Emerging economy multinationals (EMNEs) are catching up with advanced economy MNEs (AMNEs) even in emerging, high technology industries, where their knowledge-based disadvantages are most severe. We explain this phenomenon by distinguishing between output and innovation capabilities. Successful EMNEs’ focus on output capabilities need not facilitate innovation catch-up. We compare the knowledge bases of an industry-leading AMNE and a fast-follower EMNE using patent data, buttressed by qualitative information. The AMNE’s knowledge base is deeper and composed of more distinct technology groups than that of the EMNE. The EMNE has caught up in terms of output capabilities, but still lags in terms of innovation capabilities. Our in-depth comparative case analysis contributes to the literature on knowledge strategies and their impact on firm capabilities. Copyright © 2012 Strategic Management Society.

INTRODUCTION

In many industries, emerging economy multinational enterprises (EMNEs) have become global players in recent years. These firms have often caught up and begun to challenge the established multinational enterprises based in advanced economies (AMNEs) in very short periods of time. For example, Luo and Tung (2007) argue that the rapid and aggressive internationalization of EMNEs can be described as a ‘springboard strategy’ in which they acquire critical assets and capabilities abroad to successfully compete on a global stage.

In mature industries, like steel and cement, one can use the old-fashioned product cycle analysis to explain the advantages of EMNEs (Vernon, 1966, 1979). However, we observe that EMNEs are catching up and competing on world markets across the spectrum, including in emerging, high technology industries. Emerging industries offer an extremely uncertain environment. The quickly changing technologies and evolving business models of these industries can completely alter the nature of competition. Rapid catch-up by EMNEs in such industries

Keywords: emerging economy multinational enterprises; catch-up strategies; wind turbine industry; production capabilities; innovation capabilities

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is particularly difficult to explain, since it would appear that in such environments, the knowledge-based disadvantages of the EMNEs would be most severe. With this article, we attempt to unravel this puzzle. In fact, very little research has focused on understanding how ‘...knowledge elements may be...structured inside MNCs’ (Foss and Pedersen, 2004: 342) and contribute to the development of competitive advantage. Our article attempts to fill this gap by studying the catch-up of an EMNE in an emerging industry.

We study the wind turbine industry, whose pre-commercial nascent phase lasted well into the 1980s (Andersen and Drejer, 2008; Garud and Karnøe, 2003; Musgrove, 2010). The industry was born in the aftermath of the 1970s oil crises. A dominant wind turbine design and grid capability was only established by about 1990. Just a few years later, in 1995, Suzlon Energy Inc. (Suzlon), an Indian firm, entered the industry. Within the short timespan of 12 years, Suzlon reached the industry technology frontier in terms of its output capability and gained a significant global market share. The catch-up performance of Suzlon, especially as a start-up from a resource-poor nation, was spectacular. In this article, we take a deeper look at this EMNE’s knowledge strategy and the process by which it caught up with the industry technology frontier. For comparison and to clearly delineate the technology frontier, we undertake a benchmark study of an AMNE industry leader, Vestas Wind Systems A/S (Vestas) from Denmark. Vestas was among the industry pioneers and has consistently been on the technology forefront.

We use this AMNE-EMNE pair as the basis for a comparative case analysis (Yin, 1994; Eisenhardt and Graebner, 2007) utilizing patent data buttressed by qualitative data. The qualitative data, consisting of archival sources and interviews with company executives and wind industry experts, are used to study Suzlon’s output catch-up. We then analyze the two firms’ focal patents and backward-cited patents from 2000 to 2010. Specifically, by considering the networks of technology classes of backward citations, we compare Suzlon’s knowledge base with that of Vestas to assess Suzlon’s innovation catch-up.

The results of this deep comparison reveal some fundamental realities about EMNE catch-up, especially in emerging high technology industries. Our analyses show that Suzlon’s knowledge base is significantly shallower and narrower than that of Vestas. We argue that, while Suzlon has fully caught up with Vestas in terms of the output portfolio of wind turbines, it has not yet caught up in terms of innovation capabilities. This has important implications. First of all, we argue that rapid EMNE catch-up can be explained by the initial technological gap between EMNEs and the leading AMNEs. While the EMNEs are outsiders to the industry, which hinders their knowledge search and competence-creating efforts (Cantwell and Mudambi, 2005, 2011), the emerging nature of the industry means that the ramp from entry to industry frontier is relatively short. EMNEs initially lack the necessary technological knowledge to compete on world markets, so they are induced to internationalize with the purpose of acquiring this knowledge. Thus, rapid output catch-up can be understood as the implementation of processes that are fundamentally imitative, rather than innovative.

Second, an important distinction exists between the catch-up in output capabilities versus innovation capabilities. Output catch-up is associated with acquiring the technologies and skills that are directly related to the currently observable product or service. It requires the knowledge of subcomponent technology and imitation of the current product architecture. Innovation catch-up, on the other hand, is associated with acquiring technologies and skills that are related to developing and enhancing the observable product or service. It requires knowledge of the overall technology as well as the architectural innovations. Thus, innovative firms ‘know more than they make’ (Brusoni, Prencipe, and Pavitt, 2001: 597). A sole focus on output catch-up suggests that EMNEs have reached parity with AMNEs when, in fact, the industry is still operating in an innovation (AMNE)-imitation (EMNE) competitive dynamic. Therefore, while many EMNEs appear to have caught up with incumbent AMNEs, we suggest that this catch-up relates mostly to the EMNEs’ output capabilities and not their innovation capabilities.

THEORETICAL BACKGROUND

The EMNE phenomenon

The recent wave of EMNEs making their appearance on world markets can be traced to the liberalization and the introduction of market systems into vast numbers of countries beginning with the Chilean pro-market reforms in late 1970s and the Chinese reforms in the early 1980s (Cuervo-Cazurra and Dau, 2009; Dau, 2012; Peng, 1997). The fall of the Berlin
EMNE Catch-Up Strategies in the Wind Turbine industry

Wall and the collapse of the Soviet Union in 1989 brought a large group of so-called transition economies, with sophisticated labor forces and skills, into the open global economy (Fischer, Sahay, and Vegh, 1996). In the 1990s, numerous Asian countries, including India, undertook radical liberalization and began a process of integration into the world economy (Panagriya, 2004). As firms in these economies found protective trade barriers removed and were forced to compete in open markets, the most successful of them have now begun to appear on global markets as EMNEs. Although there were also EMNEs before liberalization and the introduction of market systems (Lall, 1983; Wells, 1983), the focus of this article relates to the more recent wave of EMNEs (Mathews, 2006; Ramamurti and Singh, 2009).

The motivations of EMNEs to compete in global markets vary depending on both home country and industry context. For example, emerging economy firms may internationalize to escape poor institutional environments at home (Cuervo-Cazurra and Genc, 2008) and to secure resources and competencies that redress their own resource gaps (Rui and Yip, 2008). Accordingly, their investments in advanced economy markets are often asset seeking in nature (Bartlett and Ghoshal, 2000). It has also been shown that different home country environmental and operational conditions have a strong impact on the scale, timing, and location of EMNCs’ overseas internationalization (Luo and Wang, 2012). Moreover, as a compensatory response to a late-mover position on the world stage, these firms internationalize very rapidly through foreign direct investment (FDI) and appear as fast-follower rivals of AMNEs (Luo and Tung, 2007).

Emerging economy firms face significant constraints in their development. For example, financial resources are critical to the commercial expansion into overseas markets (Hitt et al., 2000). Financial markets in most emerging economies are, however, underdeveloped, with the costs of capital being high (Khanna and Palepu, 2000; Hitt et al., 2000). Further, emerging economy firms face weaknesses in their home markets that present significant challenges to expansion and the associated scale economies. These include infrastructural shortcomings, unreliable supply chains (Cuervo-Cazurra and Genc, 2008, 2011), institutional voids (Khanna and Palepu, 1999), and the nonavailability of many complementary business services (Kumaraswamy et al., 2012). EMNEs also confront distinct challenges to cultural-cognitive legitimation when entering advanced economies (Pant and Ramachandran, 2012).

**EMNE catch-up: output capabilities versus innovation capabilities**

The process of catch-up

A number of recent studies have pinpointed the rapid technological catch-up of EMNEs with industry incumbent AMNEs (e.g., Mathews, 2006; Mathews, Hu, and Wu, 2011; Mudambi, 2008). EMNEs’ catch-up describes the process whereby firms from emerging economy markets derive parity in the technological capabilities with industry incumbent AMNEs. This allows EMNEs to successfully compete internationally. A model of the catch-up process is presented in Kumaraswamy et al. (2012).

The conceptualization of ‘catch-up’ itself is not new. A substantial body of literature examines how developing countries catch-up and eventually converge with industrialized countries (e.g., Abramovitz, 1986; Bell and Pavitt, 1993; Lall, 1990). The general hypothesis in these studies is that developing countries’ comparative underdevelopment relative to the industrialized countries carries the potential for rapid advancement. For example, Abramovitz (1986) argues that the larger the technological and productivity gap between a ‘leading country’ and a ‘following country,’ the stronger the potential for the follower to grow rapidly. Latecomer ‘following’ countries have the advantage of leapfrogging the incremental stages of leading countries’ innovations and technological achievements. In other words, the further a country is behind a leading country in its technological stock, the greater its potential for rapid growth.

We see similar patterns of catch-up at the EMNE firm level. The lack of technological knowledge in the home markets to develop the necessary capabilities of competing internationally (Cuervo-Cazurra and Genc, 2008, 2011) creates a gap between new entrant EMNEs and incumbent AMNEs. As a result, EMNEs are able to rapidly catch-up if they can quickly acquire the requisite technologies by sourcing or acquiring firms in advanced economies. Indeed, as Hennart (2012) argues, emerging economy firms’ specific advantages, such as the possession of superior technologies, are not necessary prerequisites for multinational expansion, as these can be acquired in the host countries. Thus, EMNEs can rapidly convert their initial disadvantage of technological insufficiency to an advantage by avoiding many of the pioneering costs incurred by the AMNEs. This allows...
them to reach technological parity with leading AMNEs without using substantial time and resources on technology development.

Capabilities

When discussing catch-up processes, there is an inherent difference between the output capabilities of manufacturing the products at the technological forefront and the innovation capabilities of developing and enhancing the existing technologies (Bell and Pavitt, 1993). Output capabilities describe firms’ technologies and skills relating directly to the currently observable product or service. They do not require the ability to enhance or develop the product, since knowledge requirements are well defined. Thus, output capabilities are well suited to imitation strategies and with adept management, they are amenable to rapid acquisition. Innovation capabilities, by contrast, are the technologies and skills relating to developing and enhancing the observable product or service. Therefore, they go beyond smaller adaptations and adjustments of the product and, rather, describe firms’ ability to develop the ‘next generation’ of the product. Thus, innovation capabilities not only require firms’ knowledge of the overall technology of the product, but also of complementary technologies and skills (Brusoni et al., 2001). This involves creating and leveraging knowledge over a wide range, without knowing which components or aspects are eventually used (Teece, 1992). The ability to apply such a wide range of knowledge to the specialist area implies a deep knowledge of the core technology and the ability to see complementarities that would escape a less knowledgeable party. By working with unknown and often unrelated technologies, the firms are frequently required to find new partners and develop sophisticated capabilities at working in open innovation systems (Keupp and Gassmann, 2009; Dunlap-Hinkler, Kotabe, and Mudambi, 2010).

Building innovation capabilities is a complex process, which evolves slowly over time (Henderson, 1994). Compared to innovation capabilities, the output capabilities are much easier to acquire through imitative strategies (Lall, 1990) and can result in a rapid output catch-up. This also suggests that innovation strategies are fundamentally different from imitation strategies. The deep knowledge of the overall technology, as well as architectural innovation, cannot be short circuited (Henderson and Clark, 1990).

However, the literature leaves us with little insight on how the EMNE catch-up process corresponds with output and innovation capabilities. For example, while scholars like Zeng and Williamson (2003), Mathews et al. (2011), and Luo and Tung (2007) document the emergence of a number of highly innovative EMNEs, there are other indications that latecomer EMNEs may be less innovative and more imitative (Luo, Sun, and Wang, 2011). For example, Amsden and Tschang (2003) point out that although firms from emerging economies are increasingly undertaking a range of R&D activities, the complexity of technological activities is still substantially lower than that found at the technological frontier. The simple acquisition of production knowledge does not automatically prompt the EMNE insider status in the industry that would subsequently ease the local knowledge search and competence-building efforts (Cantwell and Mudambi, 2011). This knowledge gap is even more acute in the case of emerging or ‘sunrise’ industries that are characterized by high levels of uncertainty along the dimensions of innovation and operations, strategies, demand for products and services, growth potentials, and industry environment (Covin and Slevin, 1990).

METHODOLOGY

Research design

We discuss EMNE catch-up in the context of the emerging wind turbine industry. Specifically, we describe and analyze the knowledge strategies of Suzlon, an EMNE from India, and compare this to Vestas, an incumbent AMNE from Denmark, which is one of the industry leaders in terms of innovations and global market share. Ever since Suzlon entered the wind turbine industry as an industry outsider in 1995, it has rapidly caught up with the industry’s technological frontier. It became the third-largest player in terms of global market share in 2009 (MAKE Consulting, 2010). Vestas—a powerful insider—is an incumbent industry pioneer that has been at the innovation forefront of the industry since the 1980s.

We use comparative case analysis in this research (Eisenhardt, 1989; Yin, 2003; Siggelkow, 2007). The analysis allows us to study the catch-up performance of an EMNE entrant relative to an incumbent AMNE with a rich innovation history. The two cases for the comparative study are theoretically sampled.
(Pettigrew, 1990), as they represent two extreme cases of knowledge strategies (Yin, 1994; Eisenhardt and Graebner, 2007). At one extreme is Vestas, which has a strong focus on R&D and has introduced several innovations over the years. We use Vestas as a proxy for the industry’s innovation frontier. Moreover, it originated in an advanced economy that pioneered and actively supported the emerging wind turbine industry. At the other extreme is the fast-follower Suzlon, which focused on accessing knowledge through acquisitions. It entered with relatively little knowledge of the industry and the technology. Further, it was based in an emerging economy that had just begun to support this emerging industry. Thus, the cases represent maximum variation at both the country level and the firm level and can be viewed as two polar types. The comparative analysis of these cases helps illustrate clearly how Suzlon’s strategy differed from the industry leader and how it affected its catch-up.

Data

The study draws on both qualitative and patent data. Specifically, our investigation integrates two analyses in which different data sources are utilized.

Qualitative data

In one analysis, we assemble qualitative data to understand the innovations in the industry and the knowledge strategies of the two firms. We use this analysis to establish: (1) the technology frontier of the industry; (2) Vestas’ status as a powerful insider; (3) Vestas’ innovation efforts to push the frontier forward; and (4) Suzlon’s rapid output catch-up. The qualitative analysis helps us closely compare the knowledge strategies of the two firms. Further, we can see how they facilitated Suzlon’s output catch-up. We study the process of catch-up from Suzlon’s inception in 1995 through 2010.

We use both archival and interview data to gather longitudinal information, and generate inferences, as well as for triangulation (Silverman, 2006). The archival data consist of published academic cases, academic papers, company reports, industry reports, and news articles related to the two companies and the wind turbine industry. Company and industry data were gathered using company dossier and news article databases provided by LexisNexis Academic, the official Web sites of the two companies, and the Indian, American, European, and global wind energy associations. Further, we interviewed the current and former executives at Suzlon, Vestas, and REpower (a German subsidiary of Suzlon). We also interviewed wind industry experts in Denmark and Germany, the two leading markets for the industry. The interviews were semi-structured and conducted in-person and over the phone.

Patent data

In a second analysis, we investigate Suzlon’s innovation catch-up. For that, we analyze the two firms’ entire populations of granted patents, from when patenting began in the industry (2000) until 2010, from the United States Patents and Trademark Office (USPTO). Following the tradition in the technology and innovation management literature, we use patents as proxies for a firm’s innovation capabilities (Narin, Noma, and Perry, 1987; Griliches, 1990; Jaffe, Trajtenberg, and Henderson, 1993; Nerkar and Paruchuri, 2005). To study catch-up in innovation capabilities, we compare the knowledge base of a late entrant fast-follower EMNE with an incumbent innovative AMNE. Proxying the firms’ knowledge bases, thus, forms a critical step in our analysis.

We draw on the patent literature that treats patent citations as indicators of knowledge flows (Jaffe et al., 1993; Podolny and Stuart, 1995; Almeida, 1996; Rosenkopf and Nerkar, 2001) to construct the proxies for the firms’ knowledge bases. In particular, this literature stream treats the citations made by the focal firm’s patents, also known as backward citations, as measures of knowledge inflows for the firm. We focus on the technology classes of these backward-cited patents, treating them as the knowledge sources for the focal firm’s patents. By aggregating over the filing year of focal patents, we create yearly networks of these knowledge sources for the two firms using the UCINET-6 program (Borgatti, Everett, and Freeman, 2002). These networks of knowledge sources are used to proxy each firm’s knowledge base.

A tie between two network nodes indicates that the two classes represented by the nodes are cited by a focal patent. Thus, it represents that the two nodes together sourced a knowledge flow to the focal patent. The tie strength indicates the minimum number of knowledge flows sourced by them. We then conduct a comparative network analysis along the breadth and depth of the knowledge bases to shed light on how Suzlon’s innovation capabilities differ with respect to Vestas. We consider breadth as a
separate dimension in addition to depth. So, our analysis goes beyond the dense-sparse comparison commonly found in network analyses (Gargiulo and Benassi, 2000; Kang, Morris, and Snell, 2007), which can only capture one dimension—depth or density.

To bolster our arguments further, we classify the assignee firms of the backward-cited and forward-citing patents into various categories based on their primary line of business and their products. We used the Business and Company Resource Center database provided by Gale Group and LexisNexis Academic for this purpose. If the firm was found to manufacture wind turbine generators, it was classified in the wind turbine manufacturer category. If the databases indicated that the firm’s products had applications in the wind turbine industry, it was classified into wind turbine related products, or otherwise, according to the product descriptions. For large conglomerates and firms with multiple product lines, we read the abstracts of their patents in our samples and categorized them in the most appropriate categories. The categorization provides a clear picture of the cross-industry knowledge flows enabled by Vestas and Suzlon patents indicating the breadth, depth, and impact of their knowledge.

INNOVATIONS IN THE WIND TURBINE INDUSTRY

A wind turbine is a mechanical device that converts kinetic wind energy to electromagnetic energy (Garud and Karnøe, 2003). A typical modern wind turbine consists of three blades attached to a rotor that is mounted on a tall tower. Components such as shafts, brakes, gearbox, and generator are located in a nacelle behind the rotor. Wind power is transferred from the blades to the rotor shaft and gearbox and finally to the generator, which converts the energy into electrical power on a connected power grid (Musgrove, 2010). The design and development of wind turbines require particular knowledge of electricity, electronics, mechanics, hydraulics, advanced materials, and aerodynamics (Garud and Karnøe 2003).

Wind power is one of the fastest-growing sources of energy in the world. By the end of 2010, the global cumulative installed wind power capacity was 194.390 MW, an increase of about 22.5 percent over the figure for 2009 (GWEC, 2010). This is equivalent to about 2 percent of the global energy consumption (WWEA, 2009). The industry has traditionally been dominated by Western (and particularly European) firms such as Vestas, NEG (Denmark), and Enercon (Germany). However, in the 1990s, it witnessed the entrance of a number of emerging economy manufacturers that offered turbines for considerably lower prices than the more established industry players (Musgrove, 2010). In particular, Chinese and Indian companies such as Goldwind (China), Sinovel (China), and Suzlon have displayed highly impressive growth rates, both domestically and internationally, and they have begun to challenge the more established players in the industry.

It was the oil crises of the 1970s and the subsequent rise in demand for renewable energy sources such as solar and wind energy that provided the necessary impetus for the establishment and growth of the modern wind turbine industry. This was further boosted by a favorable U.S. policy environment for wind energy in the early 1980s. During this period, the industry experienced a number of product innovations, primarily from two competing technological trajectories—one from northern California in the U.S. and another from Jutland in Denmark (Garud and Karnøe, 2003; Musgrove, 2010; Nielsen, 2010).

In California, the U.S. Department of Energy and NASA engaged a number of engineers in response to the oil crises to cooperate with companies in the aircraft industry to develop sophisticated, high-technology, large-scale, and aerodynamically optimized turbines based on aeronautical engineering principles. These turbines were particularly distinguished by their two-bladed rotor pitch regulation. In Denmark, however, different wind power enthusiasts such as farmers, carpenters, and engineers collaborated to develop robust, small-scale three-bladed turbines with reliability and ruggedness as the key concerns. While these turbines were initially small in size, a number of incremental innovations led to the wind turbines eventually being scaled up to meet broader commercial demands.

During the California wind boom of the 1980s, the Danish low technology-high reliability wind turbine proved commercially superior to its American high technology-low reliability counterpart. As a result, the Danish turbine emerged in the late 1980s as the dominant industry standard, with Danish firms and designs controlling the majority of the world market share (Garud and Karnøe, 2003). The basic design of the Danish turbine has not seen any radical changes since the mid-1990s, although wind turbines today
are both larger in size and typically use blades with full-span variable pitch that optimizes the output of the turbine by automatically adjusting the blades with the changing wind directions. The average blade span of the larger wind turbines has increased from about 100 feet in 1990 to 300 feet in 2008. New generator designs also allow the rotor to operate at varying speeds. Overall, the successive generations of turbines have been developed with a particular focus on increasing scale and reducing the overall cost of energy (Musgrove, 2010).

The latest technological discontinuity in the industry has been the advent of the offshore wind turbines. Since the beginning of the 2000s, companies have begun to develop and manufacture larger, multi-megawatt wind turbines for the growing offshore market (Musgrove, 2010). Major investments in offshore projects have been rising and it is expected that investments in offshore turbines will surpass onshore turbines by 2020 (Markard and Petersen, 2009; Krohn, Morthorst, and Awerbuch, 2009).

Innovations at Vestas

The Danish company Vestas Wind Systems A/S is an early entrant in the wind turbine industry, offering a broad range of turbines with capacities from 850 kilowatt (kW) to 7 megawatt (MW). The company was founded in 1945 as a manufacturer of a broad line of household appliances and agricultural products. In 1979, in response to the growing demand for sustainable energy sources, the company began to manufacture wind turbines. By the end of 2009, Vestas was the largest company in the industry, with a 12.5 percent global market share (MAKE Consulting, 2010). In 2010, the company had 23,000 employees and delivered 44,114 MW through 43,433 wind turbines installed in 66 countries.

Vestas has, in many respects, pioneered the industry with a number of path-breaking innovations. Since its establishment, Vestas has retained a strong focus on innovation and R&D. Vestas was among the first companies to license the rights to the early three-bladed Danish wind turbine design that later emerged as the dominant industry design (Garud and Karnøe, 2003). Moreover, the company has introduced a number of industry defining innovations. For example, in 1985, Vestas introduced the industry’s first pitch-regulated wind turbine. Five years later, in 1990, Vestas introduced a series of turbines with blades 70 percent lighter than its previous models. In 1994, the company introduced a turbine that supplied an even electrical output to the power grid, and in 1999 it introduced a turbine that maintained efficiency in low wind areas. In 2001, Vestas won a contract to manufacture and supply offshore wind turbines to the world’s first major offshore wind plant, Horns Rev in the North Sea. Vestas’ product portfolio has gradually increased over time in terms of the turbine capacity, one of the several measures to define the industry’s state-of-the-art technology.

To keep up with the changing competitive landscape of the industry that followed the offshore discontinuity, Vestas increased its focus on innovation and technological development. In 2004, it hired a new CEO and formulated a new corporate strategy to professionalize and unify its innovation activities (Pedersen and Larsen, 2009). Prior to this milestone, Vestas’ R&D and innovation activities had largely been based on tacit knowledge, developed mainly in Denmark, as an integral part of the production. Moreover, its technology development was highly silo-ed: that limited cooperation and cross-fertilization of different resources and competencies within the firm.

With the new strategy, Vestas established a dedicated R&D business unit. Its specific strategy was to focus its R&D activities to reduce the cost of energy by matching technological possibilities with consumer expectations. Vestas has followed a diligent input-oriented strategy by accessing strategic knowledge assets, such as engineers, industry know-how, and capabilities from different locations to create and develop the necessary knowledge to push the industry technology frontier. This has particularly been manifested in the intensive internationalization process of its R&D activities, which have emerged into an extensive network of R&D centers around the world (Andersson and Pedersen, 2010). Besides the R&D headquarters located in Århus, Denmark, which houses the industry’s largest and most modern facilities, Vestas has incrementally created a global R&D network consisting of in-house units in Isle of Wight (the U.K.), Singapore, Chennai (India), Houston (Texas), Beijing (China), Boston (Massachusetts), and Boulder (Colorado) (Pedersen and Larsen, 2009).

Accordingly, Vestas’ innovation strategy has largely been to tap into and access knowledge and competencies from the appropriate technology clusters through greenfield FDI. The overall rationale behind Vestas’ global R&D network is to create a network-driven set of complementary competencies identified at different technological hot spots and fit
them into an integrated and coordinated architecture. To ensure the organizational integration of the geographically dispersed and disaggregated knowledge, Vestas operates with a global operation model where the different competences needed to develop the turbines are plotted into a matrix together with the capabilities of the different R&D centers. This function is centralized at the R&D headquarters in Århus, Denmark (Andersson and Pedersen, 2010; Pedersen and Larsen, 2009).

Innovation at Suzlon

After entering the wind turbine industry in 1995, Suzlon Energy Inc. has rapidly grown into a multinational success story, with 16,000 employees in 25 countries. It offers a diverse portfolio of wind turbines with capacities from 600 kW up to 6 MW. It is the undisputed market leader in India and the third-largest manufacturer in the world after Vestas and General Electric (MAKE Consulting, 2010). The company was established in 1995 by the Indian entrepreneur Tulsi Tanti who in 1994 invested in two turbines from the German firm Südwind to ensure a consistent power supply for his textile factory.

At the time Suzlon entered the industry, the Indian market for wind energy was only beginning to develop. The Indian government had implemented favorable policies to encourage entry in grid-quality wind energy generation. These included 100 percent accelerated depreciation on the wind equipment, customs and excise duty relief, five-year tax holiday, and soft loans (Rajsekhar, Van Hulle, and Jansen, 1999). The Indian wind turbine market was mostly dominated by Vestas, Enercon, and NEPC (an Indian company that had a technical collaboration with a Danish company called Micon). Thus, Suzlon entered the industry at a period when most firms in the Indian market were selling European-made wind turbines that were relatively small by world standards. Accordingly, Suzlon’s initial strategy was to sell locally manufactured turbines of comparable technological sophistication at considerably lower prices compared to its competitors (Chandrasekhar and Sridharan, 2009; Lewis, 2007). This strategy of using its knowledge of the local context to create competitive advantage paid off rapidly as Suzlon became the absolute leader in the Indian wind energy market in just four years (Kumar, Mohapatra, and Chandrasekhar, 2009; Meyer, Mudambi, and Narula, 2011).

Suzlon’s innovation strategy can best be described as a fast-follower strategy of catching up to the technology frontier of the industry. Specifically, the company has pursued a generalist output-oriented knowledge strategy by acquiring target firms whose competences and capabilities are of direct application to the production of the wind turbines (both wind turbine manufacturers and subcomponent suppliers). Thus, being a ‘follower’ in the wind turbine industry, Suzlon has pursued a strategy of catching up to technological forefront by deliberately acquiring the necessary knowledge of manufacturing wind turbines in order to compete globally with incumbent AMNEs.

Suzlon entered the industry with little technological knowledge of wind turbines. In order to enter the industry, it partnered with Südwind, an AMNE incumbent with considerable knowledge on the technology of the wind turbines. With this initial partnership, Suzlon started to sell turbines in India. To gain engineering knowledge, Suzlon established a technical collaboration agreement with Südwind (Red Herring Prospectus, 2005). After Südwind went bankrupt in 1997, Suzlon hired its engineers and began manufacturing the turbines. Soon thereafter, the company commenced a rigorous internationalization process in Europe. With northern Europe being the center of the wind power industry and expertise in the late 1990s and early 2000s, Suzlon saw the importance of establishing itself in this region (Kumar et al., 2009). Specifically, Suzlon acquired or allied itself with a number of different European companies whose knowledge and competencies encompassed the technology frontier in wind turbines (Kumar et al., 2009; Vietor and Seminerio, 2008). With these acquisitions and licensing agreements, Suzlon accessed and integrated the required industry expertise.

The 2001 acquisition of AE-Rotor Techniek BV provided Suzlon with specialized knowledge in the design and manufacturing of rotor blades. That same year, Suzlon established a licensing agreement with Aerpac B.V., gaining access to expert knowledge in rotor blade design. To produce different varieties of rotor blades in India, it bought manufacturing and marketing rights from Enron Wind, a bankrupt American turbine manufacturer. This purchase gave Suzlon state-of-the-art production line and technical support (Lewis, 2007). In 2002, Suzlon acquired the German company AX 215 Verwaltungsgesellschaft mbH to establish an R&D unit in Germany, and in 2004 it set up a joint venture with Austrian company...
Elin Motoren GmbH to manufacture generators in India (Red Herring Prospectus, 2005). Suzlon then acquired the Belgian company Hansen Transmission International in 2006 and gained knowledge on manufacturing of gearbox and drive trains for wind turbines. The following year, it acquired REpower Systems AG, with its broad product portfolio, which included the larger offshore wind turbines.

Suzlon’s present global R&D network clearly reflects its acquisition strategy. The company has pursued a rigorous strategy of acquiring knowledge and technological competencies at the most appropriate locations to ensure a full vertical integration of the R&D value chain (Kumar et al., 2009). After the acquisition of REpower and AX 215 Verwaltungs-gesellschaft, Suzlon’s R&D headquarters was located in Hamburg, Germany, to retain the strong focus on the overall technology of the wind turbine in collaborations with smaller development teams in Germany, the Netherlands, Denmark, and India. Suzlon’s R&D center in Rostock, Germany, develops mechanical and electrical systems incorporated in the wind turbine nacelle, hub, and tower. In Netherlands, the company’s R&D center focuses on aerodynamic and rotor blade structure development as a continuation of the acquisition of AE-Rotor Techniek BV and Aerpac B.V, while the R&D center in Belgium focuses on gearboxes in accordance with the acquisition of Hansen Transmission.

Evidently, Suzlon’s proactive path of knowledge acquisitions has, to a large extent, been focused on achieving knowledge and technological competencies with direct applicability to the end product of the wind turbine. Accordingly, parallel to the acquisitions, Suzlon’s R&D efforts have become stronger and its portfolio broader. Table 1 depicts how Suzlon’s portfolio of wind turbines has displayed a radical growth—from the 350 kW in the mid-1990s to the 6 MW turbine in 2009—compared to the industry and Vestas. While Vestas has mostly operated at the technology frontier, the table shows how Suzlon has rapidly caught up with the frontier in terms of output.

### Comparing the knowledge bases

Although Suzlon and Vestas manufacture and supply a comparable portfolio of wind turbines, the preceding discussions document two radically different means of deriving this portfolio. Vestas’ status as a pioneer in an emerging industry resulted in a strategy of global in-house R&D where it actively searches for new knowledge and competences. Suzlon, however, has pursued a deliberate output-oriented strategy to facilitate rapid catch-up in the ability to manufacture wind turbines at the technological frontier. Yet, despite the differences in their knowledge sourcing strategies, Suzlon has inevitably reached parity with Vestas regarding its output capabilities, as shown by our qualitative analysis.

In this section, we investigate whether Suzlon’s rapid output catch-up has also facilitated catch-up in innovation capabilities using the two firms’ patents. To provide an overview of Vestas and Suzlon patents, Table 2 shows the number of patents filed by them and their subsidiaries over time. As seen from this table, the firms had comparable patent portfolios (60 and 40 patents, respectively) as of 2009.

### Knowledge impact

The numbers in Table 2, although comparable, do not reveal a large disparity between the two firms in terms of their patents’ overall impact. To establish that Vestas is, in fact, a powerful industry insider, we examine the impact of their patents measured by the patents’ forward citations (Trajtenberg, 1990). At the end of 2010, Vestas patents received a total of 294 citations, whereas Suzlon patents received a total of 45 citations. This suggests that Vestas’ patents have had a larger impact than Suzlon’s patents, indicating Vestas’ insider status. This result further justifies our choice of Vestas to proxy the industry’s incumbent innovative AMNE.
Further, we categorize the assignee firms of the forward-citing patents to understand the impact of the two firm’s patents on different industries. The results are shown in Table 3. The first two categories, wind turbine manufacturers and wind turbine-related products, most directly relate to the wind turbine industry. Vestas patents have received a large number of citations from firms in these categories. We argue that this marked difference implies that Vestas has a much larger impact on innovations in the wind turbine industry than Suzlon. Further, compared to Suzlon patents, Vestas patents also influence innovations in several other industries that are not directly related to wind turbines. Above all, this suggests that Vestas is a well-recognized innovator in the industry, while Suzlon’s innovation activities are less recognized.

Knowledge base comparison

We begin the comparison by focusing on the knowledge sources. For this, we categorize the assignee firms of backward-cited patents, as shown in Table 4. Compared to Suzlon, Vestas cites patents extensively from firms in the wind turbine categories. Moreover, it cites patents in several other categories that are not directly related to wind turbines. Accordingly, Vestas acquires its knowledge from a wider array of sources than Suzlon, suggesting that it has a broader knowledge base. Further, multiple citations in a category indicate more depth of the knowledge acquired in that category. As Table 4 shows,

### Table 2. Granted firm patents* per filing year#

<table>
<thead>
<tr>
<th>Filing year</th>
<th>Vestas</th>
<th>Suzlon</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2001</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>2003</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>42</td>
<td>4</td>
</tr>
<tr>
<td>2005</td>
<td>42</td>
<td>4</td>
</tr>
<tr>
<td>2006</td>
<td>42</td>
<td>20</td>
</tr>
<tr>
<td>2007</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>2008</td>
<td>52</td>
<td>40</td>
</tr>
<tr>
<td>2009</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>

*Cumulative numbers.
#None of the patents filed in 2010 were granted by December 31, 2010, the end of our sample period.

### Table 3. Impact of Vestas and Suzlon patents, identified by forward citing assignee firm categories

<table>
<thead>
<tr>
<th>Type of companies</th>
<th>SIC codes</th>
<th>Vestas No. of citing patents</th>
<th>Suzlon No. of citing patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind turbine manufacturers</td>
<td>3511</td>
<td>185</td>
<td>28</td>
</tr>
<tr>
<td>Wind turbine related products (blade fabrication, nacelle casing, turbine transport, grid connection, blade tip power generation)</td>
<td>3511, 3083, 3443, 5063</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>Electrical products (motors, machines, drives, relays, AC/DC power supply)</td>
<td>3621, 3625, 3629</td>
<td>32</td>
<td>4</td>
</tr>
<tr>
<td>Consumer electronics</td>
<td>3651, 3663</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Research (universities, research institutes)</td>
<td>8733</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Industrial controls</td>
<td>3823, 3625</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Automobile and parts manufacturers</td>
<td>3711, 3714</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Gears and bearings</td>
<td>3566, 3562, 3568</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Cranes</td>
<td>3536</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Aircraft, helicopters and parts, defense and space vehicle parts</td>
<td>3721, 3728, 3764, 3769</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Ships, oil rigs, and offshore plants manufacturers</td>
<td>3731</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Dredging and mining machinery</td>
<td>3531, 3532</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>HVAC</td>
<td>3585, 3634</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total patents</td>
<td>288</td>
<td>44</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Not all patents could be classified by their assignee firms due to missing data (assignee firm not given in patent or firm information not found in databases).
SIC code list is primarily to indicate the cross-industry knowledge flows and is not an exhaustive list.
Vestas cites extensively more within almost all categories relative to Suzlon. Accordingly, Vestas has more knowledge inflow from more categories and, thus, a deeper knowledge in core technology areas as well as in other complementary technologies.

**Table 4. Knowledge sources of Vestas and Suzlon, identified by backward-cited assignee firm categories**

<table>
<thead>
<tr>
<th>Type of companies</th>
<th>SIC codes</th>
<th>Vestas No. of cited patents</th>
<th>Suzlon No. of cited patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind turbine manufacturers</td>
<td>3511</td>
<td>240</td>
<td>68</td>
</tr>
<tr>
<td>Wind turbine related products (blade fabrication, nacelle casing, turbine transport, grid connection, blade tip power generation)</td>
<td>3511, 3083, 3443, 5063</td>
<td>88</td>
<td>31</td>
</tr>
<tr>
<td>Electrical products (motors, generators, machines, drives, relays, etc.)</td>
<td>3621, 3625, 3629</td>
<td>134</td>
<td>20</td>
</tr>
<tr>
<td>Consumer electronics</td>
<td>3651, 3663</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Electric utilities</td>
<td>4911, 4931</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Oil and gas extraction and processing</td>
<td>1311, 1321</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Research (universities, research institutes)</td>
<td>8733</td>
<td>39</td>
<td>9</td>
</tr>
<tr>
<td>Pumps and valves</td>
<td>3561, 3462</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Transportation (load handling, cargo transport, heavy duty trucks makers)</td>
<td>3537, 3715, 4491, 4213</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Automobile and parts manufacturers</td>
<td>3711, 3714</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Gears, bearings, lubricants</td>
<td>3566, 3562, 3568, 2992</td>
<td>7</td>
<td>34</td>
</tr>
<tr>
<td>Aircraft, helicopters, and parts</td>
<td>3721, 3728</td>
<td>37</td>
<td>12</td>
</tr>
<tr>
<td>Construction (buildings)</td>
<td>1541</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Part Fabricators (metal parts, aluminum dies, abrasives)</td>
<td>3351, 3363, 3291</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Engineering services</td>
<td>8711, 8712</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Food (products, processing, and packaging)</td>
<td>2011, 2026, 2033, 2043</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Waste management (handling and processing, recycling)</td>
<td>4952, 4953, 5093</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Chemicals and polymers</td>
<td>2819, 2821, 2869, 2899</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>HVAC</td>
<td>3585, 3634</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Industrial controls</td>
<td>3823, 3625</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total patents</td>
<td>622</td>
<td>209</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Not all patents could be classified by their assignee firms due to missing data (assignee firm not given in patent or firm information not found in databases). SIC code list is primarily to indicate the cross-industry knowledge flows and is not an exhaustive list.

**Comparative network analysis**

Next, we proceed with a comparison of the yearly networks of technology classes of backward-cited patents. This allows us to disentangle and compare the knowledge bases of the two companies. The networks have the following features by construction: first, the size of the network measured by the number of nodes indicates the firm’s knowledge in the technology classes represented by those nodes and, thus, the breadth of its knowledge base.

Second, presence of a tie between two nodes indicates that they have together sourced a knowledge flow. Thus, the two nodes are considered to have a technology link and are interrelated (Podolny and Stuart, 1995; Fleming and Sorenson, 2001) from the firm’s point of view. This idea is similar to Fleming and Sorenson’s (2001) concept of combinability of subclasses, but extended to the class level. However, we are careful to claim that the tie between two classes indicates only an inter-relation of some sort and not combinability per se, among those cited classes from the firm’s point of view.

Because of the yearly aggregation over filing years, we see that certain classes get frequently connected, the frequency of connection represented by the tie strength. Thus, the higher the tie strength, the more closely related the two classes from the firm’s
point of view. Because of the underlying nature of the technology, only certain classes get connected over time, resulting in node clusters or technology groupings. Formation of such technology groupings imply that the firm not only knows about the technologies represented by those classes, but also knows the interrelation among those technologies and applies them in its innovations. The well-defined technology groupings are, thus, indicative of firm’s deep knowledge in those technologies. We quantify and compare the technology groupings by employing E-I index of clustering (Krackhardt and Stern, 1988). The index is calculated as the ratio of difference between external and internal ties of cluster members to the total ties of the cluster members. A negative E-I value implies that the nodes in a cluster have stronger ties among themselves than with the nodes outside the cluster. Thus, the more negative the index, the better defined the cluster or technology groupings (Hanneman and Riddle, 2005), indicating a deeper knowledge base.

Finally, with every knowledge inflow, we argue that the firm learns more about those classes. Thus, we also use the tie strength as an indicator of the firm’s depth of knowledge in those classes. We use the overall network densities to quantify and compare this depth. Since network density is defined as the ratio of the sum of tie strengths to the number of possible ties, larger networks tend to have lower densities. Therefore, we compare densities of two networks with comparable numbers of nodes. Table 5 shows the network analysis results.

First, Vestas’ networks are composed of a larger number of nodes than Suzlon’s. Vestas’ network, thus it spans many more technologies than Suzlon’s network, suggesting a broader knowledge base.

Second, as seen from Table 5, although Suzlon’s networks exhibit node clusters from 2006 onward, their degree of closure is much smaller than Vestas’ node clusters. This is indicated by the less negative value of the mean E-I index for Suzlon than Vestas. Accordingly, Vestas’ network consists of well-defined technology groupings. Comparatively, Suzlon’s network remains loosely connected. Thus, Vestas’ network demonstrates comparably deeper knowledge of the different technologies and a higher ability to recombine technologies in developing new innovations.

Third, Vestas’ network has a higher density than Suzlon’s. This also suggests a deeper overall knowledge base. Here, we compare the densities of the Vestas network in 2002 and the Suzlon network in

<table>
<thead>
<tr>
<th>Table 5. Network analysis results for Vestas and Suzlon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filing year</td>
</tr>
<tr>
<td># nodes</td>
</tr>
<tr>
<td>2000</td>
</tr>
<tr>
<td>2001</td>
</tr>
<tr>
<td>2002</td>
</tr>
<tr>
<td>2003</td>
</tr>
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<td>2004</td>
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<td>2005</td>
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<td>2006</td>
</tr>
<tr>
<td>2007</td>
</tr>
<tr>
<td>2008</td>
</tr>
<tr>
<td>2009</td>
</tr>
</tbody>
</table>

Note: No change in 2005 for either firm.
2009, since they have a comparable number of nodes. The Vestas network in 2009 has far more nodes than the Suzlon network in 2009 and is, therefore, bound to be less dense than Suzlon’s. Even so, we find that its density is not much smaller than Suzlon’s. For visual comparisons, Figure 1 shows the evolution of the networks of the two firms.

In sum, we argue that Suzlon’s knowledge base is shallower and narrower than that of Vestas. We find that Vestas has knowledge of more technologies and that it has deeper knowledge of the different technologies that allows it to more easily develop new technologies. Vestas’ overall knowledge base, therefore, appears broader and deeper than Suzlon’s knowledge base. In the following section, we discuss this result in relation to firms’ innovation capabilities and innovation catch-up.

DISCUSSION AND CONCLUSION

In this article, we have shed light on the phenomenon of EMNE catch-up by undertaking an in-depth comparative analysis of a successful ‘catch-up’ EMNE and the incumbent AMNE market leader in the emerging wind turbine industry. Our article provides evidence to counter perceptions that EMNEs can become global players only in mature industries, which are far more stable and comparatively less knowledge intensive than emerging industries.

We highlight two contrasting findings. On the one hand, Suzlon, the EMNE based in India, has, over the relatively short period of a decade and a half, embarked on a rapid internationalization process by acquiring the necessary knowledge to manufacture world-class wind turbines. It has achieved rough parity in terms of its range of outputs with the incumbent industry leader, Vestas, based in Denmark. On the other hand, Suzlon’s strategic quest in the initial years was focused on the production of output on a technology standard and design framework established by Vestas. This becomes apparent when examining the knowledge bases of the two companies. While Suzlon has developed a comparable product portfolio to Vestas, hence having caught up in terms of output, it is yet to catch-up in terms of innovation capabilities. From an analysis of the two firms’ patents and patent citations, we find that Vestas’ knowledge base is deep and composed of a broad network of different technology sources and their well-defined groupings, which are important indicators of firm’s innovation capability. Suzlon’s knowledge base, in contrast, is shallower and narrower, indicating that it is lagging behind in terms of innovation capabilities.

These findings have important implications for how we understand EMNEs’ catch-up processes. The knowledge management literature views the firm’s knowledge base along two dimensions—breadth and depth—and notes the importance of balancing these dimensions (March, 1991; Hamel and Prahalad, 1994; Hedlund, 1994; Henderson and Cockburn, 1994; Leonard-Barton, 1995). A firm investing in innovation capabilities is essentially building a broader knowledge base. With a knowledge base that spans a variety of knowledge streams, such a firm can potentially explore across disciplines and recognize resource recombination opportunities to generate innovations (Schumpeter, 1934; Penrose, 1959; Nelson and Winter, 1982). A broad knowledge base is, then, critical for successful innovation (Bierly and Chakrabarti, 1996).

A firm investing in output capability is focused on utilizing current knowledge to its maximum possible extent to refine the firm’s existing offerings. Such refinements, however, require that the firm has a deep knowledge of the existing elements of its knowledge base. By executing the organizational routines over and over again, the firm incrementally learns more about the associated knowledge elements, also known as learning-by-doing (Arrow, 1962). Such incremental learning and its application to output refinements create a positive feedback loop, thereby deepening the firm’s existing knowledge base. Thus, innovation and output capabilities are captured by the two dimensions of a firm’s knowledge base: breadth and depth.

However, similar to the trade-off between exploitation and exploration (March, 1991; Gupta, Smith, and Shalley, 2006; Mudambi and Swift, 2011), there is an inherent trade-off between innovation and output capabilities that has direct implications for the breadth versus depth of firms’ knowledge bases (e.g., Bierly and Chakrabarti, 1996). The returns from innovation capabilities are more uncertain and may be realized in the long run. Output capabilities, by contrast, offer relatively short-term returns with more certainty (March, 1991). At the same time, there is also an important connection between the deep understanding of the existing knowledge sources and the ability to identify new knowledge sources (Cohen and Levinthal, 1990). In other words, the depth of the knowledge base developed through exploitative experiential learning, in the long run, enables exploration, thereby broadening...
<table>
<thead>
<tr>
<th>Year</th>
<th>Vestas</th>
<th>Suzlon</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>[Network Diagram]</td>
<td>None</td>
</tr>
<tr>
<td>2004</td>
<td>[Network Diagram]</td>
<td>[Network Diagram]</td>
</tr>
<tr>
<td>2006</td>
<td>[Network Diagram]</td>
<td>[Network Diagram]</td>
</tr>
<tr>
<td>2008</td>
<td>[Network Diagram]</td>
<td>[Network Diagram]</td>
</tr>
<tr>
<td>2009</td>
<td>[Network Diagram]</td>
<td>[Network Diagram]</td>
</tr>
</tbody>
</table>

Figure 1. Evolution of source networks for Vestas and Suzlon
Note: Network diagrams created using NetDraw 2.101 (Borgatti, 2002), layout: spring embedding.
the firm’s knowledge base. The newly discovered knowledge sources also need to be integrated with the existing knowledge specializations to generate innovations (Grant, 1996). This integration calls for a deep knowledge of the existing specializations (Henderson and Clark, 1990; Henderson, 1994) so that the knowledge base of an innovative firm contains several such interrelated technology specializations or groupings (Galunic and Rodan, 1998). Thus, the distinction between output capabilities and innovation capabilities is not clear-cut. In fact, the knowledge strategies of the most successful MNEs in the industry attempt to build both exploration-oriented innovation capabilities and exploitation-oriented output capabilities. Such strategies are designed to create ambidextrous organizations (Tushman and O’Reilly, 1996; Benner and Tushman, 2003). The knowledge base of such ambidextrous firms is, thus, broader and deeper compared to the other firms in the industry.

For an EMNE, in the initial years, investing in output capabilities is far more attractive than investing in innovation capabilities because of the certainty and speed of returns. An EMNE’s focus on acquiring output capabilities helps in its rapid output catch-up. However, its lesser emphasis on innovation capabilities means that its knowledge base is narrower as compared to the innovative AMNEs in the industry. Further, it is important to note that the depth dimension of the knowledge base is a function of the firm’s experience. The innovative AMNE also focuses on building output capabilities and, over time, generates a deeper knowledge base. The young EMNE’s knowledge base, thus, lags on the depth dimension as well. These arguments imply the following proposition:

**Proposition 1:** The EMNE’s knowledge base tends to be narrower and shallower as compared to the incumbent innovative AMNEs.

We posit that the differences in the capabilities of two companies are the outcome of a conscious strategy (cf. Rui and Yip, 2008). The strategy of the industry leader is focused on innovation and design, aimed at developing the ‘next generation’ of output. The strategy of the EMNE fast follower is to maintain the capability to **rapidly replicate** the next generation output as soon as it comes on stream. The EMNE emerges out of a home context with less technological sophistication (Cuervo-Cazurra and Genc, 2008, 2011), which creates a substantial technological gap relative to the incumbent AMNE. This induces the EMNE to internationalize with the purpose of acquiring the technological knowledge to replicate the output developed by leading AMNEs (Kumaraswamy et al., 2012). In this process, the EMNE can rapidly catch-up in terms of its output portfolio by acquiring narrowly focused output-related knowledge at the technological frontier, e.g., through the acquisition of knowledge-bearing component manufacturers in advanced market economies. The EMNE’s focus on output, especially with the ability to successfully serve worldwide markets, is indicative of imitative capabilities of a very high order. Indeed, this focus on output capabilities may well spawn genuine cost savings, process innovations, and cheaper, simpler output goods. In this sense, many of the innovations from emerging economy firms documented by scholars like Zeng and Williamson (2003), Mathews et al. (2011), and Luo and Tung (2007) may actually be the outcome of such higher-order imitative processes. However, this is not analogous to catch-up in innovation capabilities.

Unlike output capabilities, innovation capabilities cannot be readily acquired through imitative strategies. They accumulate over time. Innovation capabilities are, in fact, far more causally ambiguous and socially complex (Dierickx and Cool, 1989). In other words, with sufficient capital, EMNEs rapidly acquire the necessary output capabilities to catch-up to the industry standard. Yet, to be a leader in the industry, EMNEs cannot simply buy knowledge; they need to generate innovations that will push forward the industry’s technology frontier. So, replicating innovation capabilities is extremely difficult. Accordingly, the following proposition is formulated:

**Proposition 2:** The EMNE’s output catch-up occurs much earlier than innovation catch-up.

An important aspect highlighted by our study is the role played by industry nascence in accelerating EMNE output catch-up. In the 1990s and early 2000s, the emerging wind turbine industry had smaller players and the barriers to entry were low. These conditions were conducive to entry by a *de novo* firm like Suzlon. Further, they helped its internationalization strategy since acquisition targets were readily available. Therefore, while emerging industries offer an uncertain environment, they are also characterized by conditions that enable rapid output catch-up by EMNEs. However, innovation catch-up is likely to be particularly difficult in these industries. As
highlighted by our findings, innovation capabilities are harder to replicate. In addition to that, emerging industries (unlike mature industries) lack imitable standards and best practices. For a young EMNE that lacks sufficient technological knowledge, innovation catch-up in such industries is even more challenging since the target is unknown.

In conclusion, this article makes an important distinction between EMNEs’ catch-up in terms of output and innovation capabilities. However, we do not claim that the innovation–imitation relationship taking place between the AMNE and the EMNE is a permanent state of affairs. As the concept itself suggests, catch-up is a process that moves toward parity. Narula (2012) argues that as the EMNEs evolve, the observable differences between these firms and their advanced economy counterparts will diminish. As our analysis indicates, Suzlon has also focused on locating in the industry’s knowledge hot spots by setting up R&D centers in Germany, Netherlands, and Belgium to facilitate its knowledge exploration and broaden its knowledge base. It documents the company’s efforts to achieve catch-up in innovation capabilities. Clearly, the existence of a highly competitive EMNE puts pressure on the AMNE firms to maintain and enhance their innovative efforts, which may lead to a situation of EMNE and AMNE knowledge and technology convergence (Abramovitz, 1986; Kumaraswamy et al., 2012). Further, accessing knowledge through acquiring knowledge-bearing firms abroad is one of the ways an EMNE may pursue catch-up. Although Suzlon adopted such an internalization strategy, we do not imply that the process of catch-up requires an internalization strategy. Even the domestic firms in emerging economies may exhibit catch-up through learning by exporting (Salomon and Shaver, 2005) and spillover processes where local firms learn from AMNEs (Mudambi, 2008). How other strategies, such as component sourcing through arm’s-length transactions, may lead to EMNE catch-up is an interesting question requiring further research. Moreover, while this study focuses on EMNEs in emerging industries, our findings have relevance to EMNEs in mature industries. Examples such as Tata Motors or Infosys, which entered mature industries, are operating at the industry’s technology frontier and competing fiercely with their rivals from advanced economies. Whether their competition is still based on the output capabilities or has moved to innovation capabilities and, if so, whether they have the capabilities to create next generations of technology in their respective industries, are interesting questions for future research.

The main message of our article is that innovation catch-up is likely to be a slower and longer process than output catch-up. Output capabilities embracing knowledge about the overall technology of the product can often be acquired in the market, especially in nascent and emerging industries. Innovation capabilities, however, necessitate more profound knowledge of both the overall technology and architectural innovation (Henderson and Clark, 1990) and require firms to know more than the technology of the final product (Brusoni et al., 2001). Therefore, we suggest that the observed pattern of EMNE rapid catch-up in many industries may be more based on production or output capabilities and not necessarily innovation capabilities.

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