The Restructuring of Dynamic Capabilities through Corporate Expansion

Abstract – This paper analyses the restructuring of dynamic capabilities subsequent to M&A-based corporate expansion in large industrial enterprises with a substantial technological knowledge base as measured by patents. We distinguish between technology-driven acquisitions, in which technology is reported as a motive of the expansion of the acquiring firm, and market-driven acquisitions, in which product market relatedness is a motive for the expansion of the acquiring firm. We develop and test a conceptual framework relating technology-driven and market-driven corporate expansion to changes in the composition of corporate technological capabilities. We find that in technology-driven acquisitions technological relatedness increases in inter-industry expansions, and in more recent expansion strategies. In contrast, in the case of market-driven acquisitions, we find a reduction in technological relatedness when establishing the broader product combinations associated with inter-industry expansion. Hence, distinct patterns of innovation behavior are associated with each strategy for corporate expansion.

1. Introduction

Dynamic capability theory has called attention to distinct paths for capabilities in explaining heterogeneous corporate performance (Teece *et al.*, 1997; Teece, 2007). It has also been recognized that external corporate expansion can be a short cut to acquiring key new competences (Zollo and Winter, 2002; Belderbos, 2001; Dushnitsky and Lenox, 2005; Helfat *et al.*, 2007). Within this theoretical framework, this paper investigates transformations in the dynamic capabilities of firms at times of major new departures in their technological competence base, which, we contend are often associated with important merger and acquisition (M&A) deals in order to achieve a more rapid transition to new areas of capabilities.

Extant literature has investigated the acquisition of technological capabilities through external corporate expansion, when that is driven by technology-based motives (Ahuja and Katila, 2001; Cloodt *et al.*, 2006; Cassiman *et al.*, 2005). However, the accumulation of new areas of corporate technological capabilities may occur either as the intended result of a direct strategy for technological diversification in the firm (Granstand and Sjölander, 1990; Granstrand *et al.* 1997), or as the indirect and sometimes unintended outcome of a strategy for market diversification or consolidation in the product range of firms (Nerkar and Roberts, 2004). The product diversification of firms is closely related to the achievement of stronger economies of scale and joint production (Chandler, 1990; Caves, 1989, Röller *et al.*, 2001), which may coincidently entail the development or acquisition of new lines of technological capabilities. It has also been shown that if the extent of knowledge relatedness between firms is either too close or too distant, this may hamper the acquisition of technological capabilities and innovation performance (Barlett, 1993; Kogut and Zander, 1992). Several studies on strategic technological partnerships (Mowery *et al.*, 1998; Nooteboom, 1999; Nooteboom *et al.*, 2007) and M&A deals (Ahuja and Katila, 2001; Cloodt *et al.*, 2006) support this inverted U-shaped relationship between partner technological relatedness and the innovation performance of collaborative ventures. Yet market-driven corporate expansion may be less concerned with an appropriate matching of related technological capabilities than in the case of technology-driven expansion.

Previous empirical research has also documented both positive (Ahuja and Katila, 2001; Cassiman *et al.*, 2005) and negative (Cloodt *et al.*, 2006) effects on capability accumulation of technology-driven external corporate expansion. This raises the issue of the composition of new technological capabilities that are accumulated by firms in the immediate aftermath of major technology-based M&A deals. We would expect that because technological search tends to be localized and path-dependent, corporate strategies for the accumulation of new technological capabilities may typically take the form of the acquisition of related technological expertise (Nelson and Winter, 1982; Teece *et al.*, 1994; Nerkar and Paruchuri, 2005). Another feature of corporate technological trajectories that is commonly recognized in recent times is the acquisition of capabilities in the fastest growing and most pervasive general purpose technologies that are relevant in many industries (and most notably information and communication technologies, ICT) (Freeman and Louça, 2001; Gambardella and Torrisi, 1998; von Tunzelman, 1995).

Within this context, we distinguish here between two routes for corporate expansion. First, firms may move from established capabilities into technologically related or otherwise allied areas of capabilities. Second, firms may move from some established product markets into related markets, or areas in which joint production and distribution are more efficient. When these expansion strategies are pursued through M&A deals we can say that these deals are respectively either technology-driven (Graebner, 2004) or market-driven (Vermeulen and Barkema, 2001), according to whether the M&As are motivated by the first kind of strategy or the second (or occasionally by both). The central question we ask is whether, when firms are accumulating major new technological capabilities, the acquisition of ICT and related technological competences is differently motivated in technology-driven, as opposed to market-driven types of external expansion.

2. Conceptual framework

Our conceptual framework, as summarized in Figure 1, holds that external corporate expansion strategies may aim to achieve product market relatedness (market proximity) or to obtain resources that confer technological relatedness (technological proximity), which we have labeled as technology- and market-driven respectively, in the columns of Figure 1.

The different implications of technology-driven and market-driven motivations for corporate expansion can be examined in terms of variations in the technological outcomes of business integration conducted across different product distances (that is, whether integration occurs within or between industries), and in terms of changes in the nature of business integration processes that have been observed in recent times, as illustrated in the rows of Figure 1. Consideration of this latter influence is called for because over the past thirty years, strategies for corporate expansion have undergone quite substantial changes with the rise of a more knowledge-driven economy. The patterns of what constitute (or do not constitute) related technological capabilities have undergone changes as a result. In response firms have been increasingly experimenting with new kinds of business combinations to establish the extent of their relatedness. They have also been diversifying away from some business combinations that often went together historically. Thus, for example, chemical and pharmaceutical businesses were frequently combined in the past, whereas now in the era of biotechnology they are more often conducted separately. In addition, the increasing role of ICT has facilitated certain new kind of business combinations that would not have been feasible in the past. As a result of these distinctions between alternative paths of corporate technological accumulation, the impact of business integration on the composition of technological specialization is likely to differ in each case.

We can illustrate the alternative strategies for corporate coherence with reference to the accumulation of related or ICT technological capabilities. In the case of moving into related technological capabilities, technology-driven expansion is designed to establish over time such new areas of relatedness (Cell 2), while market-driven expansion may often require a rationalization of technological relatedness in the case of cross-industry integration (Cell 3). In the case of acquiring new ICT capabilities, in technology-driven corporate expansion the objective is to further extend the range of corporate technological relatedness in cross-industry integration (Cell 1), while in the case of market-driven expansion the objective is more generally to increase over time the efficiency of joint production and in the systems for distribution of combinations of related products (Cell 4).

In the next sub-section, we further develop these contentions, and formulate empirically testable hypotheses that correspond to the arguments associated with each of the four cells of Figure 1.

Development of hypotheses

Following the conceptual structure provided in Figure 1, we develop four hypotheses that relate strategy for corporate expansion to the impact upon the composition of capability accumulation. As outlined above, we examine the effects of technology-driven and market-driven strategies respectively in the cases first of business integration across industries (over greater product distance) and then in the case of business integration in more recent times (as opposed to thirty years ago). The specific details of these four hypotheses are set out in Figure 2.

Technological search and expansion tend to be localized (Nelson and Winter 1982; Rosenkopf and Nerkar, 2001; Rosenkopf and Almeida, 2003; Antonelli, 2008). However, the degree of localization may vary and it has been argued that firms are increasingly multi-technology in character. This multi-technology form of the corporation may owe to an increasing relatedness between technological fields (Gransrand and Sjölander, 1990; Granstrand *et al.* 1992; Granstrand *et al.*, 1997; Brusoni, *et al.* 2001; Teece *et al.*, 1994). One way of thinking about this would be to distinguish between technologies that are core to a firm's industry and those that lie outside the core but are related to it (Patel and Pavitt, 1998). Thus, highly localized expansion occurs when moving between one field and another within the core fields of the relevant industry. Less localized expansion typically takes the form of moving between one field of capabilities within the core and another that is related but outside the core areas of the industry (Nerkar and Roberts, 2004; Stuart and Podolny 1996; Tripsas and Gavetti 2000). While expansion within a firm's primary industry will typically be of the first kind, expansion into other lines of business is more likely to involve the second.

It has been argued that ICT capabilities provide a means for combining formerly separate areas of technological endeavor (Kodama, 1992). In this context, ICT is akin to a branch of technology that is pervasive across industries (Kodama, 1992; Freeman and Louça, 2001; Gambardella and Torrisi, 1998; von Tunzelmann, 1995), and is selectively establishing new areas of technological convergence between industries (Arora and Gambardella, 1990; Bresnahan and Gambardella, 1998; Lipsey *et al.*; 1998). Hence, when establishing links between related fields outside the core as opposed to between fields within the core, investments in ICT capabilities are especially likely to be effective. In the case of technology-driven business integration across industries the outcome is likely to be increased investment in ICT and technologies that are most closely related between the industries in question (Figure 2, Cell 1).

H1: In technology-driven inter-industry deals, there is likely to be an increased specialization in ICT and related technological fields.

Another facet of the recent multi-technology corporation has been the need to move away from historically received patterns of technology relatedness to attempt to establish newly emerging areas of relatedness. This again implies that over time firms have been increasingly experimenting with combinations of their core fields of endeavor with related fields that lie outside the core. In more recent times, technological search strategies have thus become less strictly localized and more likely to range beyond capabilities in core industry activities into fields that are related to these but remain outside the core. This implies that firms are increasingly experimenting with new combinations of related technological activities. In order to achieve such new combinations, firms have become more reliant on accessing external capabilities through a more open structure for innovation development (Arora, *et al.*, 2001; Chesbrough and Kusunoki, 2001; Hagendoorn and Duysters, 2002; Rosenkopf and Almeida, 2003; Chesbrough *et al.* 2006; Laursen and Salter, 2006; Cassiman and Veugelers, 2006). In addition, the growth of the externally networked multi-technology corporation can be attributed to the increasingly systemic and complex character of innovation (Patel and Pavitt, 1997 Fleming and Sorenson 2001). Thus, over time, technology-driven business integration has come to be increasingly inspired by greater technological convergence across formerly separate areas of activity, leading to a rising experimentation with potential new combinations, and by a recognition of the more systemic character of technological development in recent times (Figure 2, Cell 2).

H2: In more recent technology-driven deals, there is likely to be an increased specialization in related technological fields.

In market-driven corporate expansion, it is known that diversification tends to be more successful where products are related to one another (Rumelt, 1974, 1982; Teece, 1980; Markides and Williamson, 1996; Farjoun, 1998). However, the technological capabilities required for related products may or may not be related in terms of their technological characteristics. Economies of scale are achieved through the combined use of facilities in common systems of production and distribution, such as in Singer's integrated production and distribution of sewing machines and sewing machine cabinets (Teece *et al.*, 1994). In the case of inter-industry expansion (as opposed to a more focused expansion of the product range within a firm's own primary industry), it is likely that related technological capabilities will undergo rationalization (Hitt *et al.*, 1991). Instead, firms will tend to place greater emphasis on investments in the joint production and distribution systems that facilitate the relevant market combinations. Market-driven inter-industry M&A deals are likely to be associated with a rationalization of related technological capabilities in the context of joint production and distribution across formerly separate industries (Figure 2, Cell 3).

H3: In market-driven inter-industry deals, there is likely to be a reduced specialization in related technological fields.

As market-driven deals have evolved over time, just-in-time systems and similar organizational innovations have become increasingly important in conferring benefits from joint production and distribution of products formerly in different industries (Chandler, 1977, 1990; Nooteboom, 1999; Hennart, 1991). Such deals have also been associated with some selected convergence of markets and of production and distribution conditions. Inventory holding costs have fallen through larger and more effective systems for storage, transportation and distribution of related activities (Monteverde and Teece, 1982; McCann, 1998). Moreover, firms have developed an ability to better manage larger scale and more distant operating systems through the use of ICT (Langlois, 2003; Feinberg and Keane, 2006; Keane and Feinberg, 2007). Accordingly, market-driven types of expansions have evolved over time to become increasingly reliant upon complementary investment in ICT capabilities and in the capabilities for managing common production and distribution systems across related lines of business (Figure 2, Cell 4).

H4: In more recent market-driven deals, there is likely to be an increased specialization in ICT.

3. Data Construction and Methodology

Corporate knowledge base

So far, we have advanced some propositions about the composition of the process of restructuring of the corporate knowledge base following a substantial M&A-associated corporate expansion. In testing our hypotheses a key issue is the measurement of the distribution of this corporate knowledge base. We argue that a firm's patent portfolio provides a suitable means to this end, at least for the largest industrial firms. This approach is consistent with that of others that have examined firms' technological capabilities (Stuart and Podolny, 1996; Ahuja and Katila, 2001; Rosenkopf and Nerkar, 2001).

A patent represents a contribution towards new knowledge creation. A firm's patent portfolio reflects the accumulated knowledge developed by the firm over time (Jaffe, 1984; Patel and Pavitt, 1991; Mowery *et al.* 1998). The patents owned by a firm measure its efforts in knowledge creation and, accordingly, they provide an indirect input measure of the fields in which corporate technological capabilities are established in order to make such knowledge operational (Pavitt, 1985, 1988). In line with the evolutionary approach to technological change (Nelson and Winter 1982), this interpretation emphasizes the significance of gradually assimilating newly acquired knowledge into tacit capabilities that are embodied in best practices in some given fields, and which areas of advantage for a given firm can then be sustained and reproduced over time through a localized firm-specific learning path of a cumulative and incremental kind.

Dataset Construction

We tested the hypotheses on a longitudinal data set derived from 25 of the world's largest firms operating in 8 industries and involved in major M&As in the period 1969-1995. The focus on world largest firms ensures availability and reliability of data and is also consistent with prior research on M&As (Hitt *et al.*, 1991, 1996). Although companies were selected partly on the grounds of their patenting size at the end of the period analyzed, the data confirms the leading position of the selected companies in patenting throughout the period in question. Thus, we believe that our investigation should enable us to draw some general conclusions (with due qualifications) on the way in which different corporate strategies emerge in different business integration contexts, that rely in part on M&As to rapidly accumulate new technological capabilities during a phase of significant restructuring. In the selection of companies, European firms were preferred to firms of other nationalities because the study was carried out within an EU project focusing on the role of M&As on R&D in Europe. Indeed, only two US companies were included among the selected firms due to their particular relevance in the industry in which they operate. If the over-representation of European firms may be a drawback for the sake of generalizability, it may be also considered as having some advantage for the purpose of a novel empirical analysis, since most of the available literature on M&As and corporate restructuring (including the restructuring of R&D) has been concerned with the US case rather than Europe (e.g. Greg *et al.*, 1988; Jensen, 1988; Hall, 1988, 1990). Moreover, with reference to the latest M&A wave the formation of the Single Market in the EU has given a great impetus to cross-border M&As within the Union, as well as encouraging European-owned firms involvement in M&As in the US and developing countries (UNCTAD, 2000). The dataset is also constructed to ensure a balanced representation across industries, that reflects some specific areas of national technological expertise in terms of countries of origin of firms in the European case (see Table A1). The reason for concentrating our analysis on earlier corporate shifts concerning M&As antecedent to the latest wave lies mainly in the lack of data availability on actual structural breaks in the composition of corporate activity that rely on the most recent M&As (since it is too soon to observe the outcome). This explains the use of historical (the then correct) names for the companies under analysis.

The change in the composition of specialization of corporate technological profiles across fields was investigated through the use of US patent data. The use of US patent data for all selected firms, including foreign firms ensures consistency, reliability and comparability as patenting systems across countries differ in their application of standards, granting systems and value of protection granted. Several studies have shown that US patents provide a good measure of foreign firms innovative activity (e.g. Soete and Wyatt, 1983; Dosi *et al.* 1990; Basberg, 1987) and research on international samples have extensively adopted US patent data (e.g. Stuart and Podolny, 1996; Patel and Pavitt, 1997). The dataset construction has been designed to keep in mind the issues raised by the research problem addressed in this study, since births, deaths, mergers and acquisitions as well as the occasional movement of firms between industries (sometimes associated with an historical change in ownership) have been taken into account. Patents have been consolidated into corporate groups, initially on the basis of the structure of ownership of groups in 1982. Post-1982 mergers and acquisitions are mostly incorporated into the data through the practice in most groups of centralizing the patent application procedure in the parent company. In other important cases of mergers and acquisitions affecting the ultimate ownership of significant numbers of patents, the change in ownership structure is incorporated into the organization of the data, which involves in some cases the creation of a new corporate group and, in others, the expanded consolidation of groups with newly acquired subsidiaries.

For each of the 25 companies, annual patenting activity was considered from 1969 through 1995, and for each firm the periods of the sharpest increases in patenting were identified. Within each corporate patenting portfolio, for each substantial rise in patenting activity an 8-year period was identified, consisting of two sub-periods of 4 years each (before and after the patenting break under consideration). The selection of this time period for measuring a firm's knowledge base before and after an external acquisition was also adopted in previous studies (e.g. Ahuja and Katila, 2001). A patent growth rate between the two 4-year sub-periods was then calculated. Therefore, in the econometric analysis, for each firm we considered the 8-year period that yielded the highest growth rate for that firm, provided the firm had at least 50 patents in each of the 4-year sub-periods. For each sharp structural patenting break it is possible to identify specific M&A deals that contributed to the observed breaks. This way of proceeding is consistent with our research aim, since we are not concerned with the impact of (all) M&As in general on corporate patenting activity. Rather, our interest lies in the analysis of M&As that were conducted in a specific context, namely that quite small subset of M&As which have been part of an observed strategy to significantly transform the structure of the acquiring firm, and that have been of sufficient importance to have produced noticeable effects on the technological profiles of the firms involved. M&As are surely only one part of the transformational activities undertaken at such times of structural change that contribute to structural breaks in patenting. Indeed, we have no way of establishing precisely how much those deals contribute relative to the other factors that may be involved in each case — such as inter-firm alliances, purely internal transitions, and so forth, the significance of which will vary across our cases in ways we are unable to establish precisely (since an in depth case study approach lies beyond the scope of our analysis here). However, although M&As are only a part of a wider process, they are a *necessary* part, on the grounds that they are the only means of obtaining relatively sharp structural increases in activity and the addition of new lines of activities in a short period of time. M&As are here defined as the purchase of the majority of a company's capital by another company, although this very often involves deals to transfer some subsidiary or division of a larger corporate group and not just a change in the ownership of the group as a whole.

Three main types of data sources were used to identify the M&As that contributed to the observed breaks in patenting and to collect information on these deals: (1) international business press (e.g. *The Economist*, *Financial Times*, *Wall Street Journal*), (2) technical publications (e.g. *Industry Reports, Moody's manual series*) and (3) specialized databases (e.g. *Hoover's Company database*, *International Directory of Company Histories*, *Macmillan Directory of Multinationals*, *Mergent database*, *Investment Dealers' Digest Mergers and Acquisition Database*, *Who owns whom*, *Il Sole 24 ORE database*). Possible drawbacks and limitations of this method of information gathering (mainly due to the fact that newspaper and journal reports are likely to be incomplete) have been addressed by adopting meticulous cross-checking procedures. In collecting this information, the location of the corporate unit acquired or sold (rather than the nationality of the parent company from which it might have been acquired) was compared with the main country of origin of the post-M&A increase in patenting. For instance, in the case of ICI (UK) the structural break in the corporate portfolio was associated primarily with a rise in patenting activity in Belgium. Thus, the relevant acquired unit that was traced was Société Européenne des Semences (SES) located in Belgium, but previously owned by Eridiana whose headquarters are in Italy.

The two key M&As motives identified (i.e. *market* and *technology*) are operationalized by classifying M&As as *market*-driven and/or *technology*-driven. The two motives are classified independently from one another so to allow that corporate expansion strategies may sometimes combine these two elements rather than regarding them as strictly alternative to one another. This distinction of motives is intended to capture corporate strategies that draw upon *product*-related diversification and *technology*-related diversification, respectively. To identify technology-driven (T-driven) M&As, we drew on the methodology of Ahuja and Katila, (2001). We adapted the Ahuja and Katila (2001) criteria for technology-based M&A deals, which included as technological acquisitions all deals in which technology was reported as a motive in news stories, or in which the acquired firm had been granted any US patent in the five years prior to the acquisition. However, their purpose was to identify, among a large sample of many M&As, any deals in which the acquired company had some significant technological assets. Instead, we are examining alternative paths of corporate technological development in circumstances in which there was an important acquisition of a company that had some significant prior technological capabilities. Therefore, we were more concerned with the motives of the acquiring company than with the presence or absence of technological assets in the acquired firm, since such assets were always present in our case. Thus, we restricted ourselves to the first of the two criteria, namely where there was mention of a technology-based motive in news stories about each deal. In addition, we could not rely on patent data to identify technology-driven M&As, since patent measures cannot be computed if only a division of a firm is acquired rather than the complete entity, and this applies to most of the acquisitions that we are considering. To identify market-driven (M-driven) deals we examined the information provided by our data sources to establish if the acquiring and acquired firms operate in the same or in a complementary market, or not. T-driven deals account for 16 out of the 25 deals, consisting of those that were intended to support technological diversification to enable firms to create new innovative combinations, generating higher rates of innovation, and thus yield *dynamic economies of scope*. M-driven M&As account for 13 out of the 25 deals, in which M&As substantially increased the product economies of scope of the acquiring or merging firms involved. Four out of the 25 deals are classified as both market- and technology-motivated. These overlapping cases involve three intra-industry deals and a deal between firms operating in closely related industries (see Table A2). In these four cases, acquiring firms were targeting firms operating in the same or complementary markets, and technology-based motives were also reported in news stories.

For each of the 25 deals, Table A2 reports the focal firms and their industry of output, the target firm identified, and distinguishes between T- and M-driven M&As, some selected characteristics of the deals as well as the exact year of the structural break in the number of patents, the year of the deal, the rate of growth of patents and the number of patents of the acquiring firm in the first 4-year sub-period considered.[i] The two sets of differently motivated deals are discussed in the Appendix.

Variable definition and model specification

Dependent variable

The dependent variable measures corporate technological specialization in any given technological field through the use of patent data. Patents have both strengths and limitations as a measure of technological capabilities. First, they are related to innovativeness since they are granted when the criteria of novelty, usefulness and non-obviousness are satisfied (Walker, 1990). Second, they have been recognized to represent validated measures of *technological novelty* (Griliches, 1990). Third, they have an economic significance since they confer property rights upon the assignee (Kamien and Schwartz, 1982; Scherer and Ross, 1990). Moreover, the detailed cross-field structural information offered by this indicator provide us with insights suited to our research purpose. Patents also have several drawbacks. Not all inventions are patented, not all inventions patented become innovations and the inventions that are patented differ greatly in their economic value (Cohen and Levin, 1989; Grilichies, 1990; Trajtenberg, 1990). In the context of our study, the major drawback of using patents as a proxy for technological capabilities lies in the different propensity to patent across industries (Scherer, 1983). This problem might be overcome by restricting the analysis to a single industry. However, relative measures, such as the (adjusted) revealed technological advantage (RTA) index first used by Soete (1987), provide an acceptable alternative solution to this problem.

Thus, technological specialization was proxied by the RTA index of each of the 25 focal firms calculated across 56 technological fields (see Table A3), relative to other large firms in the equivalent industry. Hence, for each of the 25 focal firms the index is defined as follows:

$$RTA_{ij} = (P_{ij}/\Sigma_i P_{ij})/(\Sigma_j P_{ij}/\Sigma_{ij} P_{ij}) \tag{1}$$

where P_{ij} is the number of patents attributed to firm i in the technological field j. Thus the index shows the specialization of firm i in field j relative to other firms in the same industry, the denominator being summed over all the largest firms in the relevant industry, and not just the 25 focal firms that are here the subject of particular investigation.[ii] For each of those 25 firms, the index was calculated for each 4-year sub-period (representing respectively the phases before [RTA_{ijt-1}] and after [RTA_{ijt}] the sharp structural break in patenting related to a specific M&A deal). In order to normalize the index (which would otherwise vary between 0 and $+\infty$ and so have a lower but no upper bound), for each of the two sub-periods we calculated an adjusted RTA (*adjRTA*) index as follows:

$$adjRTA_{ij} = (RTA_{ij} - 1)/(RTA_{ij} + 1) \tag{2}$$

This adjusted index varies between –1 and +1. Positive (negative) values denote a comparative technological advantage (disadvantage) of the firm in the field in question relative to the other largest firms in the equivalent industry. Our dependent variable was then specified as follows

$$\Delta TECHSPEC_{ij} = 1 + (\Delta adjRTA_{ijt} / (adjRTA_{ijt-1} + \mu_{adjRTA\ ijt-1}))$$

$$= (adjRTA_{ijt} + \mu_{adjRTA\ ijt-1})/(adjRTA_{ijt-1} + \mu_{adjRTA\ ijt-1}) \tag{3}$$

which serves as a proxy for the change in corporate technological specialization of firm i in field j between the 4 years before (t-1) and the 4 years after (t) the structural break in patenting considered. To avoid division by zero, the mean value ($\mu_{adjRTA\ ijt-1}$) is added to *adjRTA* to obtain the expression denoting the change in *adjRTA*. Since the mean value is roughly 0.2, $adjRTA_{ijt-1} + \mu_{adjRTA\ ijt-1}$ ranges from about 0.2 to 2.2.

Independent variables

To examine the restructuring of firms dynamic capabilities subsequent to M&A-related corporate expansion in different business integration contexts, a series of covariates were included in the model. In order to construct these covariates, we firstly considered contingent characteristics of the M&A deals, and classified the US patents held by acquiring firms into 56 technological fields which represent groupings of related patent classes and sub-classes.

Two contingent characteristics of each M&A deal associated with a major rise in patenting were taken into account: 1) whether the industries in which each of the prospective partners operated were different or the same (i.e. whether deals were inter- or intra-industry), and 2) the M&A wave in which the deal occurred (i.e. whether it was in the 1970s or 1980s). For each of the 25 firms, these characteristics were then translated into two binary variables: I_i equals 1 if the deal involving the focal firm i was inter-industry, 0 otherwise; and W_i equals 1 if the deal involving the focal firm i occurred in the later 1980s M&As wave, 0 otherwise.

For each of the 25 firms, the 56 technological fields were further aggregated into one of the following broader categories: a) ICT (*ict*) technological fields, comprising communications and computed related areas[iii]; b) *core* (*c*) technological fields, being those most directly linked with the firm industry's *core* products (e.g. chemical technologies for firms in the chemical industry); and c) *related to core* (*rel*) technological fields of the firm's industry, which were identified through a two step procedure. First, a technological relatedness measure was constructed following the procedure of Teece *et al.* (1994). More specifically, for each industry I, technological relatedness (R_{jc}) between each technological field j (excluding the *core* and the ICT fields) and each of the c technological fields *core* to the industry in question was calculated as follows:

$$R_{jc} = n_{jc} - \mu / \sigma, \qquad \text{where } j \neq c \tag{4}$$

where n_{jc} is the actual number of linkages defined in terms of the number of the world's largest industrial firms in industry I that were granted patents in both j and c (that is, the number of times j and c occur together across firms in industry I); μ is the expected number of linkages in industry I; and σ is the standard error of the expectation (for a more in-depth discussion see Cantwell and Noonan 2001). Second, for each field j we took the mean of the relatedness values across all *core* fields c in that industry (μ_{Rjc}). The criterion adopted to identify the fields that occurred together with the *core* areas more frequently than if technological combinations occurred purely randomly required that $\mu_{Rjc} > 0$ or $R_{jc} > 0$ for at least 50 % of the *core* fields across which the mean value was calculated.

In order to examine the dominant trends in the changing patterns of technological specialization in each of the T-driven and M-driven business integration cases, each of the broader technological groupings just described was in turn interacted with the two M&A characteristics outlined earlier, and a series of explanatory variables was obtained through this procedure. More specifically, to capture the effects of various aspects of T- and M-driven M&As on the accumulation of technological capabilities in the context of business integration across industries (i.e. over product space), the following independent variables were deployed:

- $Iict_{ij}$ is set equal 1 if the deal involving the focal firm *i* occurred between firms operating in different industries and if *j* is an ICT field, 0 otherwise;
- Ic_{ij} is set equal 1 if the deal involving the focal firm *i* occurred between firms operating in different industries and if *j* is a core field in the primary industry in which *i* operates, 0 otherwise;
- $Irel_{ij}$ is set equal 1 if the deal involving the focal firm *i* occurred between firms operating in different industries and if *j* is a field related to the fields of the primary industry in which *i* operates, 0 otherwise.

To capture the restructuring of technological capabilities in T- and M-driven M&As in the context of business integration in different periods (i.e. a change in integration processes in the more recent phase) the following explanatory variables were included:

- $Wict_{ij}$ is set equal 1 if the M&A involving the focal firm *i* occurred in the 1980s and if *j* is an ICT field, 0 otherwise;
- Wc_{ij} is set equal 1 if the M&A involving the focal firm *i* occurred in the 1980s and if *j* is a *core* field in the primary industry in which *i* operates, 0 otherwise.
- $Wrel_{ij}$ is set equal 1 if the M&A involving the focal firm *i* occurred in the 1980s and if *j* is a field related to the *core* fields of the primary industry in which *i* operates, 0 otherwise.

Controls

In order to control for potential differences in the nationality of ownership of partners, we also took into account the geographical spread of the deal by including a variable (C_i) equal to 1 if the deal involving the focal firm *i* was a cross-border M&A, 0 otherwise. It has indeed been recognized that locational heterogeneity provides critical opportunities, which have increasingly became central to corporate business strategy (Ghemawat, 2001; Ricart *et al*,. 2004; Ghemawat and Ghadar, 2006).

Depending upon the source of variation in business integration analyzed (whether across industries rather than within them, or in recent times rather than in earlier times), a further control variable was considered. In each of the T- or M-driven cases when examining the pattern of changes in technological capabilities associated with business integration across industries, W_i was included in the model to control for the effect of more recent business integration on the entire firm's technological profile. The managerial literature investigating the M&A waves of the 1960s-1970s and the 1980s has documented that the pursuit of corporate expansion led to the rise of big conglomerates in the earlier period and to a refocusing of corporate activity upon core areas in the later period (Chandler, 1992). Research in the management field also has shifted away from a general evaluation of post-acquisition performance to an evaluation of different forms of deals such as horizontal, vertical and unrelated M&As (Hitt *et al*., 1998, Kusewitt, 1985; Capron, 1999). Therefore, in each of the T- or M-driven cases, when examining the pattern of changes in technological capabilities in the context of business integration in different periods, I_i was included in the model to control for the effects of business integration across industries on the entire firm's technological profile.

Econometric Model

The firm is the primary stratification variable so that there is a 16- and a 13-item balanced panel with 56 observations (across fields) in each stratum for the technology- and market-driven corporate expansions, respectively.

To test the pattern of restructuring of technological capabilities in T- and M-driven M&As in their respective business integration contexts, OLS regression provided the baseline model and null hypothesis estimates. These estimates were generated under the assumption that both firm-specific and technological field-specific effects have no statistically significant impact on the change of technological specialization once all the explanatory variables have been accounted for.[iv] Both a fixed effect (FE) and a random effect (RE) model were also estimated. The FE model is based on the assumption that the differences between the strata are captured by different constant terms (i.e. they differ in their conditional means), while the RE model is based on the assumption that the strata each have a different additive variance term (i.e. they differ in terms of their conditional variances).

For each of the groupings of firms that represent different types of corporate expansion, the OLS approach was tested against the fixed-effect (FE) and random effect (RE) panel estimates. In all cases, the incremental *F* test failed to accept the null hypothesis of the existence of fixed effects. Similarly, the Breusch-Pagan Lagrange Multiplier test failed to accept the null hypothesis of random effects.[v] However, while the Breusch-Pagan Lagrange Multiplier test for the RE model is highly insignificant, the incremental F test for the fixed effects model is only marginally insignificant, suggesting the possible presence of some weaker but some stronger fixed effects, with the former washing out the latter. Therefore, we abandoned the RE model specification and focused on the FE panel model specification. In order to identify the strongest (and then, the most relevant) fixed effects, for each set of corporate expansions we examined in sequence a different structure of individual unit-specific effects. We began with one-way firm-specific effects, and then proceeded to a 2-way firm- and technological field-fixed effect model specified as follows in the context of business integration across industries and in different periods respectively:

$$\Delta TECHSPEC_{ij} = \alpha_i + \gamma_j + \beta X_{ij} + \varepsilon_{ij} \quad (5)$$

$$\Delta TECHSPEC_{ij} = \delta_i + \zeta_j + \phi Z_{ij} + u_{ij} \quad (6)$$

where α_i and δ_i represent the firm fixed effects, γ_j and ζ_j are the technological field fixed effects, and ε_{ij} and u_{ij} are the residual terms. X_{ij} is a vector of the explanatory variables $Iict_{ij}$, Ic_{ij}, $Irel_{ij}$ capturing the restructuring in ICT, *core* and *related to core* technological capabilities in the context of business integration across industries and including the control variables C_i and W_i. The vector Z_{ij} refers to the explanatory variables $Wict_{ij}$, Wc_{ij}, $Wrel_{ij}$ capturing the restructuring in ICT, *core* and *related to core* technological capabilities in the context of business integration in different periods, and including the control variables C_i and I_i. This model specification enables us to control for the heterogeneity of both selected firms and technological fields.

The 2-way selected FE model was tested against the baseline OLS model. The rejection of the latter in favour of the 2-way selected FE model means that the selected firm-specific and technological field-specific effects are important in determining the change in the profile of technological specialization associated with the relevant M&A deals. In what follows, we report the two estimations for completeness – the 2-way selected FE model and OLS – but discuss the results of the 2-way selected FE estimation only.

4. Discussion of the results

For each of the technology- and market-driven cases respectively, a set of descriptive statistics and the correlation matrix are reported in Tables 1 and 2.

For the technology-driven cases the estimates of the restructuring of technological capabilities subsequent to M&A deals in the context of business integration across industries and business integration in recent times are reported in Tables 3 and 4, respectively. In technology-driven inter-industry deals the corporate technological specialization in *ICT* and *related to core* technological fields increases ($Iict_{ij}$ and $Irel_{ij}$ are significant at $p < 0.01$ and 0.05, respectively in Table 3). These results support Hypothesis 1. In the case of business integration in more recent times, corporate technological capabilities *related to the core* fields of the firm's industry have increased ($Wrel_{ij}$ is significant at $p < 0.10$ in Table 4). This supports Hypothesis 2.

For the market-driven cases, the equivalent estimates are reported in Tables 5 and 6. In market-driven inter-industry deals, corporate technological specialization decreases in technological fields that are *related to the core* fields for the firm's industry ($Irel_{ij}$ is negatively signed and significant at $p < 0.10$ in Table 4). This support Hypothesis 3. When considering business integration in recent times, in market-driven M&As corporate technological specialization increases in *ICT* ($Wict_{ij}$ is significant at $p < 0.05$ in Table 5). This supports Hypothesis 4. It can also be noted that, in the more recent period market-driven M&A deals have tended to increase specialization in technological fields *related to the core* fields for the firm's industry ($Wrel_{ij}$ is significant at $p < 0.01$). This may be because in market-driven corporate expansion investment in management and operating systems needed to combine storage, transportation and distribution in related lines of business which may require technological capabilities in fields that are related to the core fields of the firm's industry.

Cross-border M&As increase technological specialization on average in technology-driven deals, and in market-driven deals when considering more recent business integration. In these cases, C_i is statistically significant at $p < 0.01$ (see Tables 3, 4 and 6), but when considering M-driven M&As only in the context of business integration in more recent times (see Table 5). These results are consistent with research on international acquisitions, which finds that cross-border acquisitions lead to superior post-acquisition performance (Weber *et al.*, 1996; Very *et al.*, 1997), and emphasize the need to be aware of the international context so far as corporate expansion motives are concerned. In tune with much management research (Chandler, 1992), post-acquisition technological specialization has also increased in both technology- and market-driven deals in recent times, when considering business integration across industries (Tables 3 and 5). Similarly, inter-industry technology- and market-driven deals have promoted an increase in the accumulation of technological capabilities when considering more recent business integration (Tables 4 and 6). This may be read along the lines of a greater effort and ability of firms to explore new technological synergies across industries recently (Granstrand and Sjölander, 1990; Capron *et al.*, 1998; Capron, 1999; Vermeulen and Barkema, 2001), as well as the need to support a greater product-related diversification by an equivalent proportional increase in the number of technological capabilities across different industries (Chandler, 1990).

5. Conclusions and Implications for Managers

Implications for theory

In this paper, we have analysed the impact on corporate technological trajectories of two distinct modes of external corporate expansion, namely those that are technology-driven and those that are market-driven. In the case of the firms we have examined, all are large industrial enterprises with substantial technological knowledge bases as measured by patents. Therefore, in distinguishing between technology-driven and market-driven corporate expansion strategies, we are not distinguishing between the presence or absence of firm-level innovation, but rather only whether the re-organization of the firm's technological knowledge base was itself a primary motive for the expansion strategy.

The two forms of corporate expansion strategies that we have identified here are associated with the establishment of two different forms of relatedness respectively. While technology-driven expansion focuses upon the technological relatedness of existing and new capabilities, market-driven expansion focuses upon product relatedness or the relatedness of lines of business. In the case of technology-driven expansion, we find, as expected, that technological relatedness is increased through technology fusion in inter-industry expansion and technological experimentation in more recent expansion strategy. However, in the case of market-driven expansion, we find a rationalization of technological relatedness when establishing broader product combinations associated with inter-industry expansion.

Our analysis may help to qualify the nature of an inverted U-shaped relationship between firms' technological relatedness and innovation performance in collaborative or coordinated ventures (Kogut and Zander, 1992; Barlett, 1993; Mowery *et al.*, 1998; Nooteboom *et al.*, 2007) by providing an explanation for the finding of Ahuja and Katila (2001) of such a curvilinear relationship in the case of innovation performance in the aftermath of M&A deals. In their study, they showed that technology-based M&A deals (broadly defined) are associated with better innovation performance than are non technology-based M&A deals. It should again be noted that their definition of technological acquisition distinguished between cases in which acquired firms have significant technological assets, as opposed to those in which they do not. Our study has been concerned to examine, within the set of technology-based expansion strategies broadly defined in this way, those that are motivated by technology-driven objectives and those that are motivated by market-driven objectives. Hence, the Ahuja and Katila (2001) measure of technology-based acquisition uses the technology status of the target firm in an acquisition, while our definition of technology-driven expansion is concerned with the motivation of a company acquiring external technological capabilities. Ahuja and Katila (2001) reason that their observation of acquisitions, in which technological relatedness is either so close or so distant that it leads to no subsequent innovation performance benefits, may be due to managers making mistakes in terms of a failure to recognize more optimally related combinations. Our approach suggests instead an alternative interpretation of their findings, namely that such overly far away technological combinations may be the outcome of product market-driven expansion strategies that are not focused on technological relatedness, but that are mainly geared to the achievement of product relatedness. When they are market-driven, more distant inter-industry amalgamations may have a disruptive effect on a range of innovation activities (Hitt *et al.*, 1996; Cloodt *et al.*; 2006), by actually further reducing technological relatedness.

A further contribution of our study lies in a more detailed account of post-acquisition innovation outcomes. In the literature on the impact of M&As on post-acquisition innovation performance, most studies have considered only aggregate outcomes, whether measured by levels of patenting (Ahuja and Katila, 2001), R&D expenditures or employment (Hall, 1988, Hitt *et al.*, 1991). By drawing on the detailed disaggregation of US patent technological fields, we have shown instead that there are important differences in the post-acquisition development of related or ICT capabilities, depending upon whether expansion is either technology-driven or market-driven.

Implication for managers

We have just suggested that managers following market-driven expansion strategies may not be making mistakes when failing to consider in some cases the extent of technological relatedness of business combinations. However, in these cases in which acquired businesses have substantial technological capabilities even though these are not the primary target, it is clear from our investigation that major issues of technological restructuring will still require to be addressed by management. In this context it may also be useful for managers to be able to appreciate that new ICT capabilities may have different roles. For technology-driven expansion, they are important in inter-industry combinations, while in market-driven expansion they have recently become important in the restructuring of systems of production and distribution.

Limitations and further research

Several limitations of this study should be acknowledged. Our analysis is concerned with a relatively small number of cases. It would be desirable to enlarge the number of cases in order to be clearer on the robustness of our results. Similarly, a larger number of firms in each industry would allow us to examine the effects of firm heterogeneity within industries. While we have measured technological relatedness, we do not adopt any measure of product relatedness. This is not a major constraint in this study, since we focus on outcomes in terms of technology relatedness, but it would be useful to extend the argument to explicitly account for the extent of the product-relatedness of business combinations.

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Figure 1 – The areas of corporate capability accumulation promoted under alternative corporate expansion strategies and by different business integration contexts

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">External corporate expansion strategy</td></tr>
<tr><td>Technology-driven</td><td>Market-driven</td></tr>
<tr><td rowspan="2">Variation in business integration</td><td>Integration across industries</td><td>Building technological relatedness through ICT
- 1 -</td><td>Building product market relatedness through a rationalization of technological relatedness
- 3 -</td></tr>
<tr><td>Change in integration processes in recent times</td><td>Increasing strategic experimentation to achieve technological relatedness
- 2 -</td><td>Increasing efficiency of related product market combinations through ICT
- 4 -</td></tr>
</table>

Figure 2 – Derivation of the hypotheses on the areas of corporate capability accumulation

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">External corporate expansion strategy</td></tr>
<tr><td>Technology-driven</td><td>Market-driven</td></tr>
<tr><td rowspan="2">Variation in business integration</td><td>Integration across industries</td><td>increased specialization in ICT and related technological fields: technology fusion
(H1)
- 1 –</td><td>reduced specialization in related technological fields: joint production and distribution to combine product-related businesses with no necessary relationships in their technologies
(H3)
- 3-</td></tr>
<tr><td>Change in integration processes in recent times</td><td>increased specialization in related technological fields: more focused and localized search - greater experimentation over time
(H2)
- 2 -</td><td>increased specialization in ICT: reduction in joint inventory holding costs through information-based systems that combine storage, transportation and distribution across related lines of business
(H4)
- 4 –</td></tr>
</table>

Table 1 - Descriptive statistics and correlation matrix for the technology-driven sample (observations = 896)

	Variable	*Mean*	*Std. Dev.*	*Min*	*Max*	1	2	3	4	5	6	7	8	9	10
1	$\Delta TECHSPEC_{ij}$	1.340	1.551	0.094	10.793	1.000									
2	$Iict_{ij}$	0.080	0.272	0	1	0.082	1.000								
3	Ic_{ij}	0.105	0.307	0	1	-0.030	0.060	1.000							
4	$Irel_{ij}$	0.395	0.489	0	1	0.023	-0.239	-0.277	1.000						
5	$Wict_{ij}$	0.074	0.261	0	1	0.050	0.671	-0.097	-0.228	1.000					
6	Wc_{ij}	0.110	0.314	0	1	-0.033	-0.104	0.704	-0.285	0.064	1.000				
7	$Wrel_{ij}$	0.358	0.480	0	1	0.003	-0.221	-0.256	0.448	-0.211	-0.263	1.000			
8	I_i	0.750	0.433	0	1	0.043	0.171	0.198	0.467	-0.015	-0.027	-0.106	1.000		
9	W_i	0.688	0.464	0	1	0.008	-0.013	0.050	-0.110	0.190	0.238	0.504	-0.078	1.000	
10	C_i	0.750	0.433	0	1	-0.010	0.000	0.004	0.013	-0.078	0.014	-0.031	0.000	-0.078	1.000

Table 2 - Descriptive statistics and correlation matrix for the market-driven sample (observations = 728)

	Variable	*Mean*	*Std. Dev.*	*Min*	*Max*	1	2	3	4	5	6	7	8	9	10
1	$\Delta TECHSPEC_{ij}$	1.266	1.380	0.092	10.613	1.000									
2	$Iict_{ij}$	0.074	0.262	0	1	0.008	1.000								
3	Ic_{ij}	0.049	0.217	0	1	-0.037	-0.065	1.000							
4	$Irel_{ij}$	0.380	0.486	0	1	-0.042	-0.222	-0.179	1.000						
5	$Wict_{ij}$	0.082	0.275	0	1	0.014	0.716	-0.068	-0.235	1.000					
6	Wc_{ij}	0.081	0.273	0	1	-0.023	-0.084	0.652	-0.233	0.131	1.000				
7	$Wrel_{ij}$	0.427	0.495	0	1	-0.010	-0.244	-0.197	0.530	-0.259	-0.257	1.000			
8	I_i	0.692	0.462	0	1	-0.011	0.189	0.152	0.523	0.005	-0.107	-0.026	1.000		
9	W_i	0.769	0.422	0	1	0.012	0.006	0.050	-0.014	0.164	0.163	0.473	0.030	1.000	
10	C_i	0.615	0.487	0	1	-0.005	-0.100	-0.080	-0.369	-0.010	0.059	-0.065	-0.527	-0.058	1.000

Table 3- Estimations for the technology-driven sample when considering business integration across industries

Variables	*Model Specification*							
	OLS				*2-way FE Model*			
	Coef.	*Robust Std. Err.*	*t*		*Coef.*	*Std. Err.*	*t*	
$Iict_{ij}$	0.866	0.200	4.340	***	0.745	0.197	3.790	***
Ic_{ij}	0.157	0.179	0.880		-0.144	0.180	-0.800	
$Irel_{ij}$	0.526	0.108	4.880	***	0.231	0.117	1.980	**
selected firm effects	-	-	-					**/***
selected technological field effects	-	-	-					**
Controls								
W_i	0.623	0.093	6.680	***	0.998	0.120	8.350	***
C_i	0.619	0.095	6.500	***	0.254	0.117	2.160	**
No. obs.	896							
Adj R-squared	0.384				FE *vs.* OLS F(10, 881)		8.320	***
F(5, 891)	112.67	***						

*** significant at $p < 0.01$
** significant at $p < 0.05$

Table 4 - Estimations for the technology-driven sample when considering more recent business integration

Variables	*Model Specification*							
	OLS				*2-way FE Model*			
	Coef.	*Robust Std. Err.*	*t*		*Coef.*	*Std. Err.*	*t*	
$Wict_{ij}$	0.631	0.206	3.060	***	0.276	0.226	1.220	
Wc_{ij}	0.145	0.173	0.840		-0.032	0.173	-0.180	
$Wrel_{ij}$	0.415	0.109	3.820	***	0.197	0.115	1.720	*
selected firm effects	-	-	-					***
selected technological field effects	-	-	-					**
Controls								
I_i	0.773	0.096	8.030	***	0.436	0.115	3.780	***
C_i	0.544	0.099	5.490	***	0.809	0.121	6.710	***
No. obs.	896							
Adj R-squared	0.386				FE *vs.* OLS F(10, 881)		7.530	***
F(5, 891)	113.82	***						

*** significant at $p < 0.01$
** significant at $p < 0.05$
* significant at $p < 0.01$

Table 5 - Estimations for the market-driven sample when considering business integration across industries

Variables	*Model Specification*							
	OLS				*2-way FE Model*			
	Coef.	*Robust Std. Err.*	*t*		*Coef.*	*Std. Err.*	*t*	
$Iict_{ij}$	0.484	0.207	2.340	**	-0.014	0.204	-0.070	
Ic_{ij}	0.162	0.252	0.640		-0.328	0.241	-1.360	
$Irel_{ij}$	0.416	0.106	3.910	***	-0.210	0.124	-1.700	*
selected firm effects	-	-	-					**/***
selected technological field effects	-	-	-					**/***
Controls								
W_i	0.719	0.100	7.230	***	1.304	0.138	9.460	***
C_i	0.590	0.093	6.340	***	-0.095	0.137	-0.700	
No. obs.	728							
Adj R-squared	0.398				FE *vs.* OLS F(8, 715)		16.530	***
F(5, 723)	97.05	***						

*** significant at $p < 0.01$

** significant at $p < 0.05$

* significant at $p < 0.01$

Table 6 - Estimations for the market-driven sample when considering more recent business integration

Variables	*Model Specification*							
	OLS				*2-way FE Model*			
	Coef.	*Robust Std. Err.*	*t*		*Coef.*	*Std. Err.*	*t*	
$Wict_{ij}$	0.330	0.199	1.660	*	0.436	0.196	2.220	**
Wc_{ij}	0.187	0.200	0.940		0.225	0.198	1.140	
$Wrel_{ij}$	0.321	0.105	3.040	***	0.389	0.105	3.690	***
selected firm effects	-	-	-					***
selected technological field effects	-	-	-					**/***
Controls								
I_i	0.771	0.082	9.410	***	0.754	0.082	9.230	***
C_i	0.702	0.085	8.280	***	0.533	0.093	5.720	***
No. obs.	728							
Adj R-squared	0.407				FE *vs.* OLS F(4, 719)		7.350	***
F(5, 723)	100.92	***						

*** significant at $p < 0.01$

** significant at $p < 0.05$

APPENDIX:

CLASSIFICATION OF M&A DELAS

12 out of 25 deals have been classified just as technology-motivated on the grounds of news stories. This is the case of ICI acquiring Société Européenne des Semences (European leader in the production of specific seeds), Bayer acquiring Herman C. Stark Berlin GmbH (leader in electronics and special chemicals), Ciba-Geigy acquiring Spectra-Physics (producing diagnostic and medical instruments), Solvay acquiring Reid-Rowell (a research-intensive pharmaceutical firm), and SKB whose division developing products for medical applications merged with Krautkramer GmbH (specialist in the production of ultrasonic flow detector). Likewise, the cases of Degussa acquiring Asta-Werke AG (a reputable pioneer in the area of oncology), Beecham Group acquiring Scott & Bowne (maker of proprietary medicines, toiletries and household products), Schering acquiring The Cooper Companies to invest significantly in biotech, Bosch acquiring American Microsystems Inc. to develop components for fuel injections and breaking systems, Schneider merging with Sodif (producing dyestuffs), Siemens acquiring G.D. Searle & Co. (specialist in nuclear and ultrasonic medical diagnostic imaging equipment and radiation detection badges activities), Brown Boveri acquiring Studebaker-Worthington Inc. (leader in the gas turbine generator business).

Nine out of 25 deals have been classified just as market-motivated, having been driven at least in part by the desire of the acquiring company to diversify into related output sectors (Table A 2). One case concerns an intra-industry deal such as the acquisition of Kennecott (previously owned by Standard Oil Ohio) by BP. Two further cases refer to M&A deals involving firms operating in closely related industries. Namely, the acquisition of the International Minerals and Chemicals Corporation by the Wellcome Foundation (Pharmaceuticals) and the acquisition of Gasunie (European leader in gas supplying) by Shell (Oil and gas). The remaining six have been classified as market-motivated in nature since they appear to be part of a corporate restructuring strategy in which the deal improved the extent of intra-firm fit with related products within each original company considered. This is the case of BASF (Chemicals and pharmaceuticals) acquiring Brabrand (the vitamin operations of Grindsted Products A/S), DSM whose resin business merged with Unliver's Unichem/Scado UP resin and coating resin business, Upjohn (Pharmaceuticals) acquiring Admiral Maschinenfabrik GmbH, part of Admiral Equipment Co.

producing hardware, Glaxo (Food and pharmaceuticals) acquiring Bonomelli (part of the Ferruzzi group operating in food products), Daimler Benz (Motor vehicles) acquiring the electrical AEG for transportation applications, and Metalgesellschaft (Metal processing) acquiring Reichold Chemie AG (Swiss division of the chemical Reichhold Group).

Four deals out of 25 have been classified as both T- and M-driven. Three of these are intrs-industry deals for which technology motives were reported: Rhône-Poulenc which acquired the silicon operation of ICI, Thomson-Brandt which acquired the consumer electronic division of AEG Telefunken, and LM Ericsson which acquired Ericsson (a joint venture with Atlantic Richfield). The last refers to companies operating in closely related industries and involving technology motives: the acquisition of Rover Group (Transport equipment) by British Aerospace.

Table A1 - Focal firms in the sample, by nationality and industry

Nationality	***Industry***								**Total**
	Aerospace	*Chemicals*	*Electrical Equipment*	*Mechanicals*	*Metals*	*Motor Vehicles*	*Oil*	*Pharmaceuticals*	
Belgium	-	1	-	-	-	-	-	-	**1**
France	-	1	1	-	-	-	-	-	**2**
Germany	-	3	1	1	1	2	-	1	**9**
Sweden	-	-	1	-	-	-	-	-	**1**
Switzerland	-	1	1	-	-	-	-	-	**2**
The Netherlands	-	1	-	-	-	-	1	-	**2**
UK	1	1	-	-	-	-	1	3	**6**
USA	-	-	-	-	-	-	-	2	**2**
Total	**1**	**8**	**4**	**1**	**1**	**2**	**2**	**6**	**25**

Table A2 - Firms in the sample of analysis, by industry, target, motive and period of the deal, and patenting information

Focal Firm	Industry	Target*	M&A motive		M&A year	patenting structural break year	Patenting growth rate**	N. of patents in t-1 **
			M-driven	**T-driven**				
BASF	Chemicals	Brabrand	x		1982	1985-1986	25.53%	1234
DSM	Chemicals	Unichema/Scado	x		1984	1985-1986	7.63%	118
ICI	Chemicals	Societé Europeenne des Semences (SES)		x	1987	1985-1986	16.28%	608
Bayer	Chemicals	Herman C. Starck Berlin GmbH & Co.		x	1986	1985-1986	12.59%	2144
Ciba-Geigy	Chemicals	Spectra-Physics		x	1987	1985-1986	18.92%	1348
Rhône-Poulenc	Chemicals	silicon division of ICI	x	x	1988	1985-1986	32.75%	400
Solvay	Chemicals	Reid-Rowell		x	1986	1985-1986	31.36%	118
SKB	Chemicals	Krautkramer GmbH		x	1972	1973-1974	41.22%	444
Degussa	Chemicals	Asta-Werke AG		x	1983	1981-1982	13.19%	288
Upjohn	Pharmaceuticals	Admiral Maschinenfabrik GmbH	x		1978	1976-1977	45.81%	716
Beecham Group	Pharmaceuticals	Scott & Bowne Ltd.		x	1978	1974-1975	112.79%	86
Glaxo	Pharmaceuticals	Bonomelli	x		1988	1987-1988	110.29%	68
Wellcome Foundation	Pharmaceuticals	International Minerals & Chemicals Corporation	x		1989	1986-1987	111.27%	71
Schering	Pharmaceuticals	The Cooper Companies		x	1988	1987-1988	29.65%	199
Shell	Oil	Gasunie	x		1988	1986-1987	46.75%	845
BP	Oil	Kennecott	x		1981	1978-1979	43.96%	414
British Aerospace	Aerospace	Rover Group	x	x	1987	1986-1987	137.31%	67
Daimler Benz	Motor Vehicles	transport application division of AEG	x		1986	1985-1986	39.22%	306
Bosch	Motor Vehicles	American Microsystems Inc. (AMI)		x	1979	1976-1977	14.39%	820
Schneider	Mechanical	Sodif		x	1986	1985-1986	86.54%	52
Siemens	Electrical equipment	G.D. Searle & Co.		x	1980	1978-1979	4.73%	1943
Brown Boveri	Electrical equipment	Studebaker-Worthington Inc.		x	1977	1978-1979	24.32%	333
Thomson-Brandt	Electrical equipment	consumer electronic division of AEG Telefunken	x	x	1984	1983-1984	20.57%	661
LM Ericsson	Electrical equipment	Ericsson (joint venture with Atlantic Richfield)	x	x	1987	1985-1986	36.92%	130
Metalgesellschaft	Metals	Swiss division of Reichhold Chemie AG	x		1974	1973-1974	21.76%	170

* This is the only M&A of those identified that matches the year of the structural break in firms' patenting activity and the associated structural shift in the geographical pattern of the location of the inventions.

** This information refers to the focal firm.

Table A3 - List of the 56 technological fields

Technological field	*Broader industrial technological group*	*Technological field*	*Broader industrial technological group*
Food and Tobacco Products	(Mechanical)	Other General Industrial Equipment	(Mechanical)
Distillation Processes	(Chemical)	Mechanical Calculators and Typewriters	(Electrical)
Inorganic Chemicals	(Chemical)	Power Plants	(Mechanical)
Agricultural Chemicals	(Chemical)	Nuclear Reactors	(Other)
Chemical Processes	(Chemical)	*Telecommunications*	*(ICT)*
Photographic Chemistry	(Chemical)	*Other Electrical Communication Systems*	*(ICT)*
Cleaning Agents and Other Compositions	(Chemical)	*Special Radio Systems*	*(ICT)*
Disinfecting and Preserving	(Chemical)	*Image and Sound Equipment*	*(ICT)*
Synthetic Resins and Fibres	(Chemical)	Illumination Devices	(Electrical)
Bleaching and Dyeing	(Chemical)	Electrical Devices and Systems	(Electrical)
Other Organic Compounds	(Chemical)	Other General Electrical Equipment	(Electrical)
Pharmaceuticals and Biotechnology	(Chemical)	*Semiconductors*	*(ICT)*
Metallurgical Processes	(Mechanical)	*Office Equipment and Data Processing Systems*	*(ICT)*
Miscellaneous Metal Products	(Mechanical)	Internal Combustion Engines	(Transport)
Food, Drink and Tobacco Equipment	(Mechanical)	Motor Vehicles	(Transport)
Chemical and Allied Equipment	(Mechanical)	Aircraft	(Transport)
Metal Working Equipment	(Mechanical)	Ships and Marine Propulsion	(Transport)
Paper Making Apparatus	(Mechanical)	Railways and Railway Equipment	(Transport)
Building Material Processing Equipment	(Mechanical)	Other Transport Equipment	(Transport)
Assembly and Material Handling Equipment	(Mechanical)	Textile, Clothing and Leather	(Other)
Agricultural Equipment	(Mechanical)	Rubber and Plastic Products	(Transport)
Other Construction and Excavating Equipment	(Mechanical)	Non-Metallic Mineral Products	(Mechanical)
Mining Equipment	(Mechanical)	Coal and Petroleum Products	(Chemical)
Electrical Lamp Manufacturing	(Mechanical)	Photographic Equipment	(Electrical)
Textile and Clothing Machinery	(Mechanical)	Other Instruments and Controls	(Mechanical)
Printing and Publishing Machinery	(Mechanical)	Wood Products	(Other)
Woodworking Tools and Machinery	(Mechanical)	Explosive Compositions and Charges	(Chemical)
Other Specialised Machinery	(Mechanical)	Other Manufacturing and Non-Industrial	(Other)

Source: Cantwell, 1995.

[i] Although in some cases the year of the deal follows the beginning of the structural break in corporate patenting activity, strategic delays in the announcement of a deal should be taken into account. Alternatively, a major new M&A may be the means of implementing more effectively a strategic change in the focus of production and technological effort that has already been decided upon, in which case the initial break represents a period of experimentation prior to the fuller commitment associated with the M&A deal.

[ii] *De facto*, the denominator of the *RTA* index accounts for all companies operating in the relevant industries to which US patents were granted in the period 1969-95, and which belong to the world's largest firms, being listed in the Fortune 500 for US firms, or the global Fortune 500 for non-US firms, or having been assigned over 1,000 US patents since 1969. These are 784 large firms in the wider patent database (those assigned US patents), which between them account for nearly 50% of total US patenting, and for nearly 60% of US patents that have a named assignee in the period in question. All patents granted under tha names of subsidiaries have been consolidated into the relevant corporate group, allowing for M&As and divestments over time. The consolidated firms were classified according to their primary industry of output, based on the product distribution of their sales. Twenty such industiral groups were identified, of which 8 industries include firms considered in this study. The 56 technological fields were constructed to group together common categories of technological activity, derived from the USPTO class and sub-class system (see Appendix Table A3).

[iii] In Table A3 the use of *italics* denotes ICT fields.

[iv] When running this model we imposed a constraint on the intercept term and tested it through a Wald F test, which yielded statistically significant support for the constrained model for both the technology- and market-driven cases at $p < 0.01$. This enabled us to explain as part of our analysis the overall component of variation in the change in RTA values over time, rather than just treating the values of variable effects over and above the estimated constant term.

[v] When considering business integration over product space, $F(55, 835) = 1.10$ and $F(55, 667) = 1.18$ for the technology- and market-motivated cases, respectively, while when considering business integration over time, $F(55, 835) = 1.10$ and $F(55, 667) = 1.20$ for the technology- and market-motivated cases, respectively. When considering business integration over product space B-P LM chi2(1) = 0.14 and 0.54 for the technology- and market-motivated cases, respectively, while when considering business integration over time, B-P LM chi2(1) = 0.15 and 0.56 for the technology- and market-motivated cases, respectively.