

On the emergence and diffusion of technological capabilities and the theory of the MNC

Emergence et diffusion des capacités technologiques et théories de la FMN

Acerca de la emergencia y difusión de capacidades tecnológicas y la teoría de CMN

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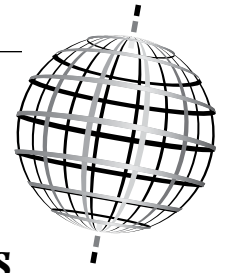
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Article abstract

This paper intersects extant theories of the MNC with empirically observed patterns in the intra-company emergence and diffusion of technological capabilities. It draws upon a database containing the complete patenting history of 24 Swedish multinationals over the 1890-2008 period, which allows for the identification of when and where in the multinational organization new technological capabilities first emerged, and when and to where they subsequently diffused into other units of the multinational organization. The results reveal an increasing share of foreign-introduced technological capabilities, as well as distinctive and differentiated diffusion patterns across headquarters, greenfield subsidiaries, and acquired units in the MNC group. We conclude that a theory of the MNC should recognize the shift towards more equal conditions for the generation of new technology within the multinational organization, but that within this overall development some conspicuous inequalities in intra-company capability diffusion remain to be accounted for.

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Acerca de la emergencia y difusión de capacidades tecnológicas y la teoría de CMN

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RÉSUMÉ

Cet article croise les théories existantes des FMN avec des modèles empiriques d'émergence et de diffusion de capacités technologiques au sein des multinationales. En s'appuyant sur une base de données, les auteurs identifient quand et où les nouvelles technologies apparaissent ainsi que les conditions de diffusions. Ils montrent que les filiales, qu'elles soient nouvellement créées ou acquises, ont une contribution croissante et que la vitesse et la probabilité de diffusion sont supérieures d'une filiale vers le centre qu'inversement. Ils différencient également les schémas de diffusion selon le type de filiales mettant en défaut le fait de considérer toutes les filiales de manière identique ainsi que le modélisent les théories de la firme.

Mots clés : Firmes multinationales (FMN), innovation, capacités technologiques, diffusion

ABSTRACT

This paper intersects extant theories of the MNC with empirically observed patterns in the intra-company emergence and diffusion of technological capabilities. It draws upon a database containing the complete patenting history of 24 Swedish multinationals over the 1890-2008 period, which allows for the identification of when and where in the multinational organization new technological capabilities first emerged, and when and to where they subsequently diffused into other units of the multinational organization. The results reveal an increasing share of foreign-introduced technological capabilities, as well as distinctive and differentiated diffusion patterns across headquarters, greenfield subsidiaries, and acquired units in the MNC group. We conclude that a theory of the MNC should recognize the shift towards more equal conditions for the generation of new technology within the multinational organization, but that within this overall development some conspicuous inequalities in intra-company capability diffusion remain to be accounted for.

Keywords: Theory of the MNC, innovation, technological capabilities, diffusion

RESUMEN

Este artículo intersecta teorías existentes sobre las CMN con patrones observados empíricamente durante la emergencia y difusión de capacidades tecnológicas intra-empresariales. Una base de datos longitudinal nos permite identificar cuándo y dónde una nueva tecnología apareció dentro de la organización multinacional, así como, cuándo y hacia qué otras unidades dentro de la organización multinacional ésta tecnología se difundió. El resultado revela una creciente participación de capacidades tecnológicas de origen extranjero, así como patrones de difusión distintos y diferenciados a través de las sedes centrales, las subsidiarias, y las unidades adquiridas por la corporación. Se concluye que cualquier teoría de CMN debe reconocer diferencias persistentes en la difusión de las capacidades dentro de la empresa las cuales no han sido suficientemente tomadas en cuenta en estudios anteriores.

Palabras Claves: Teoría de corporaciones multinationales (CMN), innovación, capacidades tecnológicas, difusión

Going back to the earliest research on multinational corporations (MNCs), the main challenge was to understand and explain the phenomenon – why did firms internationalize and why had there been such a significant increase in their international activities? For example, Vernon (1966) identified technology and product innovation as important drivers

of observed patterns of internationalization, and Hymer (1976) explained firm internationalization by introducing the concept of 'special advantages'. The notion of firm-specific advantages, developed at home and then exploited in foreign markets, subsequently became an important element in increasingly elaborate theories of the MNC (Dunning, 1977,

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1988). Theories such as these have served as the general foundation for many of the research questions and issues that have been explored within the field of international business (IB) research.

Over time, the focus of international business scholars shifted more towards MNC organizational capabilities, particularly in terms of developing and transferring knowledge. The MNC increasingly came to be understood not only as a major source of innovation but also as an efficient vehicle for transferring and integrating technology across national borders. The foundations of this more recent and still evolving stream of research were the resource-based view (Barney, 1986; Prahalad & Hamel, 1990), the evolutionary theory of the firm (Nelson & Winter, 1982; Cantwell, Dunning & Lundan, 2010), and the knowledge-based view (Kogut & Zander, 1992; Szulanski, 1996; Gupta & Govindarajan, 2000). The modern MNC has become associated with highly dispersed and often strategically and technologically advanced foreign subsidiaries (Hedlund, 1986; Bartlett & Ghoshal, 1989; Doz & Prahalad, 1991), with processes of innovation that involve enhanced levels of international knowledge sharing and interdependent foreign subsidiaries (Bartlett & Ghoshal, 1990). It is also expected to embrace managerial attitudes that make much less of a distinction between the role and importance of headquarters and subsidiaries of the multinational organization (e.g. Doz, Santos & Williamson, 2001; Parkhe & Dhanaraj, 2003; Forsgren, Holm & Johanson, 2005; Andersson & Forsgren, 2007).

In his book on the development of theories of the MNC, Forsgren (2013) outlines six theories of the MNC that he suggests have dominated the field of international business during the past 40 years. The theories differ substantially in their views on the MNC as an organization and its ability to develop and integrate technological capabilities both domestically and internationally. According to some theories, MNCs are strict hierarchies with headquarter managers as a supreme center of control, whereas others view them as more loosely coupled networks, where resources and power are shared among several and geographically dispersed units. Similarly, some theories emphasize organizational barriers that restrict the amount of knowledge exchange, whereas others identify MNCs as efficient vehicles for knowledge and capability transfer throughout different types of internationally dispersed organizational units.

In this paper, we draw upon a set of paradoxical findings about the diffusion of technological capabilities within the MNC to critically assess the relevance of Forsgren's (2013) six theories of the MNCs. The empirical discoveries were made as part of our work on patterns of innovation within a sample of 24 Swedish MNCs, whose technological activities were charted by means of U.S. patenting data and followed over the period 1890-2008. By pitting the empirical findings against extant theories we primarily

seek to contribute to the general development of the theory of the MNC. Although the empirical observations do not constitute any formal or comprehensive test of existing theories, they allow for a critical assessment of some of the theories' main assumptions about technological capabilities and how they spread across different types of unit in the MNC. The paper also makes an empirical comment upon and contribution to the literature on reverse knowledge and capability diffusion in the MNC (e.g. Håkanson & Nobel, 2006; Ambos, Ambos & Schlegelmilch, 2006; Mudambi, Piscitello & Rabbiosi, 2014), but this we see as a subordinate benefit that will receive but secondary attention in the discussions.

The outline of the paper is as follows. We start with a section that briefly describes developments in IB-research and the six theories of the MNC presented by Forsgren (2013). It is followed by a method section, which explains the data that were used and the structure of the empirical investigations. The third section presents the observed patterns in the emergence and diffusion of technological capabilities. We particularly emphasize what appear to be systematic differences in the degree and pace of capability diffusion across headquarters, greenfield subsidiaries, and acquired units in the multinational organization. The results section is followed by an extended discussion, where the empirical observations are compared to extant theories of the MNC. In conclusion, we argue for a theory of the MNC that reflects the main title of the paper, merely to set the stage for further and continued debates about the true nature of the MNC.

Theories of the MNC

The past decades have seen much research on the MNC, and there are several perspectives, views, definitions as well as theories about its nature and functioning as a form of organization. In the conventional view, MNCs are strict hierarchies, and the fundamental reason for engaging in foreign direct investment is to exploit home-based and firm-specific advantages through internationalization (Caves, 1971; Hymer, 1976), alternatively to gain access to low-cost sources of raw materials and other resources. Such home-based advantages and intangible assets have been considered essential for overcoming the disadvantages of operating in foreign countries (Buckley & Casson, 1976; Dunning, 1977, 1988; Zaheer, 1995). According to this traditional perspective, the main role of foreign subsidiaries is to serve the local market through adaptation of already existing products and services to local market needs. It is a perspective that emphasizes the difference between core and periphery, unevenly distributed capabilities, together with vertical flows of information and knowledge within the multinational organization.

More recently emerging perspectives have incorporated and emphasized the shift towards increasingly capable

and resourceful foreign subsidiaries (e.g. Birkinshaw & Morrison, 1996; Birkinshaw & Hood, 1998; Holm & Pedersen, 2000; Cantwell & Mudambi, 2005), and in parallel more extensive lateral integration, cooperation, and innovation within the MNC network (Ghoshal & Bartlett, 1990; Mudambi & Navarra, 2004). A common proposition is the abandonment of strict hierarchy, alongside more evenly distributed resources and responsibilities in the multinational organization, as well as enhanced levels of lateral connections and knowledge exchange across geographically dispersed units.

SIX THEORIES OF THE MNC

Within these general movements and changing perspectives, Forsgren (2013) identifies six different theories of the MNC, which he suggests have dominated the field of IB-research over the past decades. The review of the six theories offers a detailed account not only of the longitudinal development of research on the theory of the MNC, but also addresses and explicates some of the more fundamental shifts in theoretical perspectives that have taken place over the years. In that capacity, Forsgren's work offers a rich and encompassing framework for the analysis of conditions and longitudinal changes in the intra-company emergence and diffusion of technological capabilities.

Table 1 summarizes the MNC's main organizational traits as proposed by the six theories, and what they imply particularly for knowledge and capability creation and diffusion within the multinational organization.

Three aspects of the theories are particularly important in the context of the present paper – the proposed sources of knowledge and capabilities in the multinational organization, the extent to which intra-organizational connections and knowledge exchange extend in the vertical and/or lateral dimension, and the drivers and determinants of knowledge flows across geographically dispersed units.

The six theories of the MNC as presented by Forsgren (2013) differ significantly in their views on the sources of new knowledge and capabilities in the multinational organization. In the Dominating and Coordinating MNC, the creation of new knowledge and capabilities is more or less exclusively a headquarter matter. In the other four theories, foreign subsidiaries play a more prominent role. In the Knowing MNC, all members of the multinational organization are recognized as important resources and carriers of knowledge that is crucial for creating and sustaining MNC-specific advantage. Similarly, the Networking MNC sees foreign subsidiaries as quasi-independent firms, which develop their own business agendas and expand the MNC's operations on the basis of local network connections. Although the role of foreign units as developers of new knowledge and capabilities is not as clearly defined in the Designing and Politicizing MNC, both theories emphasize that an important part of

the interplay and adaptation between the organization and the (institutional) environment occurs at the subsidiary level.

These different perspectives on the generation of new knowledge and capabilities are well reflected in the theories' assessments of intra-organizational connections and knowledge flows. The Dominating MNC is a strict hierarchy that is governed by corporate headquarters. Headquarter managers decide upon overall strategies, which are then communicated to and implemented at lower organizational levels. The notion of 'divide and rule' implies a concentration of communication at the apex of the organization, while interactions and alliances at lower organizational levels are curtailed. The Coordinating MNC is also a strict hierarchy, in which headquarters have more or less absolute power over the operations of subsidiary units. The organization is designed and managed to reflect the goals of headquarters, whose main task it is to monitor foreign subsidiaries and by means of vertical flows of information eliminate cheating and shirking in the geographically dispersed organization.

In contrast, the lateral dimension of intra-organizational connections and knowledge flows is much more pronounced in the other and more recent theories of the MNC. In particular, the Knowing MNC stands out as an organic and social creature, where all people and units of the organization matter to the same extent; the replication and recombination of knowledge rests equally on both vertical and lateral knowledge exchange between headquarters and subsidiary units. Similarly, the Networking MNC is a federation that is less hierarchical and more loosely coupled than the Dominating or Coordinating MNC. The ability of headquarter managers to decide why and how subsidiaries should be coordinated is indeed limited, in large part because of headquarters' lack of knowledge about local business contexts. To a significant extent, headquarters are outsiders vis-à-vis their foreign subsidiaries and their local business networks.

Although the remaining theories do not necessarily emphasize the existence of lateral connections in the multinational organization, the vertical positions of headquarters and foreign units are comparatively balanced. For example, in the Designing MNC, it is the role of headquarters to design and implement efficient structures, decision rules and control systems, but this does not imply that all knowledge is centralized at headquarters. The Designing MNC aspires to develop the 'right' fit between its strategy and organization and the environment, which includes having the appropriate design of vertical and lateral communication between units of the MNC organization. The Politicizing MNC, in turn, is organic and loosely coupled, where no single unit really controls the firm in full, neither headquarters nor any individual subsidiary.

Finally, in terms of the drivers and determinants of knowledge exchange the Dominating and Coordinating

TABLE 1
Theories of the MNC

	The Dominating MNC	The Coordinating MNC	The Knowing MNC	The Designing MNC	The Networking MNC	The Politicizing MNC
Representative contributions	Caves (1971), Hymer (1976)	Buckley & Casson (1976), Rugman (1981, 1986), Hennart (1982)	Kogut & Zander (1993)	Galbraith (1973), Egelhoff (1982, 1988, 1991)	Andersson, Forsgren & Holm (2002), Forsgren, Holm & Johanson (2005)	Kostova & Zaheer (1999), Kostova, Roth & Dacin (2008)
Source of theory	Industrial organization	Transaction cost theory	Organizational capability theory	Contingency theory	Business network theory	Institutional theory
Core capability	Exploitation of monopolistic advantage in foreign markets	Internalization of markets across national borders	The creation, transfer, and recombination of unique knowledge and resources in foreign markets	Adaptation to complexity and change in foreign markets	Leveraging of internal and external business networks in different countries	Getting support from and influencing the international institutional environment
Organizational view	Hierarchy	Hierarchy	A social community with expertise dispersed throughout the company	A formal organization supported by shared values	A federation with dispersed power	A complex whole and value-laden institution
Source(s) of knowledge and capabilities	Headquarters	Headquarters	Headquarters or foreign subsidiaries	Headquarters or foreign subsidiaries	Headquarters or foreign subsidiaries; subsidiaries have first-hand knowledge of their local business contexts	Headquarters or foreign subsidiaries; subsidiaries have first-hand knowledge of their institutional contexts
Diffusion of knowledge	Vertical, restricted communication between subsidiaries		Vertical and lateral	As decided by headquarters	Vertical and lateral; headquarters one actor among many others	Vertical; flows of policy and practice from headquarters to other units
Drivers and determinants of knowledge diffusion	The desire to control		Shared identity	Shared values	Position in internal and external networks	Implementation of best practices
Difference between subsidiaries	No major difference	No major difference	No major difference; several modes of foreign expansion available	Subsidiaries differ and require different monitoring and control practices	Subsidiaries differ on account of network positions	Subsidiaries differ on account of institutional environments

MNCs depend heavily on headquarters' capacity to control the exchange of vertical information and knowledge. Other theories instead emphasize how shared values and perceptions of a common good foster a benevolent attitude towards knowledge sharing across any types of unit in the multinational organization. Because of its emphasis on shared identities, the Knowing MNC is often referred to as a social community or 'happy family'. In a similar way, both headquarters and subsidiaries of the Designing MNC embrace shared values that ensure coherent behaviors and minimize the risk of internal conflict. In the Networking MNC, the notion of a federation implies generally favorable conditions for lateral knowledge exchange, although knowledge exchange would not be as seamless as in, for example, the Knowing MNC. In the Networking MNC, the level of knowledge exchange is determined by the extent to which subsidiaries are connected within and across business networks, rather than by a shared identity or common corporate values.

In sum, Forsgren's (2103) six theories of the MNC come to different conclusions with regard to the sources of new knowledge and capabilities in the multinational organization, and their different views on intra-MNC interconnections and preconditions for knowledge exchange serve as useful precursors of observable patterns of knowledge and capability diffusion. The following section takes a closer empirical look at these issues, revealing an intriguing mix of corroborating and contradicting observations when applied across the six theoretical perspectives.

Data and method

SAMPLE

To test for and explore patterns in the emergence and diffusion of technological capabilities, the paper draws on the U.S. patenting activity of 24 Swedish multinationals over the 1890-2008 period (Appendix A). The sample includes headquarter units in the home country, foreign subsidiaries that were originally established as greenfield units, and subsidiaries that were added to the MNC network through foreign acquisitions. The sample firms were originally identified in 1990, based on selection criteria that included both firm size (in terms of annual turnover) and technological activity (in terms R&D expenditures and patenting). Excluding firms in industries with relatively low patenting intensities, such as banking, insurance, mining, power generation, and shipbuilding, and also a limited number of firms that represented or were part of industrial conglomerates, the remaining firms have accounted for a dominant share of both historical and contemporary technological activity in Sweden (cf. Sölvell, Zander & Porter, 1991).

The sample firms represent a relatively broad spectrum of industries, including pulp and paper, motor vehicles, pharmaceuticals, and telecommunications equipment. Previous studies have shown that these companies account for a significant number of inventions and also R&D expenditure in Swedish industry (Wallmark & McQueen, 1986; Håkanson & Nobel, 1993), but they are not necessarily representative of firms of other national origin. On the balancing side, the sample includes corporations with long exposure to international markets and international business, and in this capacity should offer a useful testing ground for identifying patterns in the emergence and diffusion of new technological capabilities.

In order to define the sample firms and subsidiaries in a way that allows for longitudinal comparisons, a historical examination of each individual firm identified any possible name changes as well as potential changes in ownership through mergers and acquisitions. The data also consolidates any patenting by first-order, majority owned subsidiaries for the periods during which they belonged to the parent companies. These subsidiaries were identified through an extensive and systematic search into the history of each individual sample firm, using the publications "Svenska Aktiebolag – Handbok för Affärsvärlden", "Koncernregistret – KCR", and "Who Owns Whom – Continental Europe", and from 1991 and onward information in annual reports and the corporate trees offered by the Thomson Innovation database. Complementary publications and information, such as publications on company histories and information about acquisitions and mergers extracted from the company homepages, were also used in the consolidation process.

DATA AND DATA COLLECTION

The study uses patents as a marker or indicator of the emergence and diffusion of technological capabilities. Patents are frequently used technology indicators, in the international business literature and elsewhere (e.g. Jaffe, 1986; Archibugi & Pianta, 1992; Almeida & Phene, 2004; Feinberg & Gupta, 2004), and possess the specific advantage in that they provide consistent and comparable information over extended periods of time. Patenting also correlates highly with alternative measures of technological activity and innovative performance, such as research and development expenditure and new product introductions. In a study comprising a large number of companies in four high-tech industries, Hagedoorn and Cloodt (2003: 1375, 1365) find "no major systematic disparity amongst R&D inputs, patent counts, patent citations and new product announcements", concluding that "future research might also consider using any of these indicators to measure the innovative performance of companies in high-tech industries".

Specifically, the present study relies on the firms' patenting in the United States. One advantage from using U.S. patenting data is that the general attractiveness of the large U.S. market encourages patenting of inventions that are believed to be of relatively high quality and commercial value. It thereby reduces the possibility that accidental or insignificant inventions contaminate the results. It has been found that Swedish firms' patenting in the United States do not differ significantly from patenting in other large markets such as Germany or France (Archibugi & Pianta, 1992). One potential drawback of using U.S. patenting data is that it tends to inflate the patenting activity by U.S. subsidiaries (because they have a relatively higher propensity to patent in what is their home market). Although this increases the relative number of entries and observations that may be associated with U.S. subsidiaries, it should not affect the expected pattern in the timing between new entries. In the current sample, U.S. subsidiaries account for some 12 per cent of the total number of introductions of new technological capabilities in the sample firms, so they should not have disproportionate effects on the results.

Although information from patents must be treated with some caution (Schmookler, 1950; Pavitt, 1988), no substantial biases are anticipated in the present study. Most of the sample firms are active in medium- to high-tech industries, where patenting is considered an important competitive device. While patenting propensity varies across the sample firms, causing variation in the number of patents associated with each firm, this does not in itself affect patterns in the emergence and diffusion of new technological capabilities. It should be expected that the reliability of data has improved over the measured time period, as for most firms the United States may have been perceived as relatively distant during the early parts of the period of observation (and hence not prioritized as a country in which patents were sought). It is notable, however, that the firm which accounted for the great majority of the observed U.S. patents before the Second World War – Alfa Laval – had established large-scale operations in the United States already in the late 19th century.

VARIABLES

For the measurement of the diffusion of technological capabilities, two occurrences and points of measurement are of interest: (1) Records of the sample firms' initial patenting in classes of technology that are new to the multinational group, thus suggesting the emergence of technological capabilities underlying these technologies, and (2) the

subsequent diffusion of technological capabilities within the multinational group.

Emergence of new technological capabilities: The emergence of new technological capabilities is detected when any unit of the MNC is awarded a patent in a technology in which the multinational group has not been previously active. Entry into new technologies and technological capabilities is measured at the level of about 400 classes of technology as defined by the U.S. Patent Office.¹ At this level of aggregation, it is possible to distinguish between relatively narrowly defined technologies, such as resistors and electrical connectors. Other examples include paper making and fibre preparation, chemistry carbon compounds, liquid purification and separation processes, and pulse or digital communications. For the purposes of this study, the classification makes it possible to detect the acquisition and application of technological capabilities within a comparatively narrow but related set of adjacent technologies. It thus allows for diffusion in the form of direct imitation or duplication, as well as for the extension of acquired capabilities into a relatively narrowly defined set of alternative applications.

The time of the emergence of new technological capabilities is set to the year in which the MNC received its first patent in a technology that is new to the entire multinational group. It is notable that we are only interested in the event that signals the first formation of new technological capabilities in the multinational group, and apart from subsequent recorded occurrence(s) of the diffusion of these capabilities do not investigate the firms' depth of involvement within each individual technology. Whereas an individual sample firm may have entered 75 new technologies and capabilities over the examined time period, 25 of which are recorded as diffused to other locations within the multinational group, there may have been extensive but in this paper unexplored activity and patenting within each individual technology.

Diffusion of technological capabilities: The diffusion of technological capabilities is detected when after a first unit has been awarded a patent in a technology that is new to the entire multinational group patenting activity in the same technology is also recorded in a second, third, etc. unit and location. As in the case of the emergence of new technological capabilities, the diffusion of technological capabilities is set to the year in which a second, third, etc. location is awarded its first patent in a particular technology.

In a limited number of cases, new technologies were introduced in the same year by more than one unit and location. For example, there were 35 cases of parallel

1. The U.S. Patent Office classification is primarily based on the nature and function of the inventions, not their primary adopters. The manual states that arts or instruments having like functions, producing like products, or achieving like effects, are classified together. The functions or effects that are chosen as a basis of classification must be proximate or

essential, not remote or accidental. The categories of invention are product, process, apparatus, composition of matter, and certain varieties of plants. Accessories are generally classified with the instrument to which they are peculiar (Manual of Classification, Revision No. 1, June 1993, U.S. Department of Commerce, Patent and Trademark Office).

introductions of new technologies, 25 cases of first diffusion to more than one unit and location, and 15 cases of second diffusion to more than one unit and location. Because entry into new technologies and diffusion times are measured on a yearly basis, in these cases it is unknown which unit and location was first or second, and the analyses were designed to allow for multiple paths of introductions and diffusions. Although this procedure introduced a limited number of duplicate (but not identical) observations to the analyses, it created symmetry in the potential effects on observed diffusion patterns and did not have a significant effect on any of the results and conclusions.

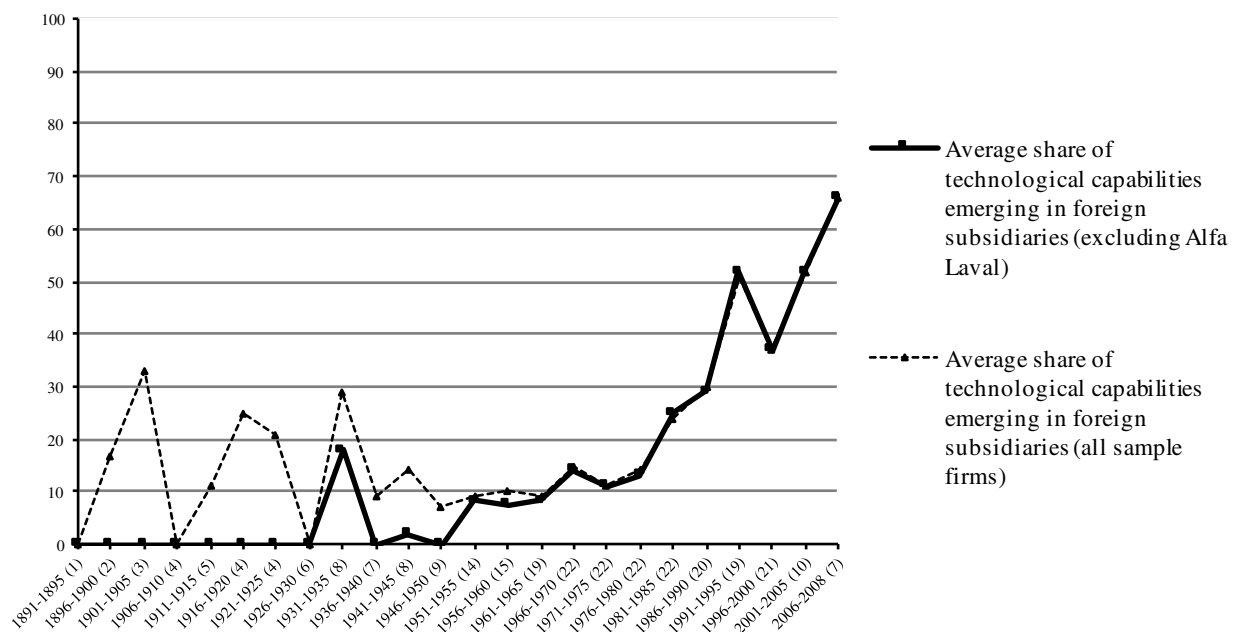
Although the empirical investigations reveal patterns in the diffusion of technological capabilities, to a certain extent the main mechanisms remain unknown. Diffusion may have been brought about in several different and possibly overlapping ways (Wilkins, 1974), including the transfer of knowledge and technology between units of the multinational group, the international mobility of individuals and their knowledge within the multinational group (for example, a Swedish engineer may have spent several

years working at the MNC's U.S. or German subsidiary), or knowledge exchange as part of collaboration or internationally coordinated research and development projects. In other cases, the diffusion of technological capabilities may be the result of acquisitions that added new technological capabilities to the existing stock of the acquiring company, or independent work on the same technology by two or more units of the multinational network. Typically, however, the intra-corporate environment is expected to play a central role in explaining patterns of cross-country technological diffusion in the MNC (cf. Reddy & Zhao, 1990; Kogut & Zander, 1993; Saggi, 2002).²

Diffusion event and time to diffusion: The event of a diffusion is recorded whenever the emergence of a new technological capability is followed by the occurrence of the same technological capability within another and geographically separate unit of the MNC (coded '1' for an event in any given year, and '0' otherwise). The types of unit considered are headquarters in the home country Sweden, foreign greenfield subsidiaries, and foreign acquired units. These units could be involved in both the introduction

FIGURE 1

The average share of technological capabilities emerging in foreign subsidiaries



Note: Numbers within parentheses equal number of firms with registered entry into new technologies

2. Citation analyses of a random sample of cases of diffusion suggest that in the current sample interaction with external firms has been an important source of knowledge. A sub-sample of 56 cases of diffusion was drawn from the sampled technologies, and analyzed in terms of organizational homes and geographical locations of inventors behind cited patents. The results suggest that a great majority or 95 per cent of patent citations pertain to external firms in the inventing unit's

local or international environment, whereas not more than 5 per cent relate to internal inventive activities (i.e. inventive activity taking place somewhere else in the unit's home corporation). Although the figures would suggest relatively heavy dependence on external sources of knowledge, they do not necessarily account for any original knowledge transfers that were instrumental in the build-up of absorptive capacity in select fields of technology.

of new technological capabilities and the replication of technological capabilities that were originally introduced elsewhere in the MNC group.

Time to diffusion was measured as the number of years between the emergence of a new technological capability and the subsequent diffusion of that technological capability to another unit of the MNC group. New technological capabilities that had not yet experienced any diffusion to another unit and location (or second or additional units, for those technologies that had already been diffused once or several times) were considered at risk for a diffusion, and in the statistical analyses thus treated as right censored observations.

Results

THE EMERGENCE OF NEW TECHNOLOGICAL CAPABILITIES

Baseline results on the emergence of new technological capabilities suggest that over time headquarters have come to play a diminishing role for the emergence of new technological capabilities among the multinational groups. Measuring the average share of technological capabilities emerging in foreign subsidiaries over 5-year periods, it is shown that the relative importance of these units has become more prominent especially from the 1960s and onwards (Figure 1). This analysis must take into the account the unusual development of one of the sample firms, Alfa Laval, in which foreign technological activity, especially in the company's U.S. and German subsidiaries, came to account for a significant proportion of all technological activity very early on (Zander & Zander, 1996).

THE DIFFUSION OF TECHNOLOGICAL CAPABILITIES

Significance of diffusion: A simple analysis of the number of new technological capabilities that are ever diffused within the MNC organization provides baseline information on the overall significance of diffusion processes. Over the entire period 1890-2008, the sample firms were recorded for the emergence of 1,822 new technological capabilities (in each of the sample firms marked by the first patent in a specific class of technology as defined by the U.S. Patent Office).³ By the end of the observed time period, 626 out of these technological capabilities had been diffused to at least one more unit and location within the

multinational group, whereas 1,196 had never diffused to any other location outside where they originated.

Diffusion by type of originating unit: Because new technological capabilities which have not yet diffused to other locations are still considered at risk of becoming diffused (meaning that observations are right censored), techniques for analyzing diffusion patterns need to rely upon event history analysis (Allison, 1995).

To investigate potential differences in the speed of diffusion for technological capabilities originally emerging either at headquarters or among the foreign subsidiaries, life-table analyses and non-parametric maximum likelihood Kaplan-Meier estimations were employed.⁴ The method makes it possible to test the null hypothesis that survivor functions for two or more strata or groups are identical, which in the current case means testing for differences in the diffusion of technological capabilities originating at headquarters versus capabilities emerging in foreign subsidiaries.

Accordingly, a first statistical model looked at the first diffusion of technological capabilities within the multinational organization but separated the data into two groups, one in which the first technological capabilities emerged at headquarters and one in which emergence was first recorded among foreign subsidiaries. Out of the two strata, 1,270 and 456 technologies emerged at headquarters and foreign subsidiaries respectively.⁵ Out of these technologies, 433 were diffused from headquarters and 209 from foreign subsidiaries. The results show a clear difference in survival functions between the two strata as observed in mean survival times (or the time to the first recorded diffusion of technological capabilities to a second location; Figure 2). The average estimated survival time for a technological capability that emerged at headquarters is 51 years versus 25 years for a technological capability initially emerging in a foreign subsidiary.⁶ The Wilcoxon test rejects the null hypothesis of no difference between the groups ($p < 0.0001$), i.e. technological capabilities originating at headquarters take significantly *longer* times to the first diffusion than capabilities emerging among foreign subsidiaries.

Additional models contain information about the second and third diffusion of technological capabilities, split into the same two groups as in the analysis of first diffusion. What is particularly notable is the reduction and ultimate disappearance of differences in diffusion patterns

3. These figures do not account for the fact that in a limited number of cases and at the level of individual MNCs there were parallel introductions of new technologies by two or more units within the same year. As described above, the effects of such parallel introductions were taken into account throughout the empirical analyses.

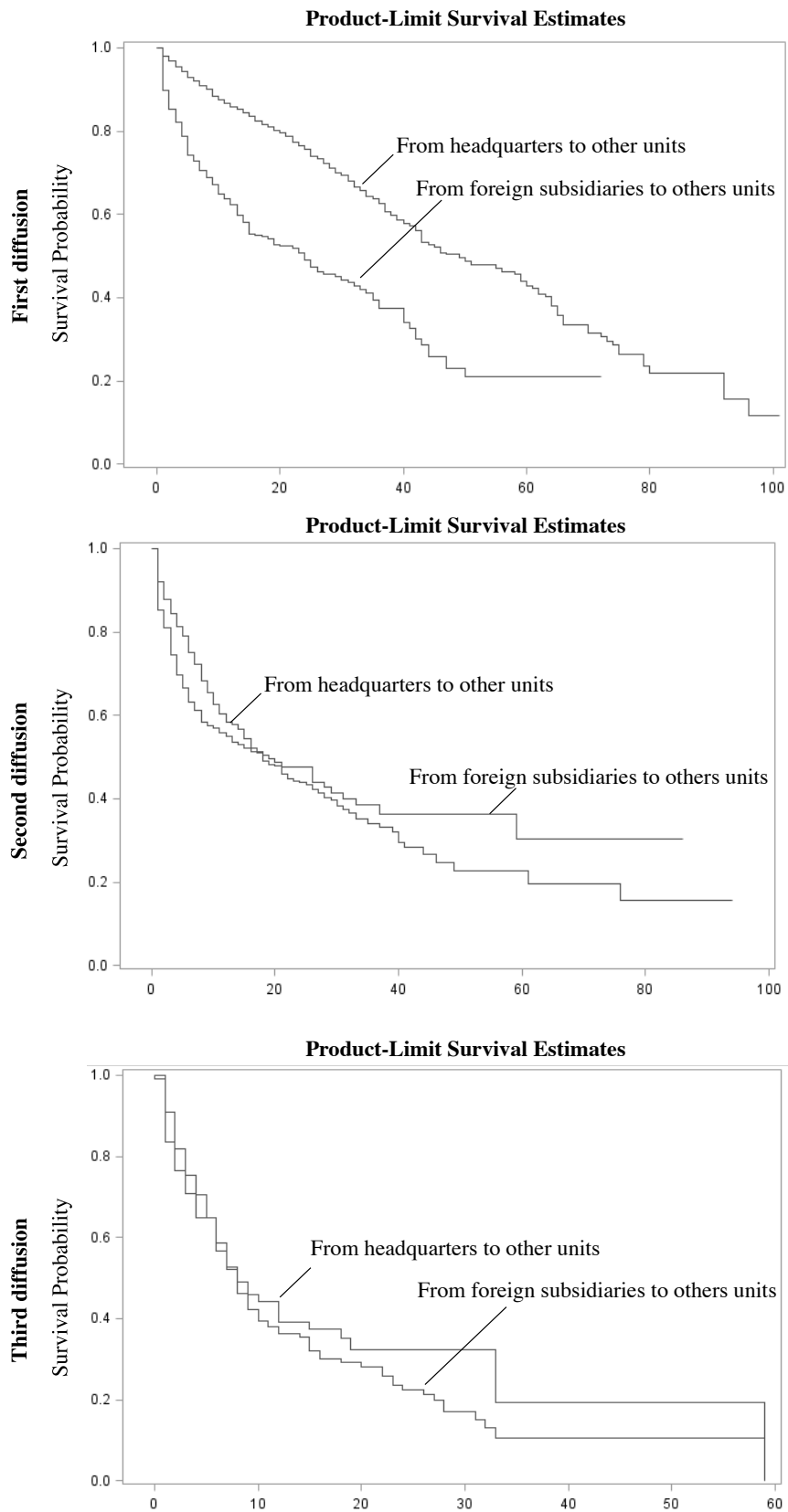
4. The life-table method of Kaplan-Meier estimates survivor functions following event times having probability distributions (in the present case, the event equals the recorded occurrence of technological capabilities in a second, third etc. location). More specifically, the survivor function is the probability that an event time is greater than t , where t

can take any non-negative number. In the case of no censoring, i.e. all observations experience an event, the survivor function is simply the proportion of observations with event times greater than t .

5. To accurately estimate the headquarter effect, these numbers exclude any technologies introduced by acquired units in the sample firms' home location.

6. The mean survival time is underestimated because the largest observation is censored and the estimation restricted to the largest event time.

FIGURE 2
Estimated survivor functions of technological capabilities diffusing from headquarters and foreign subsidiaries



as observed in the first diffusion analysis (Figure 2). Specifically, the estimated average survival time from the first to second diffusion for technological capabilities originating at foreign subsidiaries is 28 years compared to 29 years for a capability originally emerging at headquarters; there is no longer any significant difference in diffusion times between the two groups. For the third diffusion, the trend is the same as for the second diffusion and there is no significant difference between the two groups. Notably, the estimated average survival time from the second to third diffusion for technological capabilities originating at headquarters is 16 years compared to the 20 years for a capability originally emerging among the subsidiaries.⁷

Diffusion by type of unit to which capabilities are diffused: Further and more detailed analyses were concerned with the types of unit to which technological capabilities were diffused. Specifically, it was investigated whether there were observable trends in the way technological capabilities originally emerging at headquarters were diffused to greenfield or acquired subsidiaries. The same type of analysis also tested for regularities in the way capabilities originating in foreign subsidiaries were diffused to other sister units, including both greenfield and acquired units, or headquarters (Figures 3-5; results are shown only

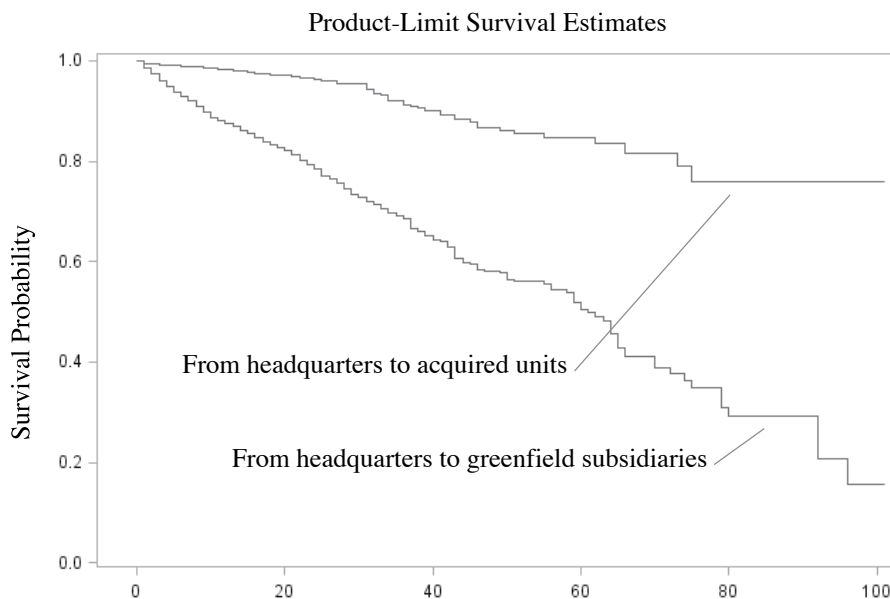
for first diffusions). Since in these analyses technological capabilities could diffuse to more than one type of destination, the life-table analyses relied on competing events methods and estimations.⁸

Concerning the diffusion from headquarters to greenfield and acquired units, the results show that the diffusion to greenfield subsidiaries takes significantly shorter times ($p < 0.001$) than for the acquired units. As for technological capabilities emerging among the greenfield subsidiaries another notable difference is observed – technological capabilities ending up at headquarters take significantly *shorter* times ($p < 0.001$) to diffuse than capabilities ending up among any of the two types of foreign subsidiary.

For the acquired units, finally, no significant differences in diffusion patterns can be observed, in part because of more limited numbers of observations. Notably, however, the overall likelihood that any capabilities diffuse to other units within the multinational group is much lower than for headquarters or greenfield subsidiaries. In other words, in terms of diffusion there are more limited movements both to and from the acquired units.

Longitudinal changes in diffusion patterns: Successively reduced numbers of observation and

FIGURE 3
Estimated survivor functions of technological capabilities diffusing from headquarters, first diffusion



7. These results could, at least in part, be attributed to the smaller number of observations for the second and third instances of diffusion. Although some technologies were diffused to as many as 16 locations during the observed time period, the number of diffusions from four and upward was too small to be considered for statistical processing.

8. For example, any technological capabilities emerging at headquarters could potentially diffuse to two different and mutually excluding destinations – greenfield subsidiaries or acquired units. For the technological capabilities emerging at either greenfield or acquired subsidiaries, the number of competing events was three – diffusion to headquarters, other greenfield subsidiaries, or other acquired units.

FIGURE 4
Estimated survivor functions of technological capabilities diffusing from greenfield subsidiaries, first diffusion

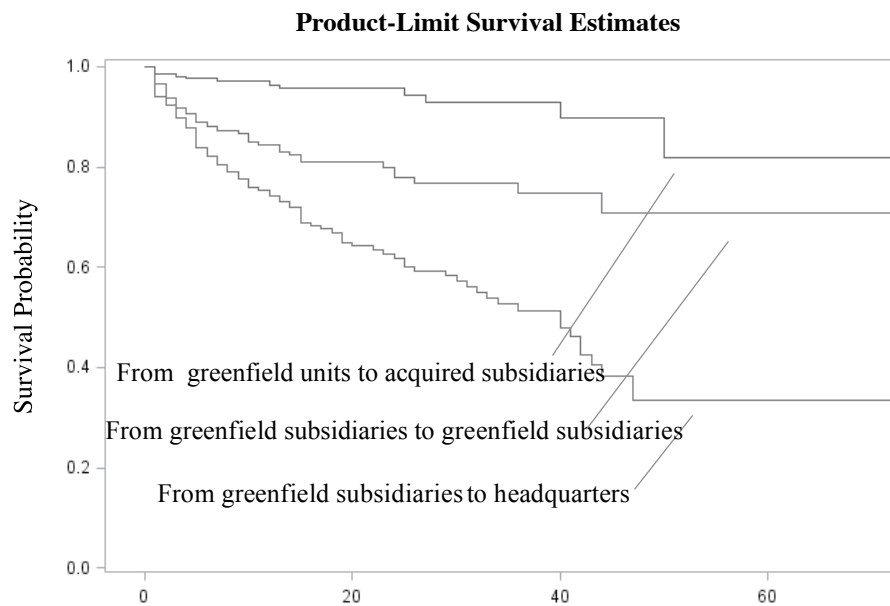
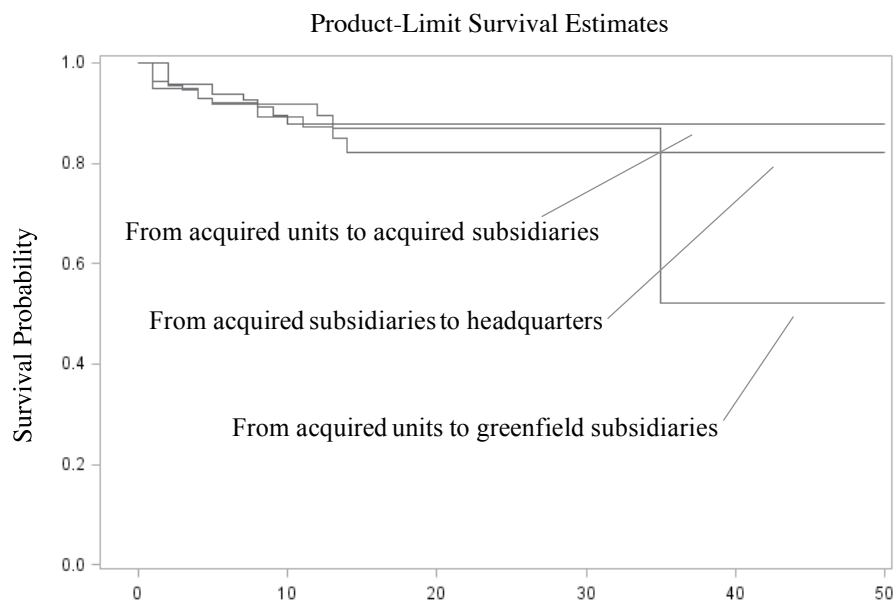


FIGURE 5
Estimated survivor functions of technological capabilities diffusing from acquired units, first diffusion



increasing proportions of right censored observations make it difficult to fully assess how patterns in the diffusion of technological capabilities have changed over time. Just about 50 per cent of all observations concern technological capabilities that emerged in 1975 or later. Separate analyses that cover only the period 1975-2008 reveal patterns

of diffusion that closely mirror to those of Figures 3-5. Also, during this period technological capabilities that emerged at headquarters diffused more slowly than those that emerged among the foreign subsidiaries (first diffusion), and for those capabilities that emerged among greenfield subsidiaries the pace of diffusion was faster to

headquarters than to other greenfield or acquired foreign units. In other words, any longitudinal changes in diffusion patterns appear to have been of limited significance.

Discussion

Although the empirical observations do not translate into any formal test of the six theories of the MNC proposed by Forsgren (2013), the identified diffusion patterns allow us to comment upon their contents and general applicability.

Considering the rather straightforward observations about the introduction of new technological capabilities in the multinational group (Figure 1), it is relatively clear that foreign subsidiaries have become increasingly important sources of new technological capabilities within the multinational organization. Notably, this observation goes beyond prior findings about increasing foreign shares of technological activity (e.g. Cantwell, 1989; Dunning, 1994; UNCTAD, 2005), as in the present study it is a matter of renewing the MNC by introducing both advanced and new technological capabilities to the multinational group. At least when it comes to the maturing and well-established MNCs, it casts doubt on theories of the MNC that emphasize hierarchy and the supreme role of headquarters, such as the Dominating MNC and to some extent also the Coordinating MNC (which is nevertheless more concerned with the issue of internalization). Although headquarters may be in charge of a multitude of functional and other activities within the multinational group, in the long run its importance for the vital task of renewing technological capabilities is unlikely to be sustained or retainable.

If some of the observations do not resonate with the early theories and conceptualizations of the MNC, they also pose significant questions to the more recently formulated alternatives. Specifically, the uncovered asymmetries in diffusion patterns call into question the forceful introduction and strength of egalitarian and shared values across units of the multinational group, or, perhaps more correctly put, the actual implementation of these values across various types of organizational units. If units of different types were to harbor similar capabilities and the same attitudes towards lateral and vertical knowledge flows, such as in the Knowing and also to some extent the Networking MNC, it would unlikely produce the systematic and significantly skewed patterns of diffusion displayed by the sample firms. Important aspects of the Networking MNC, especially those that concern the dynamics and use of geographically dispersed sources of new capabilities, appear to be corroborated by the findings. Yet, the observations also send a rather clear signal that the perception of headquarters as 'one organizational unit among others' is incorrect (at least in terms of high-value added activities such as R&D). Whatever the underlying drivers and explanations, when it comes to the diffusion of technological capabilities

headquarters behaves differently from greenfield subsidiaries and acquired units.

The particular role played by acquired foreign units is also noteworthy. The overall impression is that this is a type of unit that remains more or less detached or isolated in the multinational group. It is no doubt the case that several of the acquired units in the present sample maintain advanced technological capabilities that are on par with those of greenfield subsidiaries. Yet, these capabilities seem to come about and be utilized in quite different ways, a notion that may not have received sufficient attention in the extant theories of the MNC. Foreign units may be acquired because of their technological assets, but in terms of integration with other units of the MNC organization the short-term and potentially also long-term effects are much more limited compared to the greenfield subsidiaries.

In sum, and compared to Forsgren's (2013) conceptualization of theories of the MNC as outlined in Table 1, the empirical observations do suggest a shift of relevance towards the right hand side and more 'modern' alternatives. However, it also appears that any extreme interpretations of these alternative theories must be adjusted and modified to account for the observations at hand. The explanations for differentiated patterns in the diffusion of technological capabilities are perhaps already to be found, but they must then be addressed and brought forward with greater force and precision in future work on the nature of the MNC. As is often the case, it may be concluded that the reality of the MNC lies somewhere 'in-between' the extremes offered by the extant theories and conceptualizations.

INTERPRETATIONS OF THE EMPIRICAL FINDINGS

How, then, are the empirical findings to be explained? The first issue at hand is the initially slower diffusion of technological capabilities that originate at headquarters, and how over time the difference compared to the diffusion of capabilities from foreign subsidiaries tends to disappear. Also, it must be explained why technological capabilities that first originate among the greenfield subsidiaries diffuse more rapidly to headquarters than to any of their sister units. The second issue concerns the seemingly isolated status of acquired units, which appear to be 'out of the loop' in terms of capability diffusion within the MNC organization.

One possible explanation for the relatively slow diffusion of technological capabilities emerging at headquarters takes a starting point in the question of control and power within the multinational group. According to this explanation, whenever headquarters enter into new technologies the event will be followed by active exploitation of the new advancements in international markets. Very much in line with traditional accounts of the MNC, such exploitation will come with active technology transfer to foreign units, which over time and in some cases results in the diffusion

of related technological capabilities to select foreign subsidiaries. Notably, however, the empirical results suggest that such diffusion is significantly restricted by headquarters' ambitions to prevent unrestrained international diffusion of capabilities, specifically to retain organizational control (Blomkvist, Kappen & Zander, 2012) or to avoid what is perceived of as costly duplication of inventive effort (Zander, 1999). In this scenario, and in line with conditions that prevail in the Dominating or Coordinating MNC, headquarters actively use their hierarchical position and power to veto and in some cases recall any unwanted diffusion of capabilities to foreign subsidiaries. Although in a similar way foreign subsidiaries may be interested in exploiting any new technological capabilities in international markets, their possibility to effectively control diffusion is more limited on account of their secondary status in the corporate hierarchy.

Once any new technological capabilities have matured, and continued investments in research and development become geared towards exploiting any remaining applications and product niches, for headquarters the question of power and control becomes of lesser importance. One interpretation of the converging speeds for the second and third diffusions would be that over time headquarters consciously decide to 'let go' of technology to foreign locations. In that scenario, diffusion remains a controlled process but now instead reflects maximum exploitation by letting foreign subsidiaries explore the ultimate limits and possibilities of already well-established technologies and capabilities.

Explanations based on control and power could fit well with the observation that any new technologies developed by foreign greenfield subsidiaries diffuse much more rapidly to headquarters than to sister foreign subsidiaries. It is as if headquarters, more than any other type of unit, takes a substantial interest in whatever new discoveries are made among the foreign subsidiaries to rapidly assimilate and develop the corresponding capabilities. The question of staying informed about and in control of technological advancements may again play a central role in this explanation, alongside the inability of foreign subsidiaries to effectively object to what from their perspective would be seen as unwanted diffusion of capabilities and retraction of power to headquarters. Taken together, the effect would be a headquarters that, at least initially, is very cautious about letting technological capabilities diffuse to other units in foreign locations, yet very quick in detecting and assimilating any new technological capabilities that could become important for the future.

An alternative explanation would be that the observed differences in the speed of diffusion are driven by the absorptive capacities of various units of the multinational group (Cohen & Levinthal, 1991). In this case, it is not a matter of wanting to diffuse technological capabilities or not, but one of being capable of diffusing capabilities in the first place. This approach may explain why, for example,

new technological capabilities emerging at headquarters are relatively slow to diffuse to the foreign subsidiaries, and also why the diffusion is comparatively rapid from foreign subsidiaries to headquarters. Foreign subsidiaries are simply not as well-equipped to assimilate and exploit technology from other sources, whereas headquarters have ample resources and skills to execute rapid assimilation and integration of new technological advancements. Although this could be a reasonable explanation, it is still difficult to fully explain why in the case of headquarter capabilities speeds of diffusion become similar after the first diffusion event, because by definition a capability cannot diffuse twice to the same unit (which could be expected to build more substantial absorptive capacity over time). In any event, explanations built around absorptive capacities alone would emphasize sustained and systematic differences in the technological capabilities and abilities of various units of the multinational group.

The findings for the acquired subsidiaries are perhaps more easily explained. Especially during more recent years, many MNCs have become engaged in asset seeking investments (Dunning & Narula, 1995; Cantwell & Narula, 2001). These investments give the acquiring MNC rapid access advanced technological capabilities in foreign markets, and if they are made with the specific purpose of entering new fields of technology both mandates and local R&D activities will typically be retained by the acquired unit (Cantwell & Mudambi, 2005). In contrast to greenfield subsidiaries, however, internal connections to headquarters and other units of the multinational organization must still be developed (Tallman & Chacar, 2011), and the process of becoming an organizational 'insider' is likely to be a lengthy process. Previous studies have indeed indicated that the integration of acquisitions might be costly and arduous, partly because of differences in values and beliefs between the MNC and the acquired unit (Bresman, Birkinshaw & Nobel, 1999).

THE 'BETWIXT AND BETWEEN' MNC

Explanations such as those offered in the preceding paragraphs remain speculative, and it is clear that the empirical observations do not dismiss the relevance of extant theories and conceptualizations of the MNC. Rather, the empirical findings suggest the presence of a 'betwixt and between' MNC, which reflects a mix of the individual elements of Forsgren's (2013) proposed theories of the MNC. For example, patterns in the emergence of new technological capabilities are a clear indication of headquarters' diminishing role as a source of new technology, but at the same time the relative slowness of diffusion of technological capabilities from headquarters seems to speak for the hierarchical view expressed in the theories of the Dominating and Coordinating MNC. Similarly, the empirical observations could in part be interpreted within the frameworks of the Knowing and Networking MNC, in which headquarters

are considered to play an increasingly subsidiary role in the orchestration and exploitation of internationally dispersed capabilities. However, it would prove more of a challenge to uphold the assumption about equal positions and conditions for lateral and vertical flows of knowledge and capabilities within the multinational group.

To paraphrase Orwell (1945), when it comes to the diffusion of technological capabilities within the multinational organization the MNC identified in the present study may be understood as an organization where 'all animals are equal, but some animals are more equal than others'. It is a perspective that acknowledges the collective relevance of the extant theories of the MNCs as outlined by Forsgren (2013), but in the wider perspective questions overly stylized facts or extreme interpretations of the true nature of the MNC. Just like in Orwell's original story, it suggests the presence of an MNC that in parallel to the increasing geographical scope of technological renewal retains elements of hierarchy and, in the general sense, inequality among units of the MNC organization. With that, it is also likely to remain a political arena where different units and organizational constellations keep vying for control and influence in the international organization.

As an in-between organizational form, the type of MNC observed in the present study also highlights the importance of continued and continuous attention to the management of innovation and technology in the multinational organization. However, at this point there are no clear messages in terms of what managers should do. Given the empirical findings, the general suggestion would be to acknowledge and reflect upon the observed tendencies and work on organizational solutions that shift the balance of innovation activities and processes in any desired direction. A critical question is whether the empirical findings reflect conscious decisions by MNC managers or to a larger extent signal a naturally occurring 'drift' in the evolution of the multinational organization. There are also contingencies at the MNC level that must be considered, but which have not been explored or commented upon in the present study. Until these two questions have been satisfactorily understood and resolved, the managerial implications and recommendations must be approached with caution.

LIMITATIONS

There are of course some notable limitations to this study. The findings are confined to a sample of Swedish MNCs, which as they have been comparatively prone to internationalize their technological capabilities and could have developed distinctive organizational traits may not be representative of MNCs originating from other countries (cf. Negandhi, 1983; Wilkins, 1988). It is quite possible that MNCs of other national origins display patterns in the emergence and international diffusion of technological capabilities that are distinct from those in the present sample. As

well-established MNCs, the sample firms also represent only a subgroup of a larger and more differentiated set of MNCs, which includes firms with recent and rapid internationalization processes that could display other types of organizational dynamics (Oviatt & McDougall, 1994; Knight & Cavusgil, 2004; Zander & Mathews, 2010).

It is also possible that the current data have caught the sample firms in a still ongoing change process, the ultimate limits to which are yet to be experienced and empirically detected. In other words, the argument would be that in the long-term evolution of the MNC its true nature is still about to reveal itself. More refined perspectives on the current observations may also be sought in a closer examination of the age and specific locations of units involved in the diffusion processes, differentiated roles and typical innovation processes among individual units (Mahmoud-Jouini & Charue-Duboc, 2008), or variation across individual sample firms. Although such investigations are likely to offer additional information and possible explanations for the observed diffusion patterns, they cannot be effectively addressed within the confines of the present paper.

It should also be emphasized that Forsgren's (2013) typology offers but one of several alternative ways of approaching extant work on the theory of the MNC. The international business literature has seen several important and impactful individual theories and models of the MNC, including the heterarchy (Hedlund, 1986), the transnational (Bartlett & Ghoshal, 1989), the metanational (Doz, Santos & Williamson, 2001), or the orchestrating MNC (Parkhe & Dhanaraj, 2003). By adopting Forsgren's categorization, we have opted for not addressing and discussing each of these individual theories and models separately. With regard to this particular set of theories, the empirical findings speak generally to the issue of increasingly egalitarian MNC structures, but this is a theme and discussion that must be addressed in more focused forms in future work.

Finally, it must be re-emphasized that at this point the explanations put forward in the paper are speculative, and that the proposed concept of a betwixt and between MNC mainly summarizes the empirical observations and is not to be considered on par with existing theories of the MNC. In particular, the drivers of the empirical observations, the mechanisms of diffusion, and their general applicability must be investigated much more thoroughly before any assertive conclusions about the nature of the MNC can be drawn.

Conclusion

The main objective of the current study has been to intersect established theories of the MNC with a set of empirical observations on the emergence and diffusion of technological capabilities within the multinational organization. In conclusion, we have tentatively argued for a perspective that lies in-between any extreme interpretations and theories of the

MNC, suggesting that there have been developments towards less hierarchical structures of the well-established MNC but alongside sustained systematic differences across different types of units in the multinational group. As suggested by Forsgren (2013), the MNC is indeed a fascinating, complex and multidimensional creature. With the present study we hope to have contributed to continued efforts to gain an even better understanding of its true nature and inner workings.

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APPENDIX A

The sample of consolidated Swedish multinational firms

<u>Firm^a</u>	<u>Principal field of industrial activity</u>	<u>Total number of technologies represented</u>
AGA (1904) ^b	Industrial gases	122
Alfa Laval (1878)	Separators, agricultural equipment	107
ASEA (1883)	Power generation and distribution equipment	155
Astra (1913)	Pharmaceuticals	54
Atlas Copco (1873)	Pneumatic and hydraulic equipment	107
Avesta (1883)	Specialty steel and metals	12
Electrolux (1910)	White goods, home appliances	168
Ericsson (1876)	Telecommunication equipment	181
ESAB (1904)	Welding equipment	29
Esselte (1913)	Office equipment	32
Fagersta (1873)	Specialty steel and metals, rock drills	15
MoDo (1873)	Pulp and paper	42
Perstorp (1880)	Chemicals, conglomerate	43
Pharmacia (1911)	Pharmaceuticals	36
PLM (1919)	Packaging material	23
Saab-Scania (1891)	Automotive products, aircraft	73
Sandvik (1862)	Specialty steel and metals, hard materials	144
SCA (1929)	Pulp and paper	79
SKF (1907)	Ball- and roller bearings	123
Stora (1888)	Pulp and paper	63
Tetra Pak (1946)	Liquid packaging machinery	40
Trelleborg (1905)	Rubber products, conglomerate	38
Uddeholm (1668)	Specialty steel and metals	25
Volvo (1927)	Automotive products, food	111

^a Years within parentheses indicate the year of establishment.

^b AGA was acquired by Linde in 2000 and observations truncated in that year. Other sample firms with truncated observations include: ASEA (1988, merged with Swiss Brown Boveri et Cie.), Alfa Laval (1993, acquired by Tetra Pak), Astra (1999, merged with Zeneca Group), ESAB (1994, acquired by Charter), MoDo (2000, acquired by Metsä), Perstorp (2001, acquired by Sydsvenska Kemi), Pharmacia (1990, merged with Kabi Vitrum), PLM (1999, acquired by Rexam), Scania (1990, car division acquired by GM), Stora (1998, merged with Enso), Tetra Pak (1993, acquired Alfa Laval), Volvo (1999, car division acquired by Ford). Observations for the steel producing companies Avesta, Fagersta, and Uddeholm, and also Esselte, were truncated in 1990.
