



Weathering storms – Technological exploration of MNCs in times of financial crisis

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ABSTRACT

We generate new knowledge about financial crises and their consequences for MNC technological development, thereby addressing a largely uncharted issue at the crossroads of the organization, strategy and international business literatures. Drawing on threat-rigidity theory, we argue that financial crises have an overall negative effect on MNC technological exploration and that the strength of the effect differs across greenfield and acquired subsidiaries. Results from an empirical investigation of 21 MNCs over the 1890–2008 period suggest that the dampening effect of financial crises on technological exploration is confined to home-country units and greenfield subsidiaries, whereas it is found to be of less significance among acquired foreign subsidiaries. We suggest that such differentiation within the MNC is indicative of a previously unobserved advantage from multinationality, which allows it to smoothen the effects of financial crises on long-term technological development and corporate growth.

Introduction

Almost like a natural law, exogenous shocks continue to rattle individual firms' ability to grow and prosper. Ignited by the crash of the U.S. stock market in 1929, the crisis that followed incurred a global fall in GDP of an estimated 15 percent. Between 1995 and 2000, the Nasdaq Composite stock market index rose over 400 percent only to plummet 25 percent in a single week in April 2000, after worldwide speculation in information and communication technology stocks. More recently, in the fall of 2008 the collapse of Lehman Brothers sparked an unparalleled global financial crisis, leading to one of the most virulent recessions in decades and influencing firms all around the globe (OECD, 2009). It is yet to be seen how the scale and impact of that global financial crisis will compare to the aftermath of the Corona virus pandemic.

With their extensive international operations and networks of geographically dispersed units, multinational corporations (MNCs) play a central role in absorbing and responding to such sudden and pervasive changes in the global economy. Over the past two decades, there has been growing interest in how these firms are affected by financial crises of regional or global magnitude. Some researchers have explored the connection between crises, foreign direct investments and MNCs'

investments in foreign subsidiaries (Alquist, Mukherjee and Tesar, 2016; Álvarez and Görg, 2012; Bartels and Freeman, 2000; Bartels and Mirza, 1999; Chung, Lee, Beamish, Southam and Nam, 2013). Others have investigated how MNCs and foreign subsidiaries respond to various forms of crisis (Dikova, Smeets, Garretsen and Van Ees, 2013; Lee and Makhija, 2009; Lorenzen, Mudambi and Schotter, 2020), and how subsidiary responses to economic crisis are moderated by MNC network characteristics (Chung, Lu and Beamish, 2008).

Yet, inquiries into how financial crises affect the technological activities of MNCs are scarce. This is unfortunate, as MNCs control between one half and two thirds of the world's business research and development (R&D) (UNCTAD, 2005). In that capacity, they also play an important role in determining any pro- or countercyclical patterns in R&D investments and how these set the stage for long-term economic recovery (e.g., Francois and Lloyd-Ellis, 2003; Geroski and Walters, 1995; Manso, Balsmeier and Fleming, 2021; Wälde and Woitek, 2004; also, Barlevy, 2007; Fabrizio and Tzolmon, 2014). MNCs' international operations and geographically dispersed networks of foreign affiliates add particular complexity to their responses (Mudambi, 2011), as technological activity is often carried out within a structure that includes home-country units, foreign subsidiaries established through

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greenfield investments, and foreign acquired units. Although there is some evidence on how global crises may affect the allocation of R&D efforts within those structures (Cincera, Cozza, Tübke and Voigt, 2012), it is still unknown to what extent the effect is symmetrical across these different types of units.

Meeting this empirical void, in this paper we address the lack of attention to financial crises and the subsequent technological responses by MNCs. Reconciling the literature on technology and the MNC with threat-rigidity theory (Staw, Sandelands and Dutton, 1981), we suggest that the threat invoked by a financial crisis sets in motion a reaction that involves two distinctive but interrelated organizational processes, which together work against MNCs' explorative technological activities. We specifically argue that in times of financial crisis changes in information processing and a shift in locus of control gear MNCs towards attenuating their technological exploration, in this study captured by entry into technologies in which the MNC has not previously been active. We further suggest that the mechanisms outlined in the threat-rigidity theory will differentially impact the technological exploration of different units in the multinational group.

We test our predictions on a sample of 21 highly internationalized Swedish MNCs. Using patenting data as an indicator of the firms' technological activities over the period 1890–2008, we show that recurrent crises have had an overall dampening effect on the MNCs' propensity to enter into new technologies and further confirm a differentiated effect across greenfield and acquired units within the multinational group. Specifically, the dampening effect of financial crises on technological exploration is confined to home-country units and greenfield subsidiaries, whereas it is found to be of less significance among acquired foreign subsidiaries. We suggest that such differentiation within the MNC is indicative of a previously unobserved advantage from multinationality, which allows it to smoothen the effects of financial crises on long-term technological development and corporate growth. In the following, we first outline our theoretical arguments and then move into the empirical investigation and a discussion of our findings.

Theoretical framework

Unique proprietary technology provides the competitive advantages on which most MNCs base their initial international expansion. Moreover, their subsequent growth and long-term survival depend on their ability to continuously upgrade and renew these advantages, as over time they are eroded by imitation, competition, and environmental changes (Lee, Narula and Hillemann, 2021; Meyer, Mudambi and Narula, 2011).

It is generally believed that over the past century MNCs have developed into globally dispersed, increasingly differentiated, and also advanced vehicles for technological exploration (for a nuanced review of the literature, see Håkanson, Kappen and Zander, 2021). Historically, technological exploration was predominantly an activity carried out at or close to headquarters, only to subsequently diffuse into international markets as a consequence of exploitative efforts (Vahlne and Johanson, 2017). The development towards more internationalized technological activities coincided with the upgrading of subsidiary roles (Rugman, Verbeke and Yuan, 2011), reflecting foreign subsidiaries' growing ability to develop advanced capabilities and in turn engage in exploratory technological search efforts (Almeida and Phene, 2004; Blomkvist, Kappen and Zander, 2010). A number of studies have indeed shown that foreign subsidiaries have come to account for a larger share of research and development and that they have become an increasingly important source of new technology in the MNC (e.g., Almeida and Phene, 2004; Michailova and Zhan, 2015). This shift in technological development was primarily driven by greenfield and acquired foreign subsidiaries, with the latter appearing to have become the preferred mode of international expansion sometime in the early 1960s (Hood and Young, 1979). Indeed, evidence suggest that a substantial portion of foreign R&D activities of MNCs are now carried out by acquired

subsidiaries (Blomkvist, Kappen and Zander, 2014).

Although a considerable amount of work has described the long-term growth and evolution of MNCs, the impact of distinctive and unsettling events such as financial crises on MNCs' technological exploration has been left uncharted. This is noteworthy for two reasons. First, research on the nature of the MNC has increasingly pointed to context as a defining and impactful element (Bello and Kostova, 2012; Coviello, Kano and Liesch, 2017), and second, exploration that balances exploitation is vital for a firm's long-term prosperity (O'Reilly and Tushman, 2013). It indeed appears that the typical description of the evolution of MNCs is void of abrupt events that could potentially impact both the strategy and structure of the firm, and which differ from the economic reasoning that influences firms' investments in new technology throughout conventional business cycles (Devinney, 1990). Defined as sharp, brief, ultracyclical deteriorations of all or most of a group of financial indicators (Goldsmith, 1982), which heralds a threatening downturn of the general economy, financial crises represent such unsettling context-changers that could alter the technological search patterns of the MNC.

Development of hypotheses

Prior studies point to the dual roles of exploration and exploitation in the generation of new knowledge (March, 1991), and especially the need for balance between the two, or ambidexterity (O'Reilly and Tushman, 2013). Whereas exploitation builds on prior, existing knowledge, exploration involves searching and employing heterogeneous knowledge in view of creating new combinations (Taylor and Greve, 2006).

While a number of studies have explored mechanisms that connect crises with overall levels of firm R&D expenditures (e.g., Francois and Lloyd-Ellis, 2003; Geroski and Walters, 1995; Wälde and Woitek, 2004; also, Barlevy, 2007; Fabrizio and Tsolmon, 2014), the connection to technological exploration is captured more directly by threat-rigidity theory, which aims to explain behavioral changes due to sharp and unsettling events. Staw et al. (1981) suggest that during times of adversity several interdependent processes will unfold in the system. When a threat emerges, information processing and sharing tends to become constricted (Hermann, 1963; Gladstein and Reilly, 1985; Olsen and Sexton, 2009), implying that fewer alternatives and sources of information are consulted in order to economize on bounded rationality under time pressure (Dutton and Jackson, 1987). In a threat situation, firms are also expected to react conservatively, identify familiar routines and responses (cf. Hale, Hale and Dulek, 2006), and then assimilate new information that is aligned with them. In a scenario of a global financial crisis, decision makers will initiate internally directed actions (Chattopadhyay, Glick and Huber, 2001) and "attempt to regain control over that which seems to be uncontrollable" (George, Chattopadhyay, Sitkin and Barden, 2006: 350). In that scenario, decisions start traveling up the corporate hierarchy, and experimentation will receive only second-order priority (Gilbert, 2005; Prechel, 1994; Williams, 1957).

Like any other type of firm, MNCs are expected to react conservatively to the threat imposed by financial crises, but in contrast to a purely domestic firm they are axiomatically more exposed to the dynamics within a network of internationally dispersed and technologically capable foreign units (Noorderhaven and Harzing, 2009). Although geographically dispersed knowledge offers advantages during periods of normal economic activity, it also amplifies the consequences of impending threats in two ways. First, and related to the mechanism of constricted sharing and processing of information during times of crisis, the MNC will particularly falter in technological exploration that depends on information sharing across geographically dispersed units. Whenever faced with adversity, the MNC's possibilities for technological exploration and global-for global innovation based on inter-unit interaction (Ghoshal and Bartlett, 1988) will be reduced.

Second, and as part of the drive to react conservatively, the locus of

control is likely to shift upward in the corporate hierarchy (e.g., Dutton and Jackson, 1987; Starbuck, Greve and Hedberg, 1978; Staw et al., 1981). In the established MNC, whose organizational structure is comprised of headquarters and a network of foreign subsidiaries, centralization of decision making to headquarters likely drives out local initiatives that are responsive to local conditions and environments. Within the MNC, headquarter insights into and control over ongoing R&D projects in foreign units may be gained through more active engagement in global product councils and technical meetings (Håkanson and Zander, 1986), on-site, intra-MNC visits and meetings (Zeschky, Daiber, Widenmayer and Gassmann, 2014), and more expansive and stricter financial control over foreign units (Asakawa & Aoki, 2016). Crises may indeed be actively used by headquarters to wield ownership rights and re-establish control over subsidiary exploration, thereby curtailing responsiveness to developments in locally idiosyncratic clusters of economic activity (Blomkvist, Kappen, & Zander, 2012).

The upshot is that MNCs will respond to crisis situations by restricting variation to already established areas of technological activity, both at home and throughout the network of internationally dispersed subsidiaries. Such developments may be exacerbated by the reduction of R&D expenditures and activity (Barlevy, 2007; Wälde and Woitek, 2004) and the associated benchmarking of foreign subsidiaries in view of allocating innovation effort only to the most productive units (Kappen, 2011). In sum, drawing on threat-rigidity theory to predict the effects of financial crises on MNC innovation activity, we hypothesize that:

Hypothesis 1: During times of financial crisis, the likelihood of MNC technological exploration will decrease.

Although crises can be expected to have a universal effect across units of the MNC, especially in the face of financial crises of global economic impact, the effects of restricted information processing and retracted locus of control are likely to systematically differ between types of foreign units. First, starting as mini-replicas of home-country units, greenfield subsidiaries generally have inherited the culture, communication patterns, and technological platforms of headquarters. With the exception of exceptionally powerful foreign subsidiaries (Blomkvist et al., 2012), greenfield subsidiaries are comparatively well embedded within the MNC organization and therefore exhibit relatively high degrees of internal integration (Cantwell and Mudambi, 2005). Although internal integration can yield benefits in terms of gaining attention and recognition for technological excellence (Andersson, Forsgren and Holm, 2001), it also comes with potential downsides. Highly integrated units are more visible to headquarters (Bouquet and Birkinshaw, 2008), making it easier to detect, communicate and reduce investments in what are perceived of as redundant capacities and units (Håkanson and Kappen, 2016).

Second, while foreign acquisitions may be executed for a number of reasons, acquisitions of units hosting advanced technological capabilities may have been undertaken specifically for diversifying the MNC's overall technological portfolio and gaining access to new growth opportunities (Björkman, Barner-Rasmussen and Li, 2004; Hitt, Hoskisson, Johnson and Moesel, 1996). Blomkvist et al. (2014) provide evidence that foreign acquired subsidiaries are more likely to contribute new technologies to the multinational group than greenfield subsidiaries. Prabhu, Chandy and Ellis (2005) document how knowledge gained through acquisitions can be internally integrated to increase innovation output. Whenever acquisitions have been motivated by gaining access to new technological capabilities, and in contrast to greenfield units, which to a larger extent tend to drift into new technological areas over time, headquarters may be reluctant to control and curb such strategically induced opportunities for technological diversification and cross-fertilization (Slangen and Hennart, 2008).

Given their differentiated organizational practices and technological capabilities, any attempted integration of acquisitions within the entire multinational network can further be expected to be a comparatively costly, complex and long-term process (Bresman, Birkinshaw and Nobel,

1999). Acquired subsidiaries are sometimes viewed with suspicion by greenfield subsidiaries (Crisuolo and Narula, 2007), and there is cooperative inertia because of differences in management styles and organizational cultures (Slangen and Hennart, 2008). In some cases, key individuals in the acquiring firm will refrain from working with former competitors (Ertugrul, 2013; Blomkvist, Kappen and Zander (2015), 2019) have documented persistent differences in terms of information flows to and from greenfield and acquired foreign units, suggesting that for considerable periods acquired foreign units remain something of a special, non-integrated case within the multinational network.

Whenever financial crises cause the concentration of control to headquarters, compared to greenfield subsidiaries the effects on technological exploration can thus be expected to be less substantial among acquired foreign units. We thus hypothesize that:

Hypothesis 2: The effect of financial crises on MNCs' technological exploration will be lesser among acquired foreign units than among greenfield subsidiaries.

Methods

Empirical strategy

In this paper, we are particularly interested in capturing the effects of global crises on MNC technological exploration in the form of entry into new and previously unexplored technologies. While the degree of exploration may in part be captured by shifting levels of R&D expenditure, which could be confined to incremental development around already known technologies and solutions, entry into technologies that are new to the multinational group to a more significant extent reveals the presence of variation, risk taking and play in exploration (March, 1991).

We use event history analysis to estimate the likelihood of entry into a new technology, distinguishing between new entries being generated by MNCs' home-country units, greenfield subsidiaries, and foreign acquired units. As any of these units may be involved in a number of consecutive entries into new technologies, the precise method is repeated events with gap time specification, also known as the Prentice-Williams-Peterson (PWP) model. The PWP model stratifies on event number and accounts for the number of entries into new technologies a unit has experienced at the time of entry into any additional technologies (Blomkvist et al., 2010), which allows for different baseline hazards (i.e. the underlying likelihood for an event may differ across event numbers). Taken together, the statistical approach allows for the estimation of how financial crises influence the likelihood of entry into new technologies across different units of the MNC network, accommodating both right censoring and time-varying covariates.

Sample

To conduct the PWP model estimations, we employ a sample comprised of 21 Swedish multinational corporations, using their complete patenting histories over the period 1890–2008.² The sample captures the technological pasts of the corporations which other studies

² The sample firms and main industries include AGA (industrial gases), Alfa Laval (separators, agricultural equipment), ASEA/ABB (power generation and distribution equipment), Astra (pharmaceuticals), Atlas Copco (pneumatic and hydraulic equipment), Electrolux (white goods, home appliances), Ericsson (telecommunication equipment), ESAB (welding equipment), Esselte (office equipment), MoDo (pulp and paper), Perstorp (chemicals, conglomerate), Pharmacia (pharmaceuticals), PLM (packaging material), Saab-Scania (automotive products), Sandvik (specialty steel and metals, hard materials), SCA (pulp and paper), SKF (ball and roller bearings), Stora (pulp and paper), Tetra Pak (liquid packaging machinery), Trelleborg (rubber products, conglomerate), and Volvo (automotive products).

have shown to account for a significant number of inventions and R&D expenditure in Swedish industry (Håkanson and Nobel, 1993; Wallmark and McQueen, 1986). The sample firms represent a wide range of industries, for example, IT and telecommunications, pharmaceuticals, industrial engineering, motor vehicles and pulp and paper and were followed to the end of the observation window, or to the year that they were involved in a major merger or acquisition.

The collected patenting data 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. Majority-owned greenfield and acquired 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, Who Owns Whom – Continental Europe*, as well as information in annual reports and corporate trees offered by the *Thomson Innovation* database.

Data

Our study uses patents as markers of entry into new technologies. Patents are frequently used indicators of technological development in the strategy literature and elsewhere (e.g. Almeida and Phene, 2004; Archibugi and Pianta, 1992; Jaffe, 1986) and possess an advantage in that they provide information that is both consistent and comparable over time. Patenting correlates with alternative measures of technological activity and innovative performance, such as research and development expenditure and new product introductions (Devinney, 1993; Fabrizio and Tsolmon, 2014; Geroski and Walters, 1995). Hagedoorn and Cloodt (2003: 1375, 1365) find “no major systematic disparity amongst R&D inputs, patent counts, patent citations and new product announcements” and conclude that “future research might also consider using any of these indicators to measure the innovative performance of companies in high-tech industries.”

It is generally believed that patent analyses can be a useful tool for understanding phenomena of technological development within organizations as they provide rich and fine-grained information about technologies, pinpointing the people, places, times, and technological characteristics of every patented technology (Gittelman, 2008). While patents used to be regarded as a general proxy for inventions, they are also increasingly seen as a proxy for the creation of specialized capability inputs into innovation within companies (Cantwell, 1995). In other words, while patents have traditionally been seen as the result of R&D processes, they may also reflect technological capabilities used as an input into ongoing research efforts by MNCs.

The patents considered in this study are those that have been granted in the United States. The completion of a U.S. patent application requires that the domicile of the inventor (rather than the nationality of the research unit) is recorded, which makes it possible to establish where the research and development underlying the invention was carried out.³ This is an important advantage because firm-specific patenting policies (for example, involving the registration of patents under the name of the parent company rather than the inventing subsidiary) might otherwise conceal the correct geographical distribution of technological activity. An additional advantage from using U.S. patenting data is that the general attractiveness of the large U.S. market encourages patenting of inventions that are 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 does not differ significantly from patenting in other large markets such as Germany or France (Archibugi and Pianta, 1992).

³ In the small proportion of patents that were associated with several inventors of different nationalities, the geographical location of invention was recorded as that of the first inventor.

Variables

Dependent variable: The main variable and event of interest is entry into new technologies. Entry into a new technology is detected when any unit of the MNC is awarded a patent in a class of technology in which the multinational group has not been previously active, set to the year in which the multinational received its first patent in that new class of technology. The shorter the time between the unit's successive entries into new technologies, the stronger its propensity to explore new technology rather than exploit capabilities within already existing and known fields of technology.⁴

Entry into new technologies is measured at the level of about 475 classes of technology as defined by the U.S. Patent Office. For matters of convenience, these classes of technology will be referred to as ‘technologies’ throughout this study. At this level of aggregation, it is possible to distinguish between relatively narrowly defined technologies, such as electrical connectors, paper making and fiber preparation, chemistry carbon compounds, liquid purification and separation processes, and pulse or digital communications.

Independent variables: Our main independent variable accounts for whether technological activity in the sample MNCs has taken place during a period of normal economic conditions (0) or during a financial crisis (1).

To operationalize a financial crisis in accordance with its definition as a sharp, brief, ultracyclical deterioration of all or most of a group of financial indicators (Goldsmith, 1982), we draw on Bordo et al. (2000, 2002) research on historical, global stock market crashes and subsequent recessions to identify a list of significant financial crises over the 1890–2008 period. To be considered a financial crisis, the U.S. stock market has had to experience a sharp decline in real value in excess of 20 percent. In terms of stock market interdependencies, the U.S. stock market has been shown to be “by far, the most influential in the world” (Eun and Shim, 1989: 243) and shocks in that market transmit quickly to others around the globe. Using the 20-percent cut off, the list of crises includes, amongst others, the global financial crisis in the early 20th century, the two world wars, oil crises and the burst of the dot com bubble in 2000 (see Table 1).

For each crisis extracted from Bordo et al. (2000, 2002), we constructed a crisis period that started with the sudden onset of the stock market decline and then continued for a number of years after the crisis had technically come to an end. We considered the crisis repercussions to extend half-way to the next crisis, to account for the fact that the post-crisis period would typically have involved a period of return to

Table 1
Financial crises¹.

Start	End	Main cause
1906	1907	World financial crisis
1916	1921	War, deflation, disarmament
1929	1932	Roaring 1920s and Great Depression
1936	1949	Tight monetary policy, war and post-war slump
1968	1970	Bretton Woods
1972	1975	Oil shock
1976	1979	Oil shock
2000	2002	Dot com bubble

¹ Financial crises were determined on the basis of real stock prices (decline >20%), and derived from Bordo et al. (2000, 2002).

⁴ Time to entry is measured as the number of years between either the first recorded patenting in a specific unit and its first recorded entry into a technology that is new to the multinational group, or the number of years between any two successive entries (for example, the number of years between the 1st and 2nd entry into a new technology, or between the 2nd and 3rd entry, etc.).

normality and possibly also a peak in economic activity preceding the next crisis (Roper and Turner, 2020). Notably, the far-reaching consequences of the great depression, the First and Second world war, and a subsequent succession of shorter-term financial crises suggest that the implications for firm operations and activities have been recurrent and substantive.

Because the granting of a patent lags behind the application date, in more recent times by up to two years, it is reasonable to assume that in the full effects of a crisis on patenting will not be revealed until some time after its onset. We therefore lagged the analysis of observed patenting and potential entry into new technologies by two years, which means that the effect of a sample firm's technological activity undertaken in, for example, 1999 was captured by the ultimate granting of patents in 2001.

Control variables: One limitation of the PWP model we employ, which is shared with other repeated-events models, is that it does not correct for unobserved heterogeneity. To some extent, the homogeneity of the sample firms in terms of geographical origin of parent firms, management styles, and organizational traits should have created similar conditions across firms and individual subsidiaries. Also, all units in the sample have reached a stage of documented capabilities to contribute significantly to the technological portfolio of the firm, as signified by their ability to patent. Although ideally the data should have included several control variables, the unavailability of data especially at the foreign subsidiary level and over the long observation window precluded their full inclusion in the statistical models. Nevertheless, a number of control variables and a stratified statistical model should help reduce unobserved heterogeneity.

To capture potential effects related to the extra-corporate environment, we included size of the local market as a proxy for the munificence of the local technological and business environment. Size of the local market is measured in annual GDP expressed in the log of millions of USD (expressed in 1990 terms), using data obtained from the GGDC Total Economy Database. As with other time-varying controls, GDP figures were lagged two years to account for the gap between patent application and granting.

The study of MNC technological activity based on U.S. patenting data tends to inflate the patenting activity by greenfield subsidiaries and acquired units located in the United States, because these units have a relatively high propensity to patent in what is their home market. As in our sample the United States accounted for 47 percent of the total number of foreign unit entries into new technologies, we included a location dummy for *U.S. subsidiary* in our models.

A first set of intra-firm control variables captures the potentially differentiated propensity to enter into new technologies across home-country units, on the one hand, and either greenfield foreign subsidiaries or acquired foreign units, on the other. The *greenfield foreign subsidiary* dummy variable distinguishes between and greenfield foreign subsidiaries (1) and other units of the MNC group, including home-country units and foreign acquired units (0). A second dummy variable, *acquired foreign unit*, captures the distinction between acquired foreign units (1) and other units (0).

We employed two additional intra-firm controls to capture the possibilities for both home and foreign subsidiaries to either benefit from technological cooperation within the multinational group, or, alternatively, to deal with the intra-corporate competitive environment among technologically sophisticated units of the MNC (Blomkvist et al., 2010; Dellestrand and Kappen, 2012). We introduced an *internal network* variable measuring the number of foreign greenfield subsidiaries with proven but not necessarily unique technological capabilities at the time of each annual observation. The variable *technological diversity* measures the number of foreign subsidiaries in the MNC that had produced entry into technologies that were new or unique to the multinational group.

Finally, a set of *industry dummies*, including pulp and paper, automobiles, information and communications technology, mechanical engineering and pharmaceuticals, reflects the fact that patenting

propensity and involvement in foreign technological activity differs across industries, and also that the response of MNC subsidiaries to global crises may be industry dependent (Filippov and Kalotay, 2011).

Results

In total, the 21 firms accounted for between 15 and a maximum of 185 (median 58) entries into new technologies. The number of entries into new technologies by home-country units, excluding right-censored observations, ranges between 14 and 154 (median 45). The number of entries into new technologies by greenfield foreign subsidiaries, similarly excluding any right-censored observations, ranges from 0 to 41 (median 2). For acquired foreign units, the number of entries ranges between 0 and 28 (median 3).⁵

The correlation matrix in Table 2 shows mostly moderate correlations between the main and control variables, the exception being the correlation between *GDP* and *U.S. dummy* and *internal network* and *technological diversity*. In the robustness tests, we exchanged either of these controls for the other with no significant effects on the main results.

The results from the repeated event analyses are shown in Table 3. Model 1 presents the results only for the control variables – *GDP*, *greenfield foreign subsidiary*, *acquired foreign unit*, *internal network*, *technological diversity*, and the *industry* and *U.S. subsidiary* dummies. *GDP* is statistically significant and positive, suggesting that the likelihood of entry into new technologies is higher among units located in larger and more munificent markets. It further shows a statistically significant effect for *greenfield foreign subsidiary* and *acquired foreign unit* ($p < 0.001$), suggesting that within these groups the likelihood of entering into new technologies is generally lower than among the home-country units. As expected, the *U.S. dummy* is positive but it is not statistically significant ($p = 0.119$, not reported in the table).

The addition of *crisis* in Model 2 shows that financial crises have a significant and negative effect on the likelihood of entering into new technologies ($p = 0.014$). The hazard ratio shows that the post-crisis periods reduce the likelihood of entry into new technologies by some 13 percent. The effects of *GDP*, *greenfield foreign subsidiary* and *acquired foreign unit* remain significant and negative, i.e., although crises reduce the level of technological exploration it is significantly higher in larger markets and among the home-country units. The intra-corporate difference is substantial, as the hazard ratios suggest that belonging to either greenfield subsidiaries or acquired foreign units reduces the likelihood of entry into new technologies by some 90 percent.

We next examined if greenfield foreign subsidiaries and acquired foreign units were affected differently by the crisis, specifically if, as stated in Hypothesis 2, the effect of financial crises on technological exploration will be lesser among acquired foreign units than among greenfield foreign subsidiaries. To test for this possibility, Model 3 includes the interactions between *greenfield foreign subsidiary* and *crisis* as well as between *acquired foreign unit* and *crisis*. The results show that during periods of financial crises the level of technological exploration remains comparatively high among the foreign acquired units ($p =$

⁵ Additional qualitative investigation into the greenfield and acquired subsidiaries suggested that the majority of units observed were so-called fully fledged subsidiaries (responsibilities for production, R&D and sales). Specifically, the six most prolific subsidiaries in terms of new technological entries in the sample were the US subsidiary of dairy equipment producer Alfa Laval (a greenfield subsidiary), the U.S. subsidiary of white goods manufacturer Electrolux (acquired subsidiary), the U.S. subsidiary of telecommunications equipment manufacturer Ericsson (greenfield), the German subsidiary of ball-bearing manufacturer SKF (greenfield), and the U.S. and German subsidiaries of specialty metals producer Sandvik (greenfields), all of which were performing a wide variety of activities along the value chain. This suggests that the sample comprises comparable subsidiaries that have mandates beyond purely R&D activities.

Table 2

Descriptive statistics and correlations for main covariates.

	Mean (Std Dev)		1	2	3	4	5	6	7
1. Crisis	0.67 (0.47)	1.000							
2. Greenfield foreign subsidiary	0.66 (0.47)	0.001	1.000						
3. Acquired foreign unit	0.13 (0.34)	−0.035	−0.536	1.000					
4. GDP	12.65 (1.66)	−0.078	0.122	0.385	1.000				
5. Internal network	8.53 (5.50)	−0.101	0.198	0.199	0.339	1.000			
6. Technological diversity	3.32 (2.76)	−0.154	0.161	0.186	0.380	0.751	1.000		
7. U.S. subsidiary dummy	0.148 (0.355)	−0.037	−0.060	0.348	0.668	0.037	0.083	1.000	

Table 3

The effects of main and control variables on the hazard rate for entry into new technologies (Prentice-Williams-Peterson recurrent event model).

	Model 1	Hazard ratio	Model 2	Hazard ratio	Model 3	Hazard ratio
GDP	0.149 (0.071) $\chi^2 = 4.399$ $p = 0.036$	1.161	0.153 (0.072) $\chi^2 = 4.496$ $p = 0.034$	1.165	0.154 (0.072) $\chi^2 = 4.564$ $p = 0.033$	1.167
Greenfield foreign subsidiary	−2.219 (0.173) $\chi^2 = 164.552$ $p < 0.0001$	0.109	−2.232 (0.178) $\chi^2 = 157.370$ $p < 0.0001$	0.107	−2.288 (0.179) $\chi^2 = 163.710$ $p < 0.0001$	0.102
Acquired foreign unit	−2.369 (0.183) $\chi^2 = 167.259$ $p < 0.0001$	0.094	−2.378 (0.186) $\chi^2 = 162.966$ $p < 0.0001$	0.093	−2.637 (0.234) $\chi^2 = 126.608$ $p < 0.0001$	0.072
Internal network	0.013 (0.013) $\chi^2 = 1.042$ $p = 0.307$	1.013	0.014 (0.013) $\chi^2 = 1.042$ $p = 0.307$	1.014	0.014 (0.014) $\chi^2 = 1.056$ $p = 0.304$	1.014
Technological diversity	−0.037 (0.021) $\chi^2 = 3.102$ $p = 0.078$	0.963	−0.042 (0.022) $\chi^2 = 3.551$ $p = 0.060$	0.972	−0.042 (0.022) $\chi^2 = 3.500$ $p = 0.061$	0.959
Crisis			−0.144 (0.058) $\chi^2 = 6.086$ $p = 0.014$	0.866	−0.197 (0.066) $\chi^2 = 8.988$ $p = 0.003$	0.821
Greenfield foreign subsidiary x crisis					0.072 (0.200) $\chi^2 = 0.131$ $p = 0.717$	1.075
Acquired foreign unit x crisis					0.399 (0.184) $\chi^2 = 4.716$ $p = 0.030$	1.491
U.S. subsidiary dummy	Yes		Yes		Yes	
Industry dummies	Yes		Yes		Yes	
N (annual observations)	9361		9361		9361	
Events	1631		1631		1631	
Censored	7730		7730		7730	
Wald (sandwich)	364.686 $p < 0.0001$		374.646 $p < 0.0001$		383.833 $p < 0.0001$	

Precise p values, standard errors within parentheses.

0.030), while there is no corresponding effect among the greenfield foreign subsidiaries ($p = 0.717$).

Taken together, the results lend support for Hypothesis 1, which suggested that the likelihood of technological exploration is lower during times of financial crises, and Hypothesis 2, which suggested that the effect is lesser among acquired foreign units than among greenfield subsidiaries.

Robustness tests

We performed a number of tests to check the robustness of the overall results. To explore the potential effect of applying different time lags between date of patent application and the granting of patents, we reran the main model based on a one-year rather than two-year lag during the period up until the Second world war, and also tried a model including a one-year lag throughout the entire period, without any changes to the main results. As before, technological exploration was

significantly lower for periods affected by financial crises, while the results for all of the control variables remained unchanged. We further ran tests which shortened the carry-over period of financial crises to one-third of the period until the onset of the next crisis; this did not have any significant effects on any of the main results.

In an additional robustness test, we relaxed the assumptions about crisis homogeneity. We specifically explored if the financial crises connected to the First and Second world war and other financial crises would have differentiated effects on the sample firms' technological exploration. The turmoil connected to the two wars could be expected to have significantly severe effect on the firm's operations, and in some cases firms may also have been forced to re-structure and re-direct their activities toward new and previously untried products and technologies. To test for a differentiated effect, we created separate dummies for *wartime crisis* and *crisis*, and re-ran the models. The results showed negative effects on technological exploration for both types of crises, but the negative effect did not turn out to be statistically significant for *wartime crisis*.

We also ran models that excluded either one of the *internal network* and *technological diversity* variables and tested models that excluded either *GDP* or *U.S. subsidiary*. We finally replaced the *industry* dummies with firm dummies. None of these alternative model specifications had any significant effects on the main results.

While the classification employed by the U.S. Patent Office suggest that patents belonging to the same class of technology draw upon similar technological capabilities, movement into new classes of technology may in some cases represent entry into rather closely related technologies, while in others it represents a more significant deviation from already established technological capabilities. To capture these qualitative differences in technological relatedness, we recoded the data and examined entry patterns at the level of 56 broader fields of technology (Cantwell and Andersen, 1996). Although we did not have any specific hypotheses about the extent to which the results would differ from those at the level of classes, any detected movements into a new field of technology would more likely reflect exploration rather than mere exploitation. The results from analyses at the level of 56 fields of technology, which reduced the overall number of observed entries by 65 percent and observed entries among foreign units by 80 percent, turned out to be fully consistent with those received at the level of patenting classes.

Post hoc analyses

We conducted an additional set of analyses to probe deeper into the financial crisis mechanisms and effects. One specific aim was to explore how operational aspects may have moderated the effects of crises on the sample firms' propensity to enter into new technologies. As more fine-grained data for the complete sample and window of observation was scarce, we opted for running a detailed analysis on the so-called dot com bubble. The bursting of the bubble was a severe, global stock market crisis during the years 2000–2002. In the United States, for example, firm market value on Nasdaq plummeted from 6.7 trillion to \$3.2 trillion, and in the Dow Jones Composite Internet Index, which on March 10, 2000 closed at 509.84 at one point stood 84 percent lower (Cassidy, 2002).⁶

As a number of the original sample firms were involved in major mergers or acquisitions either in the years before or after the year 2000, to strengthen comparability of observations before and after the crisis years, the sample for analyses of the dot com crisis was reduced to seven firms: Atlas Copco (pneumatic and hydraulic equipment), Electrolux (white goods, home appliances), Ericsson (telecommunication

equipment), Sandvik (specialty steel and metals, hard materials), SCA (pulp and paper), SKF (ball and roller bearings), and Trelleborg (rubber products, conglomerate).

The same type of analysis that was applied to the full sample over the entire window of observation, but now restricted to the smaller sub-sample and limited only to the dot com financial crisis, produced very similar results (the full results are reported in Online Appendix A). In line with the previous results, the overall effect of the dot com crisis was a statistically significant reduction in the likelihood of entering into new classes of technology.⁷

To further explore how the operational effects of the crisis may be connected to the propensity to enter into new technologies, we introduced a time-varying measure of yearly percentage point increases or decreases in total sales and total number of employees as indicators of the impact of the crisis on the sample firms' technological exploration. Because of the lag between the date of patent application and the granting of a patent, as before, we lagged the effects of these changes by two years (for example, the analysis and effects of changes in the number of employees in 2004 would not be detected in observed patenting until 2006).⁸ The specific aim was to test how the impact of the dot com crisis may be moderated by the extent of real operational effects among the sub-sample firms. The results from the analyses (the full results are reported in Online Appendix B) indicate that firms among which the operational effects of the financial crisis were more substantial were also those that reduced their technological exploration the most. While these results are not statistically significant ($p < 0.10$ in the case of changes in total number of employees), they are suggestive of how firm-specific and contextual factors, many of which remain unaccounted for in the present study, may amplify or attenuate fundamental managerial threat-rigidity responses during times of perceived financial crisis.

Discussion

We set out to answer two interrelated questions pertaining to MNC technological exploration and its relationship to financial crises. Allowing threat-rigidity theory to inform literature on the evolution of the MNC, we argued that financial crises set in motion processes that result in the reduction of technological exploration, and that the effect will differ between greenfield foreign subsidiaries and acquired foreign units. In line with our expectations, the empirical evidence confirms a decrease in the likelihood of MNC technological exploration during times of financial crises, and also that the effects of financial crises on technological exploration are moderated by type of foreign subsidiary.

Our findings suggest that during crises management centralizes decision making to headquarters and the home country, which is where the majority of technological activities and exploration efforts take place. This is also where the most sizeable reduction of technological exploration takes place. While the onset of crises is likely to be accompanied by concerted efforts to control and constrict technological activity also among the foreign subsidiaries, our results suggest that such efforts are of limited effectiveness. A relative lack of headquarter information about foreign operations (Ciabuschi, Forsgren and Martín, 2011), foreign unit resistance to increased headquarter control (Blomkvist et al., 2012), and also the difficulties of communicating and managing

⁷ The overall effect of the dot com crisis was similar across the seven sub-sample firms. Six of the companies experienced a reduction in the number of entries into new classes of technology, and in four of these cases the reduction was statistically significant ($p < 0.05$). As expected, the effect was particularly visible in the case of Ericsson in the IT industry, where the number of new entries per year was reduced by 60 percent during the crisis years (a reduction from on average three entries into new classes of technology during non-crisis years to just above one during the crisis years).

⁸ The availability of financial and operational data shortened the measurable period preceding the dot com crisis by two years.

⁶ In Sweden and many other countries, developments were similar. In the spring of 2000, the general stock index in Sweden fell by 20 percent in six weeks, with Ericsson (one of the sample firms) spearheading the decline.

operations across cultural and geographical distances are some of the factors that may limit the effectiveness of centralized control over foreign subsidiaries.

Although sustained technological exploration among acquired foreign units may be an unexpected outcome of threats such as global financial crises, it is suggestive of how geographically dispersed and differentiated technological capabilities can help MNCs smoothen the long-term effects of recurrent and relatively prolonged droughts of technological exploration. It has long been recognized that foreign units can make unique and important contributions to the technological development of the multinational group (Cantwell and Mudambi, 2005; Kuemmerle, 1997). Our findings provide evidence that sustained technological exploration among acquired foreign units may cushion the MNC group from the otherwise stalling effects of financial crises, thereby setting the stage for a comparatively rapid return to growth and expansion during periods of normal economic activity. Such dynamics and balancing of exploitation and exploration are unavailable to firms that have to absorb the shocks of global financial crisis within geographically confined locations (Archibugi, Filippetti and Frenz, 2013; Filippetti and Archibugi, 2011; Paunov, 2012).

Overall, the results confirm the notion of MNCs as differentiated organizational systems, including differentiated technological capabilities (Cantwell and Mudambi, 2005) and asymmetric knowledge flows within the multinational group (Blomkvist, Kappen and Zander, 2019), which ultimately affect degrees of headquarter attention and control over foreign subsidiaries (Belenzon, Hashai and Pataconi, 2019). Our findings particularly point to the special roles played by foreign acquired subsidiaries, which combine an outsider status within the MNC with an unusual potential of opening up new technological trajectories for the multinational group (Blomkvist et al., 2014, 2019). Studies on the structures and dynamics of the MNC should take these particular characteristics into account, and to the extent it is possible distinguish and separate between greenfield and acquired subsidiaries in future conceptual and empirical work.

Limitations

Several important limitations to this study must be kept in mind. We draw on a limited sample of Swedish MNCs, whose experiences and responses during financial crises may not reflect those of MNCs of other national origin. We know that our results are not sensitive to the presence of any single outlier firm, but they must be corroborated by larger-scale studies that also include MNCs of a wider variety of countries of origin. It would nevertheless be reasonable to assume that responses to financial crises are somewhat similar among large and internationally active firms and that the tendencies in the currently observed effects on technological exploration may be found also among a good number of other MNCs.

It is further inherently difficult to establish and find consensus about the definition and extension of financial crises. We have drawn on the work by Bordo et al. (2000, 2002), which usefully covers an extensive period of economic activity, but the adoption of other classifications of crises may nevertheless produce different results. Studies on the effect of recessions suggest that periods of economic decline may be associated with enhanced technological exploration. Manso et al. (2021) find a positive correlation between recessions and technological exploration, measured as the fraction of patents in new classes of technology relative to patents in classes already known to the firm. Although crisis effects likely differ from those at play during periods of general economic decline, the combined results could suggest that during periods of financial crisis MNCs narrow the scope of technological exploration, while at the same time intensifying their activity in those relatively few

classes of technology that are selected for future investments. In other words, during times of financial crisis MNCs would become “thin but tall”, i.e., reduce their technological exploration and entry into new classes of technology but in those classes that are indeed entered make substantial efforts to make the associated technologies work for the future.

Finally, it has been assumed that the global repercussions of U.S. financial crisis are equally distributed, but it could be the case that at the country or regional levels the ripple effects are of systematically different magnitudes and managerial consequences (Coombs and Laufer, 2018), and, for a number of different reasons, may also differ from one crisis to another. To explore how among the sample firms the effects of global crises on technological exploration may differ at the regional or country levels is beyond the scope of this paper.⁹ As other evidence on market interdependencies suggests (Eun and Shim, 1989), it is reasonable to expect that financial crises unfolding in the U.S. economy will have an overall, non-negligible effect on the operations of MNCs with exposure to a large number of foreign markets.¹⁰ This would particularly be the case if, as in the current study, the MNCs have originated from home markets of limited size and have a long history of international business operations.

Summary and conclusions

Drawing on threat-rigidity theory, we have investigated how global financial crises over the 1890–2008 period have affected home-country and international technological exploration in a sample of 21 MNCs. Our findings show that financial crises have an overall negative effect on the firms’ technological exploration, in this study defined as entry into classes of technology that are new to the multinational group. We have further shown that the strength of the effect differs across greenfield and acquired foreign subsidiaries. Specifically, the dampening effect of financial crises on technological exploration is confined to home-country units and greenfield subsidiaries, whereas it is found to be of less significance among acquired foreign subsidiaries. We suggest that such differentiation within the multinational group is indicative of a previously unobserved advantage from multinationality, which allows the MNC to smoothen the effects of financial crises on long-term technological development and corporate growth.

Our study adds new knowledge about how global financial crises influence technological exploration among MNCs, which in many economies play a central role for innovation and long-term economic development. Further research on how MNCs weather the storms of financial crises, looking deeper into internal organizational structures and processes of internal communication and control, can add important pieces to our understanding of the dynamics of those recurring cycles of economic shocks and recovery that are characteristic of the global economy.

Precise *p* values, standard errors within parentheses.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jwb.2022.101416](https://doi.org/10.1016/j.jwb.2022.101416).

⁹ We ran models that included controls for either geographical area or country location of foreign units, but found no significant effects on the main results.

¹⁰ It could be the case that the international importance of developments in the U.S. market became particularly strong after the Second World War, partly as an effect of increasingly integrated financial markets. We performed tests that were restricted to only the post-1945 period, which produced results that were fully in line with those reported in Table 3.

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