

**THE EFFECT OF MERGERS AND ACQUISITIONS ON THE TECHNOLOGICAL
PERFORMANCE OF COMPANIES IN A HIGH-TECH ENVIRONMENT**

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Abstract

A large part of the literature from industrial organisation and management expects that, compared with unrelated M&As, related M&As show superior economic performance because of synergetic effects that follow from economies of scale and scope. The current contribution takes the debate on the effect of different M&As somewhat further by studying the effect of M&As on the technological performance of companies. In this study the technological performance of M&As is related to a high-tech sector, i.e. the computer industry. The main result of this research is that the so called strategic and organisational fit between companies involved in M&As seem to play an important role in improving the technological performance of companies

(mergers, acquisitions, technological performance)

INTRODUCTION

The central topic of this paper concerns the possible effect that mergers and acquisitions (M&As) have on the technological performance of companies. This subject of the technological effect of M&As is clearly related, but not identical, to the more general question regarding the economic benefits of M&As, for instance in terms of their effect on the profitability of companies.

In that context a number of influential industrial organisation studies suggest that companies realize diminishing profitability for an extended period of time after an M&A because of the cost of integration and poor performance of acquired units (e.g. Caves, 1989; Cosh, Hughes, Lee and Singh, 1989; Mueller, 1986; Ravenscraft and Scherer, 1987; Scherer, 1988). However, some recent contributions, e.g. Odagiri and Hase (1989) and Scott (1993), suggest that long-term positive results for M&As are found for diversification through M&As across related product lines. Largely inspired by Rumelt (1974), the management literature has moved away from a general evaluation of the economic performance of M&As to an evaluation of different forms of M&As, such as horizontal, vertical and unrelated M&As (Hitt et al, 1998; Kusewitt, 1985; Lubatkin, 1987; Montgomery and Wilson, 1986; Singh and Montgomery, 1987). Although there is still considerable disagreement within the literature, a substantial part of it expects, primarily on theoretical grounds, that related M&As show superior performance because of synergetic effects through economies of scale and scope.

In the following we will attempt to take the debate on M&As somewhat further by studying their effect on the technological performance of companies. As indicated by Link (1988) little research was done on this particular subject before the late-1980s. In recent years a small number of contributions to the management literature (Chakrabarti, Hauschildt and

Sueverkruep, 1994; Gerpott, 1995; Grandstrand, Bohlin, Oskarsson and Sjoberg, 1992 and Hitt, Hoskisson, Ireland and Harrison, 1991) have put this topic on the research agenda.

It is important to note that the technological performance of M&As deals with the long-term effects of M&As. As mentioned by Chakrabarti, Hauschildt and Sueverkruep (1994), technology related incentives for M&As affect long-term strategic variables which tend to be underestimated in much of the current empirical research, that usually focuses on the short-term, economic effects of M&As. In these long-term effects the expected synergetic characteristics of M&As can contribute to technological performance through the successful introduction of new technologies, new products and processes by the combined companies which could eventually lead to improved profitability of companies. As suggested by a reviewer, there can also be short-term effects of M&As when the acquiring company intends to only obtain access to R&D and technological capabilities to simply produce an already existing, combined technological output. However, when these existing capabilities are used in the further development of new technological output, these short-term effects are expected to be limited in comparison to the long-term, synergetic technological effects of M&As. This effect of by merging companies is a well-known classic issue in the innovation literature dating back as far as Schumpeter (1942) where increased size of companies and synergies, through internal growth or by means of M&As, are positively related to long-term technological performance.

The technological effect of M&As is also discussed in some previous research on a related issue, i.e. the motivation for M&As. Frequently mentioned motives are: increased market share, improved efficiency, expanded R&D efforts, investment adjustment, firm growth, risk reduction, speedy market entry (Chakrabarti, Hauschildt and Sueverkruep, 1994; Hitt et al, 1996; Ikedo and Doi, 1983; Oster, 1994). In older work on M&As from the 1970's,

increasing R&D activities and improving technological performance seem hardly relevant as motives for M&As, see de Jong (1976). In Chakrabarti and Burton (1983) technological motives for M&As appear to be only moderately important across industries. However, studies by Grandstrand, Bohlin, Oskarsson and Sjoberg (1992), Link (1988) and MacDonald (1985) do suggest that M&As are an important element in the technology acquisition strategy of companies, in particular in R&D intensive (high-tech) industries.

We will continue along this line and study the effect of M&As on innovation in a high-tech sector, the computer industry. Obviously, M&As are also important in other sectors but, as mentioned above, the relation between M&As and technological performance is probably most evident in high-tech sectors. Furthermore, technological input and output in high-tech sectors can be measured by standard indicators such as R&D expenditures and patents, see also the section on the dependent variable for a discussion of the use of patents as an indicator of technological performance.

In the following we will first outline a general perspective on the effect of M&As on the technological performance of companies. This general perspective on M&As and the related set of hypotheses both stress the importance of understanding the conditions under which M&As might have a positive effect on the technological performance of companies. In that context we will emphasize the role of strategic and organizational fit in explaining technological performance differentials. Although both play a substantial role in many analyses of M&As and economic performance, strategic and organizational fit have received far less attention in much of the current work on M&As, technological performance and related issues. After the theoretical background and hypotheses have been explained, our paper continues with a discussion of our data, the variables and the measures used in this

study. This is followed by sections in which the actual analysis, the discussion of the results and the conclusions from this paper are presented.

THEORETICAL BACKGROUND AND HYPOTHESES

In a number of seminal contributions to the literature, M&As are seen as an important element in the overall strategy of companies to respond to uncertainty within the economy at large, uncertainty within particular industries, or uncertainty in the context of repeated transactions with other companies (Pfeffer, 1972; Sutton, 1980; Williamson, 1996). The absorption of at least parts of their environment (i.e. other companies) by means of M&As is one of the alternatives that companies have if they attempt to reduce uncertainty, increase their control over their environment or reduce their dependency on this environment. (Other mechanisms that are relevant but which are not discussed or analysed in the context of our current research are strategic alliances that take the form of a variety of legal and organizational modes.) According to Pfeffer (1972) this absorption of other companies by means of M&As in order to respond to uncertainty can take place through either the integration of other companies in sector(s) in which a company is already operating, or a diversification into another sector because the company has become too dependent on its existing environment. Studying M&As from a more sector-specific perspective, Link (1988) and MacDonald (1985) arrive at somewhat similar conclusions as M&As are seen as a mechanism to increase control over the environment of companies in quickly changing, R&D intensive, industries.

However, increasing control over the current or the new environment of companies cannot be taken as a goal in itself. The search for new, rewarding opportunities has to be part

of this process of absorption of a company's environment. As a consequence, in order for a company to be successful, the objective of increasing control and integration by means of M&As, ultimately, has to lead to improved performance. In the context of companies operating in a high-tech, R&D intensive environment, improved performance implies that integration by means of M&As has to support the continuous search for new technological capabilities. We expect that, if M&As are successful, they enable companies to further develop new skills and improve their exploratory learning (Dodgson, 1993) so as to increase the technological performance of companies.

In other words, M&As for the benefit of the combination as such seem hardly instrumental for companies that intend to increase control over their environment, improve their technological skills and raise their technological performance. Recent contributions by Baysinger and Hoskisson (1989), Hitt et al (1991), Hitt et al (1996) and Markides (1992) indicate that diversification and increases in the diversified scope of companies as such can result in decreasing R&D inputs and decreasing technological outputs. Following some suggestions in the literature (Datta, 1991; Hitt et al, 1998; Jemison and Sitkin, 1986) we propose that in order to be successful not only in establishing M&As, either in the current environment or in a new environment, but also to generate the expected results, M&As are contingent upon both a 'strategic fit' and an 'organisational fit' that enable M&A partners to collaborate in future activities. This implies that in order to achieve synergetic effects through M&As, the strategic fit through market, product and technological complementarities or relatedness of companies has to be supplemented by an organisational fit in which the organisational structure of the merging companies appears to match. Effective control over

parts of the environment by means of M&As which also leads to improved performance is expected to be dependent on this strategic and organisational correspondence of the companies involved.

In the following we will discuss crucial elements of the strategic and organizational fit necessary to improve the technological performance of companies in a high-tech environment, separately. We reconstructed these elements of the strategic and organizational fit from the literature where these issues are analyzed in the broader context of the general performance of M&As (e.g. Datta, 1991). These conditions for the success of synergetic M&As are analyzed in terms of strategic fit related to the degree of the existing product-market relatedness of M&As, the technological correspondence of M&As and their organizational fit. These different elements of the fit between companies cover the current markets of companies, their present and future-oriented technological activities and the similarity in their organizational structure.

Strategic fit: related and unrelated M&As

In the literature one finds several categorisations of M&As in terms of their 'relatedness' which usually can be traced back to the original classification scheme of the US Federal Trade Commission (Montgomery and Wilson, 1986). Horizontal M&As involve companies that are closely related as to the products or services they to produce, i.e. both companies operate in the same product-market. Vertical M&As involve companies that had a potential or existing buyer-seller relationship prior to the M&A. Conglomerate or unrelated M&As involve essentially companies that are unrelated in terms of the product-markets in which they are operating and of which the M&As are part of a widely diversifying strategy.

A substantial part of the literature seems to suggest that in general conglomerate

M&As are less successful than horizontally and vertically-related M&As (for instance, Datta, 1991; Kusewitt, 1985; Oster, 1994; Porter, 1987; Singh and Montgomery, 1987). As shown by Datta (1991) there are also studies that find little or no evidence of such a relationship. On theoretical grounds, however, the idea that a strategic fit of companies, in terms of a relatedness of the product-markets in which companies are operating, remains appealing. Obviously, related M&As can be expected to profit from economies of scale and scope that should generate more synergetic benefits than in the case of unrelated M&As of companies that have no other relationship to each other than becoming part of one overarching system of corporate control.

As our study focuses not on the economic performance of M&As in general but on the specific issue of technological performance, the relationship between the degree of relatedness of M&As and performance might be of a slightly different nature. In the case of horizontal M&As, we can expect that joint or complementary innovation programs of the combined companies will generate new products and new technologies in which both scale and scope effects seem to be beneficial to the technological performance of the merged companies. For vertical M&As, cost reduction by means of integrating upstream or downstream 'partners' can be expected to generate economic results that can be reinvested in innovative programs. The integration of sophisticated suppliers or users can also help to identify both market needs and introduce new production technologies that contribute to the technological performance of companies. For unrelated M&As these effects of scope and scale economies are in general more difficult to materialise and the literature suggests that these M&As are mainly intended to achieve financial synergies. This leads us to expect that related M&As, of both a horizontal or a vertical nature, and conglomerate M&As affect

technological performance differently. (However, as suggested by one reviewer, it has to be stressed that synergistic results of M&As, on which we focus in this paper, are still dependent on positive financial economies in order to achieve the necessary interrelationships. In other words, without short-term economic results for M&As, long-term results in technological performance may never materialize.)

Under these conditions, the above suggests the following hypothesis:

H. 1 *Related M&As lead to higher technological performance of companies than unrelated M&As.*

Strategic fit: technological relatedness of companies involved in M&As

So far most of the debate on the strategic fit of companies involved in M&As seems to focus on the industry-aspect of the relatedness of companies in terms of their product-markets. As our research deals with the technological performance of M&As, it seems appropriate to also consider the issue of technological relatedness of companies that enter into M&As.

Technological relatedness of companies, then, refers to the degree to which companies are active in particular fields of technology development that they share with (potential) partners in M&As. These fields of technology have to be understood in terms of the activities of companies related to relatively broad categories of technological disciplines and engineering capabilities, such as electronics, electrical engineering, chemistry, bio-engineering and their sub-categories, that coincide with fields of technology as for instance identified by patent-classes. As with the line of reasoning for product-markets, we can expect that M&As of companies from similar, horizontally related, fields of technology and also technologically, vertically related, M&As will outperform technologically unrelated M&As. Also here, synergies in scale and scope are the main reasons for expecting these different outcomes.

Compared to technologically unrelated M&As, the synergies and combined technological activities of related M&As are expected to enable companies to shorten the innovation lead-time, share technological expertise and to engage in larger, combined projects than would be possible within the once separated companies.

Somewhat surprisingly, the literature on the strategic fit of companies involved in M&As seems relatively silent on this particular topic. Jemison and Sitkin (1986) appear to only hint at the relevance of this aspect of strategic fit. Gerpott (1995) discusses technological fit in the context of the successful integration of different R&D activities after an acquisition has taken place. Assuming that the successful integration of different R&D activities leads to improved technological performance, Gerpott's (1995) empirical findings suggest that the higher the degree of technology relatedness of companies involved in an M&A, the more successful the M&A will be. According to this line of thought for understanding the importance of technological relatedness of M&As, following a similar logic as with product-market relatedness, we suggest that:

H. 2 *Technologically related M&As will lead to higher technological performance of companies than technologically unrelated M&As.*

Strategic fit: research intensity of companies involved in M&As

The technological aspect of the strategic fit of M&As, discussed in the previous section, covers the 'breadth' of the potential sharing of technological capabilities of companies across fields of technology. As far as the 'depth' of technological relatedness, i.e. the similarity in actual research effort and research input, is concerned, the question remains whether R&D intensive companies look for M&A partners that have a similar or higher level of research activity. Also, the question comes to mind whether companies with low levels of R&D might

use M&As to acquire companies with higher levels of R&D, either in an attempt to improve their research capabilities within their existing fields of activity or in an attempt to diversify into more research-intensive industries.

Early research by Chakrabarti and Burton (1983) suggests that companies in mature industries with low R&D intensity appear to form M&As with companies in R&D-intensive industries in order to diversify into high-tech areas. However, MacDonald (1985) found no evidence of such dissimilarity. His research mainly indicates that R&D intensive firms aim at M&As with companies from other R&D intensive sectors, that are similar in their R&D orientation in order to reach synergies in future R&D. Hall (1990) also mentions the importance of synergistic motives for explaining M&As in R&D intensive industries. She suggests that R&D intensive companies form M&As with other R&D intensive firms, whether they are from similar or from different industries.

The above suggests that it is important to consider the effect of the R&D intensity of M&A partners on their combined technological output. Then, if one controls for the research intensity of the sectors in which M&As take place, we can expect that M&As with companies that have an R&D intensity above their sector average tend to lead to higher technological output. A major motive for M&As with above average R&D intensive companies is that these companies can be expected to have certain research capabilities and relevant skills that are future-oriented. This is probably important in a variety of industries but in particular in a high-tech environment where R&D capabilities are crucial for the further growth and development of companies (Freeman and Soete, 1997; Henderson and Cockburn, 1994). In other words, the 'depth' of this technological relatedness is found in the actual above-average effort of M&A partners to create new knowledge through R&D that is expected to gradually

improve their technological performance. Contrary to this, M&As with companies with an R&D intensity below their sector average will lead to lower technological performance of the combined companies. As the combined R&D activity of these merged companies decreases, we can expect that a gradual erosion of the technological capabilities of these companies which will be translated into a decreasing technological performance. Hence:

H. 3 *The R&D intensity of partner-companies in M&As affects the technological performance of the combined company: combinations with companies of an above sector-average R&D intensity improve the post-M&A technological performance of companies, whereas combinations with companies of a below sector-average R&D intensity decrease the post-M&A technological performance.*

Organisational fit: company size and M&As

Although the concept of organisational fit between companies involved in M&As covers a large number of aspects related to administrative routines and company-specific characteristics (Datta, 1991; Jemison and Sitkin, 1986), similarities or differences in size of companies do, in our opinion, to a large extent catch many aspects of organisational fit. Size of companies also relates to differences in organizational forms such as multi-divisional company structures and single-divisional companies that characterize differences between small and large companies (Chandler, 1990). As a 'proxy' for organisational fit we can understand size of companies to express 'certain ways of doing business'. In other words, large companies have generally developed a completely different way of organising themselves, for instance along divisional structures and other formal organisational routines, that is quite different from small and medium sized companies where informal structures are still most common. This not only applies to differences in general, but in particular to the

different roles that large and small companies play with regard to technological development (Dosi, 1988; Freeman and Soete, 1997). This implies that M&As between companies of different sizes have organisational consequences, in terms of the actual organisational fit of companies, that can affect the technological output after the M&A has taken place. There is some evidence that the organisational differences between large and some small companies in the actual management of the innovation process are diminishing (Haggblom, Calantone and Di Benedetto, 1995) but we expect that by and large these differences still exist. In particular, we can expect different procedures for R&D allocation and differences in strategic technology decision making.

The empirical research seems to support this understanding of the differences in organisational fit between large and small firms. Chakrabarti, Hauschildt and Sueverkruep (1994) found that combinations of large and small companies are confronted with organizational problems affecting technical success after the M&A took place. Similarly, Gerpott (1995) established that the size ratio of acquiring and acquired company affects the degree to which R&D functions are successfully integrated after an M&A. Smaller ratio's (indicating a merger of companies that are close to being equals in size) are found to be related to more successful integration, whereas large size-differentials within the M&A generate major difficulties with integrating the R&D activities of M&A partners.

What this part of the empirical literature suggests is that the lack of organizational fit between companies of different size-classes has some serious consequences for the integration of the innovative activities of different M&A partners. This seems to contradict a large part of the literature (Haspeslagh and Jemison, 1991; Hoskisson and Hitt, 1994; Jemison and Sitkin, 1986) that suggests that the disparity between sizes of merging companies might

be relatively easy to deal with in case of the integration of manufacturing, marketing and sales. However, in the complex world of non-routinized and specialized R&D associated with specific technological capabilities, organizational integration aimed at technological performance might be more complex and more difficult to achieve than improved performance related to largely standard activities such as manufacturing and sales (Nelson and Winter, 1982). This implies that, if companies are too far apart in terms of their size and related aspects of their organisational structure, the realisation of improved technological performance after the M&A might not be as simple as assumed on the basis of simple arithmetic. In other words, adding up the research and other technological activities of smaller partners to those of a large company, assuming that the integration process will take place rather smoothly, underestimates the organisational intricacies of such an M&A between unequal partners. Hence:

H. 4 *There is a positive relationship between the degree of similarity in terms of the size of companies involved in M&As and the post-M&A technological performance of companies.*

METHODS

Sample

The level of analysis in this study refers to the companies that are engaged in M&As and not the individual M&As as such. The main reason for this approach is that technological performance is generally measured at the level of the company and not at the level of an individual M&A. In particular for a small acquisition the effect on the technological performance of each individual 'transaction' is difficult to trace, whereas the combined effect of a number of acquisitions of a company is detectable. Also, the registration of technological

performance, e.g. through patents, usually takes place at the level of the company at large and not at the level of an acquired or merged unit.

As mentioned above, some previous research reveals that M&As are expected to affect technological performance of companies, in particular in R&D intensive industries. We chose companies in the international computer sector as the primary group for the analysis because of its high-tech character (OECD, 1997) and the uncertainty that characterises technological and economic development in this industry. In this study the computer or data processing industry is defined by companies that produce mainframes and other computers, peripherals, CAD/CAM/CAE equipment, data communications equipment and other data processing products. The uncertainty surrounding the computer industry is well-documented in a large number of popular publications and in the academic literature, see e.g. Duysters (1996); Harper (1996); Korzeniowski (1988); Malerba et al (1991); Mansell (1993) and Raphael (1989). These uncertain conditions are caused by endogenous technological change within the industry itself, the dependence on technological developments in the supplying micro-electronics and other components industries and the convergence of computer and telecom technologies which has led to lateral entry in both industries (Duysters and Hagedoorn, 1998). The above implies that we analyse the effect of M&As on the technological performance of these computer companies whereas the M&As in which these companies are involved might of course be related to a variety of manufacturing industries. We excluded service related M&As from the analysis, including software related M&As, as these service activities are known to generate little or no technical innovations measured by means of patents.

The above implies that, as in so many other somewhat comparable studies, we use a

single-industry design, albeit with a choice for a large and international sector with a substantial number of M&As, to control for potential industry effects. We study the effect of a total number of 201 M&As, made during the period 1986-1992, in a sample of 35 companies. Thirty of these companies have their headquarters in the USA, three companies are from Asian countries and two companies are European. These 35 companies (see Appendix I) with M&As, are taken from a total of 100 companies that account for more than 90% of the international computer market (Gartner, 1994). In terms of market share the 35 M&A-active companies in our sample represent nearly 70% of the international computer market. The other 65 companies, all relatively small firms, did not have any M&A during the period under investigation. Given the major differences between these sub-populations, in terms of the size of companies and their relevance to the computer industry, it is impossible to use the other sub-population as a control group.

Variables

We took the patent intensity growth of US patents of the companies in the sample from 1989 to 1994 as an indicator of the dependent variable technological performance. We took the number of patents that firms applied for in all IPC classes to measure their technological performance. As with so many other indicators, this patent indicator is subject to a debate regarding its bias and shortcomings (Archibugi, 1992; Cohen and Levin, 1989; Griliches, 1990). However, despite some shortcomings it is generally accepted as the most appropriate indicator that enables us to compare the technological performance of companies in terms of new technologies, new processes and new products (Acs and Audretsch, 1989; Aspden, 1983; Bresman, Birkenshaw and Nobel, 1999; Brouwer and Kleinknecht, 1999; Cantwell and Hodson, 1991; Devinney, 1993; Freeman and Soete, 1997; Griliches, 1990; Napolitano and

Sirilli, 1990; Patel and Pavitt, 1995; Pavitt, 1988). Even authors that are somewhat critical of the overall use of patents as an indicator of technological performance or innovation, such as Arundel and Kabla (1998) and Mansfield (1986), admit that they are more than appropriate in the context of the current, high-tech sector. Also, the less patents are used for cross-sectional analysis that ignores inter-sectoral differences in the propensity to patent, the better this indicator reflects the technological performance of companies in one sector.

Some recent research comparing patents with other indicators of new product and process development (Devinney, 1993; Brouwer and Kleinknecht, 1999) has established that there is "... a systematic relationship between a firm's innovation output (i.e. sales of innovative products) and its actual patenting behaviour ..." in particular in high-tech industries such as the computer industry (Brouwer and Kleinknecht, 1999, p. 622).

Although, the literature already indicates that patents can be an appropriate indicator of technological performance and new product and process development, we also considered new product and process announcements as such. We looked at new product announcements, for instance through Dialog's NPA/Plus, as an alternative indicator of technological performance of companies. After consulting a small sample we decided not to use this as an alternative measure. These new product announcements are based on marketing press releases and little or no screening appears to be undertaken by the databank operator. Patents, on the other hand, in particular those registered in an advanced economy such as the USA, are screened for their original contribution during the pre-application period and during the actual application period by company-engineers, patent lawyers and patent office officials and as such this indicator appears less biased than new product announcements from the marketing departments of companies.

The screening of new product and new process announcements through technical ‘mapping’ and ‘technometrics’ with technical benchmarks based on inter-subjective engineering and technical input could provide some additional insight that might be useful for very detailed studies on the measurement of technical performance of individual products (Grupp, 1994). However, given the objectives of this study and the usefulness of patents as a general indicator of technological performance we prefer to follow the ‘mainstream’ of innovation studies and apply patents as our main indicator.

As the size of companies will have its effect on the technological performance of companies, as suggested by many innovation studies, we will take the growth in ‘patent intensity’ (the ratio of the number of patents and total revenues) as the actual dependent variable.

The time-lag between M&As and the change in technological performance covers an average period of six years (from the mean of the years for the independent variables, 1989, to the final year for which the changes in technological performance is measured, 1994). According to Singh (1971) and Buono and Bowditch (1989) it takes on average nearly five years before organizations are assimilated and gains of the M&A are materialized. According to Scherer (1984b) and Pakes and Griliches (1984) it takes on average about one year before inventions through R&D lead to patent applications. Taken together these two periods add up to an average time-lag of about six years. Given the degree of variance found for both the period of organizational assimilation and the effective innovation time-span, as reported in previous research, we experimented with several alternative analyses. We used shorter intervals as well as different time-lags, without compromising the size of the sample. The outcomes of these alternative analyses were similar to the results presented in this paper.

In the statistical analysis presented below we will apply the following independent variables:

Related and unrelated (conglomerate) M&As are measured in terms of the (dis)similarity of the SIC code of the industries of M&A partners at the three digit level (Kusewitt, 1985). For related M&As in the computer industry we constructed a list of related SICs (see Appendix II) based on studies of the computer industry (Duysters, 1996, Harper, 1996, Malerba et al, 1991, Mansell, 1993). This list of related SICs was presented to a small group of senior specialists from the computer industry who all confirmed that these industries are generally accepted as related industries. For each M&A the SIC code of the target company was obtained through Securities Data's data base on M&As (see section on Data sources). The actual measure being used for each computer company in the sample is the share of its related M&As as a percentage of all its M&As.

Technologically related and technologically unrelated M&As are measured in terms of the (dis)similarity of the patent classification (IPC) code of the patents owned by the M&A partners at the three digit level. These patent classes represent the generally accepted perception of fields of technology by scientists and engineers (Griliches, 1990) to a similar degree as for instance industrial classes represent generally accepted classifications of industries by economists. For technologically related M&As we constructed a list of related IPCs (see Appendix III). The same group of specialists from the computer industry, that we consulted on the industry relatedness, confirmed that the patent classes taken to measure technological relatedness could be used to indicate the technological relatedness of M&As. If the majority of the M&A target's patents falls in related IPC classes, then the target company is considered to be technologically related. The actual measure for each company is the share

of technologically related M&As as a percentage of all its M&As.

R&D intensity of M&A partners is measured as the ratio of the R&D intensity of the M&A partners, based on their average R&D expenditures of the two years before the M&A, controlling for the average sector R&D intensity. We assessed the R&D intensity of each single firm against its industry average. If e.g. a target company has a 1.5 higher R&D intensity than the industry average, the value of the ratio would be 1.5. In order to arrive at one overall ratio for the combined set of M&As we added up the ratios and divided this number by the number of M&As. This number is divided by the ratio of the acquirer to end up with the value of the variable. If the acquirer has a ratio of 0.5 (half the intensity of the industry average) and the combined set of targets have a ratio of 1.5 then the value of this variable is 3. The ratio of the acquired firm is 3 times higher than that of the acquiring firm. That means that the ratio is 3 (1.5 divided by 0.5). Thus, the higher the value of this measure, the higher the R&D intensity of the target(s) in comparison to the R&D intensity of the acquirer.

Similarity of size of M&A partners refers to the ratio of the size of both companies involved in the M&A. Size is measured as the natural logarithm of total revenues in the year before the M&A. Logarithms are taken to correct for a small number of very large companies. We divided the size of the acquiring firm by the size of the target firm. Because in all the cases the acquiring firm was the larger of the two, a lower ratio implies more similarity among the firms. The ratio's of size for companies with a number of M&As are also added up and divided by the number of their M&As.

Control variables

The R&D intensity of the companies in the sample (1986-1992), i.e. R&D expenditures as a

share of total revenues, is taken as a control variable because we expect a direct effect of R&D on patent activity as research efforts will (at least partly) be transformed into patents. In the literature the relation between R&D and patents has been studied extensively. Kamien and Schwartz's (1982) have established that, on average, there is a direct relation between innovative effort or input and technological output. However, it is added that other factors can influence the transformation and the relation may not be linear. In studies by Bound, Cummins, Griliches, Hall and Jaffe (1984), Scherer (1984a) and Hausman, Hall and Griliches (1984) it is mentioned that patenting output decreases gradually with an increase of R&D expenditures.

Research on the effect of the internationalization of innovative activities through international M&As suggests both positive and negative effects of this international diversification on technological performance, but the positive effects seem to be dominant (Freeman and Hagedoorn, 1995; Hitt et al, 1997 and Hoskisson and Hitt, 1994). These positive effects are largely due to different local advantages generated by international R&D sourcing through acquired companies. Therefore, we will control for the international and domestic character of the M&As of the companies in the sample. The international and domestic character of the M&As of a company is determined by the share of international M&As in the total number of its M&As as registered according to the home-country of the headquarters of companies during the period 1986-1992.

A third control variable that we introduce relates to the possible effect of experience with establishing of M&As on the performance of M&As. It is well-known that one of the main problems for companies active in the field of M&As is the difficult task of acquiring adequate information on target firms. It is obvious that, depending on the situation, target

companies might have an incentive to somewhat misrepresent their innovative potential by overstating or understating their technological capabilities and the value of their research programs. This 'inspection problem' with M&As or the problem of the possible lack of adequate information can be solved partially by experience as companies establish some routines and learning capabilities regarding the valuation of other companies. As suggested by Hitt et al (1998) and Oster (1994) companies that have built up some experience in M&As might find it easier to assess the value of target firms. Experience with the actual incorporation of the innovation programs of other companies in the overall innovation strategy will also help to improve the post-M&A performance. This suggests that experienced M&A active firms have higher post-merger technological performance than inexperienced companies. Experience with M&As is measured by taking the natural logarithm of the number of M&As made during the seven years period from 1986 to 1992.

Data sources

Data on M&As for the period 1986-1992 is derived from a data bank owned by Securities Data which we used via on-line access. This data bank contains information on world-wide M&As and its relational form facilitates the linking of data files to each other and also to other data banks. Within the M&As data base there is information on the year the M&A was established and company information on the acquirer, the target, the parent acquirer and the parent target firm. The industry information is provided in SIC codes of the acquiree and acquirer.

Data for the size of companies and their R&D expenditures is taken from several issues of Gartner Group's annual Yardstick top 100 world-wide covering a period from the early eighties to the early nineties. The Yardstick top 100 world-wide is an authoritative

statistical review of the international computer industry comprising the top 100 computer companies. Data in the Yardstick was updated annually through surveys and research by Gartner Group consultants and industry analysts. When data was missing, estimates were taken from industry analyst input and from other available industry sources. The Yardstick contains calendar year information, not information based upon fiscal years, which allows us to make better comparisons between companies. Also, the Gartner data is adjusted for the effect of currency exchange rates.

We obtained additional data on R&D expenditures, size and revenues of companies involved in M&As through well-known data bases such as Compustat, Disclosure and Worldscope.

The data on patents for the dependent variable (technological performance) is taken from the US Patent and Trademark Office database (US Department of Commerce). Although this US data could imply a bias in favour of US companies and against non-US firms, the group of non-US companies in this sample represents a group of innovative and rather large firms that are known to patent world-wide. Furthermore, the innovation literature suggests several other reasons to take US patents as an indicator. Frequently mentioned are the importance of the US market, the 'real' patent protection offered by US authorities, the level of technological sophistication of the US market which makes it almost compulsory for non-US companies to file patents in the USA. See Patel and Pavitt (1991) for a discussion on the use of US patent data.

ANALYSIS

In order to test the hypotheses we applied a lagged ordinary least square regression model (see

table 2). The correlations in table 1 do not suggest multicollinearity and there is also no indication of autocorrelation (see the Durbin-Watson statistic in table 2). However, given the relatively high R^2 of the model we undertook some additional tests to detect possible multicollinearity. First, we regressed each independent variable on all the other independent variables, see Appendix IV. This is described as the most preferred method of assessing multicollinearity in Lewis-Beck (1993). The advantage of this method over the frequent practice of examining bivariate correlations among the independent variables is that this method takes into account the relationship between an independent variable and all other variables. This test in Appendix IV did not detect multicollinearity either as adjusted R^2 below 0.6 are seen as more than acceptable (Lewis-Beck, 1993). In addition, we performed a number of other multicollinearity diagnostics, taking a closer look at VIF and Tolerance values (see table 2). Again, there were no signs of multicollinearity. Finally, we evaluated the condition indexes and examined the variance proportions of the coefficients (see Appendix V) without finding any indication of multicollinearity.

----- insert table 1 about here -----

----- insert table 2 about here -----

Table 2 demonstrates that, as expected in hypothesis 1, our analysis generates a significant, positive relationship between the degree to which companies use related M&As and their technological performance. For hypothesis 2, which concerns the aspect of technological relatedness, we found a positive but statistically insignificant effect of these technologically related M&As on the technological performance of companies.

Our results do, however, show that the acquisition and merging of companies with above average R&D intensity significantly improve the technological performance of the

acquiring firm (hypothesis 3). Also, the expected relationship between the degree of similarity in terms of the size of companies involved in M&As and the technological performance of the acquiring firms (hypothesis 4) was indeed established in our analysis (lower scores are associated with greater similarity).

The control variable for the R&D intensity of companies seems to have a significant, albeit negative, impact on the improved technological performance of companies. This indicates that, as already found in other contributions discussed in the above, patenting output decreases with an increase of R&D expenditures. In other words, an increase in R&D intensity of companies does not imply a growth in technological performance. Our findings for the second control variable suggest that, as found in some previous research, international M&As improve the technological performance of companies. However, experience of companies with M&As does not seem to have a significant, positive influence on their technological performance.

DISCUSSION

Our analysis demonstrates that major aspects of the strategic and organizational fit of companies engaged in M&As seem important for generating improved technological performance in a high-tech environment. Our findings suggest that the strategic fit between companies in related product-markets increases the innovative potential of M&As. This finding adds additional support to much of the empirical evidence of previous research on the economic performance of M&As that indicates that related diversification through M&As is more beneficial to companies than unrelated diversification (Oster, 1994; Porter, 1987; Singh and Montgomery, 1987). The role of this particular aspect of the strategic fit of companies in explaining performance improvement supports much of the conventional

wisdom from e.g. economics regarding the economies of scale and scope that companies can achieve when they expand into related activities. The strategic fit of M&As in terms of broad product-market categories seems to generate a base-line for joint activities that secures the overall relevance of these M&As to the improved performance of the combined companies. However, it is important to note that this aspect of the strategic fit is still largely related to the existing activities of companies, whereas the technological capabilities of merging companies are expected to be also dependent on future-oriented technological aspects of their strategic fit.

Things seem to become somewhat more complicated when we look at this technological aspect of the fit of M&As. We found somewhat mixed evidence regarding the impact of the technological fit of merging companies on their technological performance. It appears that linking up to above-average R&D intensive companies generates better results than merging with companies that have a similar profile in terms of their technological track record. We recall that some of the older literatures (Link, 1988; MacDonald, 1985) already indicated that M&As with R&D intensive firms would enable acquiring companies to increase control over high-tech environments that are relevant to them. When companies establish M&As with companies with an above-average R&D intensity, this implies that they are integrating partners that are more likely to be engaged in new activities and as such this adds to the formation of new capabilities and learning skills within the new entity. In other words, these R&D intensive M&As are instrumental to the more general process of exploratory learning (Dodgson, 1993) and they play an important role in the improvement of technological competences that are crucial for companies to remain competitive in a high-tech environment (Haspeslagh and Jemison, 1991; Hitt et al, 1998).

It is obvious that the 'depth' of the technological relatedness of M&As, i.e. the similarity in levels of R&D effort, affects the increased R&D potential of the combined companies. When companies engage in M&As with companies with higher R&D inputs, these M&As are expected to be future-oriented as the increased R&D intensity of these companies focuses on the search for new technologies, products and processes. As such these R&D increasing M&As have a long term, strategic effect that we found to lead to improved technological performance of the combined companies.

However, there is considerable chance of duplication of existing technological capabilities, with a similar 'breadth' of technological relatedness of companies, when they only share broad patenting profiles based on previous technological achievements. In that case, there are fewer learning opportunities and companies are expected to have more difficulty engaging in new activities and developing new technological capabilities that will lead to improved technological performance. In other words, unlike the 'depth' of technological relatedness, the 'breadth' of technological relatedness of M&As only reflects the status quo of the technological capabilities of companies and, as such, expansion through technologically similar M&As cannot be expected to lead to improved technological performance. Combining companies with similar technological capabilities and a somewhat similar technological track-record merely duplicates existing capabilities which have little effect on the future technological performance of the combined companies.

The organizational fit of companies, their similarity of size, which we found to be important to explain improved technological performance, seems to benefit the actual integration process of merging companies. Previous research (Chakrabarti et al, 1994; Gerpott, 1995) already mentioned that large differences in size of companies indicates

dissimilarities in the organisational setting of partners, which might frustrate the actual post-merger integration process. From the perspective of the technological performance of M&As, our research shows that a large difference in size of companies, indicating a poor organisational fit, generates weaker performance than in the case of greater organisational similarity of partners. The popular business literature provides many examples from high-tech industries (in particular biotechnology, software, microelectronics and computers) where large companies have great difficulty in integrating small companies with a different 'culture' while keeping key-employees from these acquisitions 'on board'.

Although not directly related to the effect of strategic and organizational fit on the technological performance of companies, our research suggests some interesting results for international M&As and the effect of experience with M&As on technological performance. It appears that companies that have a preference for international M&As, that benefit from several international R&D sources and from different regionally concentrated technological competencies, improve their technological performance. As discussed in the above this highlights the importance of international learning through M&As as being very important for companies in a high-tech environment that has also become highly internationalised (see also Barkema and Vermeulen, 1998).

Somewhat surprisingly, we found no clear evidence of the positive effect of the experience of companies through a larger number of M&As. Increasing the number of M&As does not seem to necessarily improve the performance of companies in a linear way. However, most companies in this sample have some experience with M&As as they made more than one M&A in a few years. What this finding does indicate is that, if there is an experience effect regarding M&As at all, the effect of increased experience would most

probably wear off beyond a rather low threshold. Also, as suggested by Hitt et al (1998), for companies to learn from their M&As, the sheer number of M&As as such could be less decisive than their effective learning capability with regard to M&As and other external sources of innovation.

CONCLUSIONS

Our study focuses on a single, high-tech industry, albeit a large one and with an international population consisting of a variety of companies, that are studied for a period of nearly a decade. As our results might reflect some industry and period-specific factors, elaboration of the study in different settings could generate useful additional insights. With this caveat in mind, we can draw the following conclusions.

Our research demonstrates that M&As can contribute to improving the technological performance of companies in a high-tech environment. However, it has to be stressed that both the organisational and the strategic fit of the companies involved in these M&As are crucial for the technological success of M&As. These critical factors were already discussed in some earlier contributions that concentrated mainly on the general effect of M&As on economic performance and profitability. Not only does our current research establish the important role that organisational and strategic fit seem to also have for the technological performance of M&A-active companies, it in particular emphasises the importance of linking-up to other research-intensive companies. This suggests that the acquisition of these companies, through which the acquiring company can improve its technological skills and expected learning capabilities, has a positive effect on the technological performance of acquiring companies after M&As have taken place.

The current contribution does not investigate the short-term economic benefits of

M&As but it concentrates on the technological performance of companies that might have long-term strategic consequences, eventually leading to increased economic performance. In that context these M&As can be interpreted as an attempt of companies to increase both control over their environment in order to respond to uncertainty and to improve their performance. The successful integration of other companies in a familiar environment and the search for new opportunities through M&As are both mentioned in that context as major mechanisms in a two-fold strategy to improve technological performance. The relevance of market relatedness of M&As stresses the importance of uncertainty reduction by means of integration of companies that are active in similar sectors and that have some similarity in terms of product-markets. The integration of R&D intensive companies, however, creates the necessary new skills and capabilities that enable the company to learn about new perspectives that can decrease its dependency on its existing environment and improve its performance. Therefore, the external acquisition of technological capabilities by means of M&As can, if proper attention is paid to the strategic and organizational fit of companies, prove to be an important strategic advantage for companies in high-tech sectors.

Table 1 Univariate statistics and Pearson correlation coefficients, n=35

	Mean	Standard Deviation	1.	2.	3.	4.	5.	6.	7.	8.
1.Technological performance	0.0044	0.0080	1.000							
2.Related M&As	0.9630	0.0972	0.591**	1.000						
3.Technologically related M&As	0.9289	0.2394	-0.247	-0.111	1.000					
4.R&D intensity of M&A partners	0.8507	0.4029	0.030	0.034	-0.538*	1.000				
5.Similarity of size of M&A partners	0.8915	0.0726	-0.068	-0.098	0.137	0.276	1.000			
6.International character of M&As	0.7417	0.3825	-0.076	-0.165	-0.114	-0.052	0.348	1.000		
7.Experience with M&As	1.1036	0.9376	0.341*	0.258	-0.237	0.037	-0.522*	-0.313	1.000	
8.R&D intensity of companies	0.0925	0.0387	0.523*	0.100	-0.430*	0.550*	-0.022	0.019	0.123	1.000

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 2 Regression estimates of the influence of M&As (1986-1992) on the technological performance of companies (growth of patent intensity, 1989-1994) in the international computer industry, n=35

Variables	Beta	T	Collinearity statistics	
			Tolerance	VIF
Constant		-1.15		
Related M&As	0.607	4.88***	0.904	1.106
Technologically related M&As	0.293	1.80	0.529	1.892
R&D intensity of M&A partners	1.056	5.68***	0.405	2.468
Similarity of size of M&A partners	-0.362	-2.16*	0.499	2.004
International character of M&As	0.306	2.17*	0.704	1.420
Experience with M&As	0.186	1.26	0.638	1.567
R&D intensity of companies	-0.522	-3.53***	0.640	1.562

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$

$R^2 = 0.888$ $Adj R^2 = 0.790$ $Std Er = 0.00537$
 $F = 9.064$ $Sign. F = 0.003$ $Durbin-Watson = 1.404$

	df
regression	7
error	28
total	35

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APPENDIX I COMPANIES IN THE ANALYSIS

3Com	Exabyte	Network Systems
Acer	Fujitsu	Olivetti
Apple	General DataComm	Recognition Equipment
AST Research	Genicom	Seagate
Cadence	Gerber Scientific	Sequent
Compaq	Groupe Bull	Silicon Graphics
Conner	IBM	Storage Tech
Control Data Systems	Intergraph	Sun Microsystems
Cray Research	Maxtor	Tandem
Data General	Mentor Graphics	Unisys
Digital Equipment	National Computer Systems	Wang
Digital Communications	NEC	

APPENDIX II RELATED AND UNRELATED M&As ACCORDING TO SIC CODES OF PARTNERS

Related M&As are between companies that are both found in the following SIC classes:

- 357. Computer and office equipment
- 366. Communications equipment
- 367. Electronic components and accessories
- 369. Misc. electrical machinery, equipment and supplies (Batteries, Disk, Tape)
- 382. Measuring and controlling devices

All other cases refer to unrelated M&As.

APPENDIX III TECHNOLOGICALLY RELATED AND UNRELATED M&As ACCORDING TO PATENT CLASSIFICATION OF PATENTS OF PARTNERS

Technologically related M&As are between companies of which the patents correspond with the following IPC classes:

Seq. nr. (IPC code)	Description
27	Office computing and accounting machines
40	Misc. electrical machinery, equipment and supplies
43	Electronic components and accessories and communications equipment
55	Professional and scientific instruments

All other cases refer to technologically unrelated M&As

**APPENDIX IV MULTICOLLINEARITY TEST (REGRESSION ESTIMATES
OF EACH INDEPENDENT VARIABLE ON ALL OTHER
VARIABLES)**

Variables	R ²	Adj. R ²
Related M&As	0.481	0.135
Technologically related M&As	0.528	0.213
R&D intensity of M&A partners	0.704	0.506
Similarity of size of M&A partners	0.633	0.388
International character of M&As	0.673	0.455
Experience with M&As	0.705	0.509
R&D intensity of companies	0.497	0.165

APPENDIX V COLLINEARITY DIAGNOSTICS *

		Eigenvalue	Condition Index	Variance Proportions							
Model	Dimension			Constant	A	B	C	D	E	F	G
1	1	7.093	1.000	.00	.00	.00	.00	.00	.00	.00	.00
	2	.441	4.010	.00	.00	.00	.00	.00	.07	.46	.00
	3	.215	5.741	.00	.09	.00	.16	.00	.13	.06	.00
	4	.133	7.313	.00	.04	.06	.01	.01	.49	.16	.00
	5	.071	10.021	.00	.78	.01	.38	.00	.01	.03	.00
	6	.043	12.815	.00	.02	.88	.01	.02	.06	.03	.00
	7	.003	48.855	.05	.00	.04	.44	.84	.23	.01	.46
	8	.002	63.920	.94	.07	.01	.01	.13	.00	.26	.54
* Dependent variable: Technological performance											
A = R&D intensity of companies B = Related M&As C = R&D intensity of M&A partners D = Technologically related M&As E = International characters of M&As F = Experience with M&As G = Similarity of size of M&A partners											