovation ↓ Global techno-scientific collaborations	International exploitation of innovation
Integration into global research	Immediate integration into the global innovation network	Integration into the global innovation network was a gradual process	No real integration at this point

It is apparent from Table 3 that in China the internationalisation of R&D evolved from undertaking market and production activities, to accumulating adaptive R&D capabilities over the relatively long presence in this emerging market. The internationalisation of R&D in the China R&D centre was the result of a gradual upgrading of investments over three decades and the increased embeddedness in the Chinese system of innovation. The active engagement with the Chinese government over its entire period of existence in China has been a significant factor, which led to the initiation of joint R&D projects and to establishing links to local institutes through joint ventures, such as for second-generation biofuel.

Initially, China as a location was short on advanced capabilities in enzymes but had a large and growing market. The same was true for the Brazilian site. R&D developed as an add-on to the existing production facilities as the market matured, opportunities grew and the company needed local capabilities to accommodate them. From the generation of innovation through adaptation to the Chinese market (*global exploitation*), the company gradually engaged with competencies locally, and in Novozymes's global innovation networks the Chinese site managed to develop new products (*global generation of innovation*), to also engaging in technological consortia involving local universities and leading firms in selected research areas (*global techno-scientific collaborations*). This came partly from the institutional set-up, with requirements for local technology content, and partly from the high national priority towards renewable energy and second-generation biofuel development. Despite the early engagement in China, the R&D activities only recently became integrated into the global R&D strategies. This story of entry and evolution in China followed a classic evolutionary path that is likely also to be the evolution of the Brazilian subsidiary.

Contradicting past understanding, the Indian R&D site did not evolve from a long-term establishment of a global production network like in China. Rather, it was a strategic takeover of one of Novozymes's partners with complementary strengths not readily available in Novozymes's global innovation network. The strategy was to utilise local Indian advanced capabilities and skills to serve Novozymes's global R&D operations. This preceded the strategy to build strategic collaborations actively within and outside the value chain to create opportunities for developing new global technology applications and to open up the market potential in India, which is underdeveloped. India as a location provided a very conducive environment for enhancing and specialising Novozymes's R&D capability. A local R&D presence was a crucial factor in attracting key alliance technology partners. Due to the brown-field investment, the takeover, Novozymes's India site was immediately engaged in global operations, and techno-scientific collaborations with other research centres happened concurrently with the establishment and entry process. It was engaged in *global generation of innovation* simultaneously with *global techno-scientific collaboration* to take advantage of a very dynamic environment.

7. Conclusions

This article explicitly focuses on the evolution of an MNE's internationalisation of R&D as an element of its construction of global innovation networks, within the empirical setting of emerging markets. To achieve this, we set out to analyse the R&D strategies of one lead-firm in biotech (Novozymes) from an advanced country (Denmark). The company was deployed at R&D sites in China, India and Brazil, three of the world's most important markets in terms of size and growth. Rather than solely pursuing a HBE strategy to take advantage of these high-growth markets, two of these R&D sites also undertake advanced R&D. In fact, the R&D facilities in China and India are now centres of excellence, constituting core elements of the firm's global innovation. Moreover, this firm simultaneously pursued both market-driven exploitation strategies (HBE) and supply-driven augmentation strategies (HBA). Consequently, both subsidiaries simultaneously engaged in all three types of internationalisation of

R&D, namely: *international exploitation*, *global generation* and *global techno-scientific collaboration (augmentation)*.

However, the sequential order in which the R&D centres evolved in the two locations differs immensely. Despite the distinctive evolution in India (HBA => HBE) and China (HBE => HBA), both sites are advancing in the same direction. In Brazil, the activities so far are exploitation (HBE) but furthering the engagement towards augmentation is in the current plans for the site. While the establishment of R&D in these locations was down to where Novozymes imagined the highest growth rates, the importance of developing specific technology applications through leveraging strategic local network collaborations cannot be undermined. This brings us to the theoretical implications of the article. When constructing global innovation networks, multinational enterprises combine augmenting and exploiting strategies. Hence, the article demonstrates that international R&D activities not always evolve in a sequential and ordered trajectory. In particular in emerging markets, where strategic drivers of the location as well as the evolution of the company and its R&D activities in the given location combined constitute the drivers of R&D internationalisation.

This article is based on one single and extreme case study, i.e. a biotech multinational enterprise from a small open economy. Broadening the scope of the research to MNEs from a variety of industrial sectors and home economies is highly relevant. Furthermore, it is also relevant to assess the potential spill-overs, upgrading opportunities, and local embeddedness in emerging markets following the different types of MNE strategies for internationalisation of R&D.

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