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The impact of M&A on the R&D process An empirical analysis of the role of technological- and market-relatedness

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Abstract

Using information on 31 in-depth cases of individual M&A deals, we show that technological and market-relatedness between M&A partners *distinctly* affects the inputs, outputs, performance and organisational structure of the R&D process. While the findings in the literature on the effect of M&A on R&D are quite mixed, we can sharpen results by analysing data at the level of the R&D process. This comes at the price of a smaller sample and more qualitative data, for which caution in the interpretation is necessary. M&A between partners with ex-ante complementary technologies result in more active R&D performers after the M&A. In sharp contrast, when merged entities are technologically substitutive, they significantly decrease their R&D level after the M&A. Moreover, R&D efficiency increases more prominently when merged entities are technologically complementary than when they are substitutive. These two findings on the R&D level and the performance support the scope economy effect of M&A, on the one hand, and reject the scale economy effect of M&A, on the other. Next, for cases in which partners were active in the same technological fields before the M&A, the reduction of R&D is more prominent, while the R&D efficiency gain is smaller if merged entities were rivals in the product market prior to their merger than if they were non-rival. This suggests that rival firms reap little technology gains from mergers.

JEL classification: D21; O31; O32

Keywords: M&A; R&D; Scale and scope; Market-relatedness; Technology-relatedness

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1. Introduction

Firms have been using mergers and acquisitions (M&A) intensively as instruments for growth for many years. Concurrent with the heavy M&A activity, innovation has become increasingly important as a way for companies to achieve and maintain a competitive advantage. With both M&A and innovation being centrepieces of today's competitive strategy development, it is important to understand the consequences of M&A transactions on the innovative potential of firms. Unfortunately, most of the existing studies on the effects of M&A are limited to shareholder value or short-run firm performance (Mueller, 1980; Jensen and Ruback, 1983). The link between M&A and R&D is, despite its importance, even less well examined in the literature, at least directly. Views on how technological activities of firms are affected through M&A are often conflicting. For instance, R&D inputs can either increase or decrease: R&D may decrease after M&A due to the elimination of duplicated R&D; but M&A may realise scale and/or scope economies in R&D and therefore merged firms may have a bigger incentive to perform R&D than before their M&A. Results of testing which theoretical hypotheses fit the data better are mixed (Hall, 1999; Hitt et al., 1991; Ravenscraft and Scherer, 1987). Only a limited number of empirical studies really focus on the consequences of M&A on companies' technological activities, at least directly. Most of these empirical studies were carried out in the US and tend to find, on average, negative effects on R&D inputs; however, all show a high variance in results and hence fail to find any robust results.

The contribution of this paper is two-fold. First, we advance the discussion at a conceptual level by arguing that the impact of M&A on R&D and innovation depends on the relatedness between the target and the acquirer. We contend that both *technological-relatedness* and *market-relatedness distinctly* affect the relationship between M&A and innovation and should be accounted for simultaneously. To the best of our knowledge this has not been accomplished yet in the literature. The impact of a merger between firms active in the same technological fields is expected to lead to a rationalisation of the R&D process, while firms active in complementary technological fields are more likely to realise synergies and economies of scope in the R&D process through their merger. Relatedness on the output market is another important dimension. M&A activity through the aggregation of markets could lead to economies of scale in output and/or distribution. This will feedback into the innovation process. Similarly, economies of scope in product markets, or product diversification, will lead to efficiencies in the R&D process and hence indirectly stimulate R&D. Finally, increasing market power in the output market will have a positive effect on R&D performance, but there is no consensus in economic thinking as to whether it will lead to more or less R&D activities. While technological- and market-relatedness of partners in M&A might condition the measurable impact of M&A on the R&D process, we believe that addressing both these different effects jointly already constitutes an important conceptual contribution.

A second contribution of this paper is empirical. Sufficiently detailed data is required for advancing the joint analysis of the distinct effects of technology and market relatedness on the impact of the M&A on the R&D process. Using a new EU data set which was collected by directly interviewing key personnel of high- and medium-tech firms that have been involved in M&A, we measure the effects of M&A at the R&D management level rather than at the firm level, as was done in previous empirical studies. As a consequence, we can accurately link a particular M&A deal to associated changes in the R&D strategy. Although the sample is rather small – 31 deals and 62 companies – the data obtained provide in-depth information for each M&A deal. In particular, we have collected not only traditional R&D indicators, such as R&D expenditures, R&D personnel, or patent counts, but also in-depth measures such as change in R&D portfolios and the degree of R&D reorganisation. Wherever possible, these data were cross-checked with published documents such as year reports, press releases, newspaper articles and industry publications. As a result of these in-depth measures, we can study not only *to what extent* M&A have an impact on R&D but also *how*, by scrutinising the dynamic reorganisation processes of the firms associated with M&A. Furthermore, from the data, we construct indicators for technology- and market-relatedness, which allow us to test the impact of relatedness in more depth than has been done in existing studies. Nevertheless, some caution is in order when interpreting our results as they are derived from survey data with a limited sample size.

Our results can be summarised as follows. First, when merged entities are technologically complementary, they become more active R&D performers after the M&A. In sharp contrast, when merged entities are technologically substitutive, they significantly decrease their R&D level after the M&A. Second, R&D efficiency increases more prominently when merged entities are technologically complementary than when they are substitutive. These two findings on R&D level and performance support the scope economy effect of M&A on the one hand and reject the scale economy effect of M&A, on the other. Third, if we focus on the cases in which merged entities are technologically substitutive, the reduction of R&D is more prominent and the R&D efficiency gain is smaller if merged entities were rivals in the product market prior to their merger than if they were non-rival. This suggests that rival firms reap little technology gains from M&A.

Finally, we also dig into the sources from which changes in R&D activities originate. We find that when merged firms are technologically substitutive, key employees tend to leave more often, the R&D portfolio becomes more focused, the R&D horizon becomes shorter and internal funds available to R&D decrease.

The paper is organised as follows. Section 2 surveys the existing literature on the impact of M&A on R&D. We draw from both the economics and the technology management literature. Section 3 summarises the major theoretical effects M&A can have on the R&D process as found by the existing literature. In addition, we discuss the consequences of these effects for our measures of R&D input, output, performance and organisation, depending on the technology- and market-relatedness between the merging entities. Section 4 describes the data and Section 5 reports the results of our statistical analysis. The section concludes with a discussion of how the relatedness between partners in the M&A conditions these discussed effects. Concluding remarks are presented in Section 6.

2. Literature review

In sharp contrast with the extensive literature that exists on the impact of M&A on the financial and economic performance of companies, only a limited number of studies focus directly on the consequences of M&A on the companies' technological activities. Furthermore, only empirical studies exist, while the theoretical literature remains mute on this issue. Nevertheless, the theoretical literature on M&A indirectly provides several predictions about the relationship between M&A and R&D. In our search for insights that bear upon the relationship between M&A and R&D, and more particularly on the impact of relatedness, we will review both theoretical and empirical studies from the *economics* (financial economics and industrial organisation) and the *management* literature.

The *theoretical studies in financial economics*, or corporate control literature, suggest that M&A are used to correct for internal inefficiencies, agency problems and capital market imperfections (e.g. Jensen and Ruback, 1983). With respect to R&D, this literature indicates that the increased financial leverage from M&A activities affects the financing of R&D activities by increasing the opportunity cost of funds allocated to R&D and leading to the elimination of R&D projects and/or a higher risk-aversion in R&D project selection.

The *theoretical studies in the Industrial Organisation* literature (e.g. Caves, 1989; Roller et al., 2001) shed some light on the role of relatedness in output markets between the merging firms. M&A among firms that share the same production technology holds the potential for operational synergies. These are the classical economies of scale and scope in production. In addition, M&A among firms competing in the same output market have the advantage of collusive synergies, capitalising on gains in market power. With respect to the effects of M&A on R&D, the *Industrial Organisation* literature provides mixed predictions. In the presence of scale and scope advantages in R&D, ex post R&D efficiency will be higher after the merger (Cohen and Levin, 1989; Roller et al., 2001). However, the possibility to better coordinate R&D investment after the M&A will typically lead to lower R&D expenditures, unless technology spillovers are important (Kamien and Schwartz, 1982; De Bondt, 1997).

The *empirical studies in the economics* tradition provide statistical analysis on large samples, mostly for the US. Most of these studies rely on publicly available information sources for M&A activities, R&D investment levels and patents at the industry or firm level (Hall, 1990, 1999; Ravenscraft and Scherer, 1987; Lichtenberg, 1992; Hitt et al., 1991, 1996; Blonigen and Taylor, 2000). They have generally found that acquisitions have a negative impact on the post-acquisition R&D input and output of acquiring firms. A number of empirical studies have tried to test the impact of *market-relatedness* on the profitability of M&A. That related M&A would create more value does, however, not show up as a stylised fact (Rajan et al., 1998; Bodnar et al., 1997; Chevalier, 2000).[1] In summary, most empirical studies in the *economics* tradition have generally found that acquisitions have a negative impact on the post-acquisition R&D input and output of acquiring firms. Unfortunately another consistent finding in these studies is the lack of strongly significant effects. This is not surprising, given the absence of an in-depth analysis of the conditions governing the relationship.

The *Technology Management* literature tries to dig deeper into the processes governing the impact of M&A on innovative output. Most emphasis is on the process of realising technological synergies through M&A. Seth (1990) a.o. stresses the importance of understanding how synergies are realised. An important factor driving the potential synergies that can be realised within the M&A is whether or not the merging entities "strategically fit". This is determined by their "*relatedness*". The Strategic Management field has explored this issue of relatedness and value creation in more depth (a.o. Rumelt, 1974; Seth, 1990; Piscitello, 2004). To better understand the relationship between M&A and R&D, the dimension of technological-relatedness is of particular relevance. Similarity in research base facilitates the integration of the acquired and acquiring knowledge bases from both technical and organisational perspectives (Kogut and Zander, 1992; Grant, 1996). Common skills, shared languages and similar cognitive structures enable technical communication and learning. When the knowledge bases are unrelated, assimilation or application of the new knowledge is likely to be difficult and resource consuming, if not counter-productive (Haspeslagh and Jemison, 1991). Although firms with larger knowledge bases stand to gain more from combining know-how through M&A, they are also more likely to witness fairly major changes in existing routines, when own and acquired knowledge is dissimilar (Ahuja and Katila, 2001).

Empirical studies in the strategic management tradition are often based on small sample survey results (Capron, 1999; Capron et al., 1998; Chakrabarti et al., 1994; Granstrand and Sjolander, 1990; Bresman et al., 1999; Ernst and Vitt, 2000). This literature predicts a more favourable impact of M&A on R&D, at least when (1) firms are involved in M&A for technology sourcing purposes, (2) the M&A integration process is effectively managed, (3) firms are able to retain key people, and (4) firms have a strong own internal knowledge base, which allows to better evaluate potential targets and to realise synergies from combining know-how from the target and acquiring firm.

Identifying the technology-relatedness between target and acquirer further improves the evidence on the impact of M&A on R&D. Ahuja and Katila (2001) consider a sample of 72 leading firms in the global chemicals industry that were involved in 1287 acquisitions in the period 1980–1991. They identify the factors leading to higher innovative performance, as measured through the number of patents obtained 1–4 years after an M&A. Besides the absolute and relative size of the acquired knowledge base, they focus on the impact of relatedness of the knowledge base of acquirer and target, as measured through the number of common patents and patent citations. They find significant evidence for nonlinearity, where both too close and too distant cases need to be avoided, the first for lack of complementarity and the second because of integration problems. In addition, they identify as success factor a higher absolute (but not relative) size of the acquirer's knowledge base. Chakrabarti et al. (1994) investigate the technical and economic results of technology-driven M&A on 30 dyad interview cases. Among the factors that seem to be important to explain technological failure, they find cultural differences, size asymmetries between target and acquirer, and production technology differences. Ernst and Vitt (2000), in a sample of 43 acquiring EU firms, trace the inventive performance of 61 key inventors, i.e. individuals with high patent activity and high-quality

[1] A problem in these aggregate studies is the construction of an operational measure for market-relatedness. Using industry codes as a measure for market-relatedness, Chevalier (2000), for instance, finds that the event responses are largely independent of measures of the extent to which the merger is related.

patents. Those inventors that stayed were more likely to have reduced inventive performance, the larger the cultural differences between R&D departments and the greater the technological distance between merging entities.

The empirical studies in the management literature examine the effect of technological relatedness of the M&A partners on the R&D process, but neglect the potential interaction with external, market-related factors identified in the economics literature. In what follows, we attempt to control for both dimensions of relatedness – technological and market relatedness. In line with Piscitello (2004), we contend that the interconnectedness between the companies' technological-relatedness and market-relatedness needs to be considered to better understand the relationship between M&A and R&D.

3. M&A and the R&D process: effects, consequences and relatedness

3.1. Research design

The major conclusion from the existing studies is that any results on the relation between M&A and the innovation process are weak and/or difficult to generalise. First, most data used to analyse these effects in the economics literature are standardised large sample data such as R&D expenditures, patent counts and productivity. These data could reveal to what extent mergers and acquisitions have an impact on innovation, but they do not tell us *how*. The importance of zeroing in on the acquisition management process implies, however, that 'depth' is a necessary dimension in empirical studies, requiring information that is typically beyond publicly available data sources. The case study design employed for collecting our data allows us to uncover *how* M&A impacts innovation by interviewing key people and scrutinising the dynamic reorganisation process of the firms associated with M&A. Second, most data previously used are aggregated at the firm level and are too noisy to analyse the impact of a single M&A deal on innovation because a firm often engages in more than one acquisition (sometimes more than 10 per year). We performed our case study analysis at the deal-level, and furthermore analyse the impact at the business unit-level, which is finer than most firm-level data previously used. Third, the *breadth* of this study is unique because we explore different effects of M&A on R&D and innovation simultaneously, as opposed to the existing literature.

In summary, the information gathered through the case studies helps to find evidence corroborating or refuting existing hypotheses about the relation between M&A and innovative inputs, outputs and performance by uncovering *how* they are linked at a *more accurate* level (Yin, 1994). The price we pay for this depth and breadth of the study is a smaller size of our sample. We had to limit ourselves to studying 31 mergers or acquisitions, which will have its implications for our analysis, as discussed below. Furthermore, relying on interview data opens the door to biases not present in more standardised data. Therefore, we see the results of this study as being more exploratory – identifying the measures that companies took with respect to R&D and innovation following a M&A.

The main hypothesis developed in this paper is that the *relatedness* between partners will condition the effect that a merger or acquisition has on the R&D process. Failing to control for this important segmenting variable may lead to weak or inconclusive results, as is mostly the case in existing empirical studies on the effect of M&A on innovation. From the literature review we extract six potential processes through which M&A will have an impact on the R&D process. Although hypotheses exist about the consequences of M&A for R&D inputs, R&D outputs, R&D performance, R&D organisation and R&D mission at the level of each of these processes, separating these consequences for each process empirically is difficult. Typically, the joint effect will be measured. However, by segmenting the M&A according to relatedness between partners, we are able to characterise some of these effects unambiguously. Because we identify various measures of R&D inputs, R&D outputs, R&D performance, the organisation and management of R&D, and R&D mission, the data allow us to test our hypotheses on the relation between relatedness of the target and acquirer and the consequences of the M&A for the R&D process in more depth and breadth than the existing literature. We expect that the impact of different types of relatedness will manifest itself in different effects. First, there exists a *direct effect* of M&A on the R&D process whenever the R&D processes of the partners are related. We capture this relatedness of the R&D processes by defining the *technology*-relatedness of the partners. Second, there potentially exists an *indirect* effect of the M&A on the R&D process. Most M&A are not driven by innovation-related motives, but indirectly will impact the R&D process through the reorganisations taking place in the output markets and production processes. The *market*-relatedness of the partners in the M&A intends to capture this indirect effect that works through the output market and production process and reinforces the different direct effects on the R&D process.

We start out by describing the six potential processes and their consequences on R&D (Section 3.2), after which we will discuss how the relatedness between M&A partners will trigger a specific combination of processes (Section 3.3).

3.2. M&A and the R&D process: effects and consequences

3.2.1. Indivisibilities/specialisation, i.e. spreading fixed costs of R&D over more R&D output

A first important factor derived from the economics literature is the existence of economies of scale in R&D. Economies of scale due to specialisation are realised through both the spreading of fixed costs over more output and the elimination of common inputs for the production of the same output. In order to disentangle the consequences of M&A on the R&D process, it is helpful to distinguish both of these effects. While the elimination of common inputs is discussed below, the possibility to spread fixed costs over more output increases the incentive to invest in R&D. One should expect an expansion of the R&D activities due to the economies of scale in this activity. M&A where this effect is important are, therefore, unlikely to cut R&D in the form of personnel, labs and equipment, or to terminate R&D programs, but rather are expected to increase the scale of typical R&D projects. Furthermore, the new entity will attempt to reorganise the R&D process by centralising knowledge, reorganising R&D teams and specialising in R&D tasks, while setting up parallel projects. These changes should lead to higher R&D output, measured through the speed of developing knowledge and introducing new products and processes, and to higher R&D performance, including more productive R&D personnel and R&D management. The M&A based on economies of scale in R&D will tend to focus the organisation on specific technological fields.

3.2.2. Indivisibilities/specialisation: spreading fixed costs of R&D over different types of R&D output

A second important factor derived from the economics literature is the existence of economies of scope in R&D. Economies of scope arise whenever the total cost of producing two goods jointly is lower than producing each of the goods separately. Combining different R&D programs within the same organisation can create economies of scope in R&D, leveraging R&D investments across different R&D projects. A similar logic as in the case of economies of scale is applicable. Again the new organisation is unlikely to cut R&D in the form of personnel, labs and equipment, or to terminate R&D programs, but rather is expected to increase the scale of typical R&D projects to achieve critical mass. Furthermore, the new entity will attempt to reorganise the R&D process by redeploying resources such as technical personnel and equipment and creating joint research teams. These changes should lead to higher R&D output measured through the speed of developing knowledge, especially in the development of new technological competencies. R&D performance is also expected to increase. The M&A based on economies of scope in R&D will tend to broaden the mission of the organisation's R&D process.

3.2.3. Elimination of common R&D inputs

Economies of scale and scope are not only realised through the spreading of fixed costs over more and different outputs, but also through the elimination of common inputs. An obvious effect of M&A activity on the R&D/innovation process is the elimination of duplicative R&D inputs: firing of personnel, closure of R&D labs and termination of R&D programs. Restructuring the R&D organisation, through reorganisation of R&D teams, replacement of R&D management and cutbacks, should, however, positively affect R&D performance. Frequently, the cost-cutting restructuring is associated with a shortening of the time horizon and drives the R&D process more towards development relative to research.

3.2.4. Synergies, i.e. combining different R&D/knowledge inputs[2]

M&A combine different R&D inputs and potentially realise new outputs or achieve efficiencies that could not be achieved previously or only at prohibitive costs. Combining resources and capabilities of the acquirer and the target might create knowledge and capabilities that did not exist before. This is discussed in the economics literature, but more in-depth in the technology management literature. After the M&A, projects are now feasible that were not feasible before because of the transfer and fusion of existing knowledge and technology, which reduces the cost of operation across R&D projects and increases the incentive to invest in R&D. M&A would, therefore, affect the R&D organisation through the transfer of knowledge, the (re)organisation of joint teams, specialisation of R&D tasks and the sharing of R&D resources. These activities allow the new entity to attain critical mass in a broader portfolio of technologies, resulting in increased R&D output and improved R&D performance. The M&A will typically also broaden the scope of R&D that is performed.

3.2.5. Technology market power and appropriation

M&A can increase market power both in the output market and in the technology market. This last effect has recently received more scrutiny from antitrust authorities, as M&A can clearly affect the competition in technology. However, whether the merged entity is able to secure more technology market power depends on whether the M&A creates barriers to entry in technology, or whether the threat of potential future technological entry remains intact. Furthermore, the effects of increased market power on the inputs to the R&D process are ambiguous, as indicated in Section 2. The increase in market power might lead to less innovation, on the one hand, and long-term R&D projects and more basic research, on the other. Nevertheless, we expect the effect on the *returns to the R&D process* to be positive. Firms attempting to take advantage of technology market power will organise R&D by centralising knowledge and focusing on specific technological fields by terminating concurrent R&D programs.

3.2.6. Bureaucracy and internal R&D organisation

M&A affects the internal organisation and bureaucracy of the R&D management within a company. This could clearly also influence the innovative behaviour of companies through its effect on the organisation of R&D. The effect of M&A on the organisation of R&D is an aspect of the R&D process that has typically received little attention in the economics literature, but more so in the technology management literature. We expect this effect to be more important whenever the objective of the M&A is not directly innovation-related. In these cases, the primary effect of the M&A is related to the output market and the production process, but there is an important (negative) indirect effect of the M&A on the R&D process. Instead of economies in R&D, diseconomies might surface. This effect should be contrasted with the effects related to economies of scale and scope. The effect on the R&D process would be to reduce R&D inputs, outputs and performance. The lack of skills in order to learn from the target, high internal resistance to M&A and slower decision-making could furthermore damage the innovation potential of the M&A. In addition, agency problems that result from the M&A will affect the motivation of researchers at the new entity, in turn affecting R&D inputs and performance. The loss of key researchers and the lack of motivation of researchers would indicate motivational problems after the merger. Intensive post-acquisition restructuring and sell offs will be associated with shortening of the time horizon for research projects and a focus on development rather than more basic research, with severe cutbacks in the launch of new projects.

3.3. M&A and the R&D process: effects, consequences and relatedness

In this section, we examine how the relatedness between M&A partners will trigger a specific combination of forces. We consider both technology- and market-relatedness and their interaction. Within the *technology-relatedness* between acquirer and target we make a distinction between firms active in

[2] Note that this is not equivalent to economies of scope. Economies of scope are measured across different outputs, while here we consider the input level.

the same technology fields (STF) versus firms active in complementary technology fields (CTF). If the target and acquirer are active in the *same technological fields* (STF) we expect economies of scale and, in particular, the elimination of common inputs and obtaining market power in the technology market to be the dominant forces, while some diseconomies in the R&D process might surface as the organisation grows larger. If the target and the acquirer are active in *complementary technological fields* (CTF), economies of scope together with the generation of synergies should dominate the effects on R&D inputs, R&D outputs and performance, while the elimination of common R&D inputs is likely to be observed insofar as some duplication exists. Contrasting M&A between same technology firms (STF) with M&A between complementary technology firms (CTF), we would expect the "STFs" to dominate in reducing R&D inputs and in R&D rationalisation, while the "CTFs" should be more active in resource redeployment, resulting in the attainment of critical mass in different technological fields, and a better exploitation of technological competencies while accessing new R&D fields. Furthermore, M&A between "STFs" are more likely affected by bureaucratic and internal organisational problems, leading to problems in the R&D organisation such as less motivated R&D personnel and reduced R&D performance. Finally, we expect that an M&A between "STFs" will more likely lead to a focusing of the R&D mission, with a shortening of the time horizon and an emphasis on development as opposed to research.

The above hypotheses relate to the direct effects of M&A on the R&D process. However, many M&A will have indirect effects on the R&D process. We hypothesise that the *market-relatedness* of firms indirectly affects the R&D process. Because of overlapping product lines and, hence, R&D processes, an M&A between market related targets and acquirers – rivals before the M&A – is likely to benefit from important economies of scale, both through specialisation and elimination of duplication. Especially the latter effect should dominate whenever the motivation for the M&A is not innovation-related. As the effects on the R&D process are not central to the M&A decision, bureaucratic effects are also more likely to surface. Both these effects lead to a negative effect on R&D inputs and are likely to reduce R&D output as R&D is not the main motivation for the M&A. In particular, it is unlikely that after this M&A new R&D initiatives will be launched. Whenever the M&A creates market power in the output market, which is more likely in the event of an M&A between firms in the same output market, we expect returns to R&D to improve. While the effect of market power on R&D inputs has been hotly debated since Schumpeter, R&D performance should improve. This might weaken the negative effect hypothesised on R&D performance due to the former effects on the creation of more bureaucracy for the R&D process.

Table 1 summarises the different potential effects on the R&D process and our hypotheses about the interaction between the relatedness between target and acquirer and the consequences of these effects: the effects on R&D inputs, R&D outputs, R&D performance, R&D organisation and R&D mission. A quick glance at the table immediately reveals why the previous literature has found mixed results of M&A on these different measures: the total effect of a M&A on R&D inputs, R&D outputs and R&D performance can increase or decrease depending on the forces that dominate the M&A. After classifying the M&A according to their technological- and market-relatedness, the effect of an M&A on the R&D process becomes more clear-cut. For "CTF" firms, M&A are predicted to lead to more R&D inputs, R&D outputs and a higher R&D performance. Relative to "CTF" firms, "STF" firms are more likely to cut R&D inputs. A positive effect on R&D outputs and performance is more likely in both cases. M&A between firms in the same market, however, are more likely to have a negative effect on R&D inputs and outputs compared to M&A between firms that are less related through the output market.

4. Description of the data

Our sample includes 31 merger or acquisition deals in medium- and high-tech industries concluded in the last 15 years, with 62 firms involved. This sample cannot be regarded as representative of the M&A population because the sample is not random. Interviewees selected the acquisition for which to respond to the questionnaire. One would expect managers to select

Table 1
Predicted effects of M&A on the R&D process by technology relatedness

	R&D input	R&D output	R&D performance	R&D organisation	R&D mission	Conditioning factors		
						Firms active in same technological fields (STF)	Firms active in complementary technological fields (CTF)	Firms active in same product-markets
Effect 1: indivisibilities/specialisation, i.e. spreading fixed costs of R&D over more R&D output	+	+	+	Centralising knowledge, re-organising R&D teams, specialisation, parallel projects	Focus-specific technological fields	•		• (second-order)
Effect 2: indivisibilities/specialisation: spreading fixed costs of R&D over more and different types of R&D output	+	+	+	Resource redeployment, joint research teams	Broadening scope of R&D		•	• (second-order)
Effect 3: Elimination of common R&D inputs	−		+	Restructuring, i.e. reorganising R&D teams, replacing top R&D managers	Shortening time horizon, development more than research	•		•
Effect 4: synergies: combining different R&D/knowledge inputs	+	+	+	Knowledge transfers, joint research teams, mutual specialisation of R&D tasks, reorganisation of R&D teams, resource redeployment	Broadening scope of R&D		•	
Effect 5: technology market power and appropriation			+	Centralising knowledge	Focus-specific technological fields	•		• (second-order)
Effect 6: bureaucracy and internal organisation	−	−	−	Reorganisation of R&D teams, replacing top R&D managers	Shortening time horizon, development more than research	• (second-order)		•
						R&D input/R&D output/R&D performance	R&D input/R&D output/R&D performance	R&D input/R&D output/R&D performance
Total effect	?	?	?			?/+/+	+/+/+	−/−/?

Table 2
Sample distribution

Dimensions	Types	No. of observations	Frequency (%)
Sector	Same business	25	80.6
	Same product lines	11	35.5
	Different product lines	14	45.2
	Different business	6	19.4
Market-relatedness	Rivals	10	32.3
Technology-relatedness	Same technological fields[a]	17	54.8
	Complementary technological fields[b]	14	45.2
Nationality	Cross-border	22	71.0
Total sample		31	100.0

[a] In seven M&A out of the 17 classified in the "same technological fields" category, merging firms also were in complementary technological fields before the deal.

[b] M&A are assigned to the "complementary technological fields" category if before the deal (i) merging firms were in complementary technological fields and (ii) they were not in the same technological fields (i.e. they did not have overlapping technological capabilities).

deals that they considered a success.[3] Furthermore, the size of the sample is limited. Due to our limited sample of M&A we are only able to do some univariate analysis and look at differences in means. We focus the discussion on how relatedness between partners shapes the influence of M&A on innovation. The survey also contains interesting information on the impact of the debt level, prior relationships, etc.[4] However, given our limited number of observations, a multivariate analysis is not possible. This is unfortunate since a multivariate analysis would allow us to study the impact of relatedness controlling for other influencing variables. This notwithstanding, we do think that a statistical analysis of data from case studies, when properly designed, can shed new light on the issues at hand. In this sense, our work extends the available knowledge on M&A.

The case studies were based on a structured questionnaire that allowed collecting qualitative data in a standardised format suitable for statistical analysis. In the questionnaire, we organised the information for each of the cases at two levels: the new post-M&A entity and the acquisition deal. In particular, we were able to compare the situation of each of the merging firms before and after the deal. The qualitative data were collected through an interview by an experienced researcher with at least one qualified contact person at each acquiring company. Typically, this person was the Vice President for R&D or Strategy (or equivalent level). The qualitative and judgemental information obtained through the interviews was then cross-checked with firms' published documents and other publicly available information. When necessary, we arranged follow-up phone interviews with firms' managers so as to be sure that the collected data were accurate and reliable. Before engaging in all of the case studies, we organised a number of "pilot" cases in order to further refine our questionnaire. Therefore, the data, while qualitative in nature, are substantive and not only based on perceptions and impressions of the related managers. Table 2 summarises some characteristics of the sample, and Table A.1 in the Appendix provides an overview of the different cases and their classification. For each merging firm, we report the industry in which the firm operated before the M&A and the characteristics of its R&D activity. First of all, note that all sample M&A are "horizontal", i.e., before the deal, merging firms operated in the same sector (at the two digit NACE-CLIO classification). So the sample does not include vertical and conglomerate mergers. Nonetheless, horizontal deals comprise different M&A types: the two companies may operate in the same sector but in different businesses, or in the same sector and businesses but in different product lines. Properly, horizontal deals concern those M&A that occur between companies operating in the same product lines, to be defined at a

[3] This bias is favourable for our analysis, as we examine the impact of M&A on the R&D process. Therefore, we would like to restrict attention to the impact of successful M&A. We are looking for characteristics of the deals that allow us to segment the effects on the R&D process.

[4] See our full report to the European Commission or DG Research, 3rd European S&T Report, 2003, for other interesting results.

finer level than the usual NACE-CLIO 2-digit classes; accordingly, while we follow the established convention by referring to deals in the same industry as "horizontal", we show how the sample distributes across types that have been more finely defined. Companies operating in the same business turn out to account for 25 out of the 31 deals (80.6%), with more than half of them specialised in different product lines (14 out of 25 deals). Initiatives taken by firms coming from different businesses make up the residual share (19.4%).

In this paper, we focus attention on *market*- and *technology*-relatedness. Rather than determining these dimensions exogenously by the researchers on the basis of aggregate production and patent classification schemes, we directly asked the respondents to assess the market- and technology-relatedness of the partners involved. We then cross-checked this information against available public information we used for developing the case study for each M&A.[5] Two experienced researchers coded the variables independently, with a high coincidence in coding, and resolved any conflict through a careful re-examination of the available information and follow-up phone interviews with firms' managers. Therefore, while it is not possible to eliminate all subjectivity in these measures on the part of the respondents, based also on our previous research we are quite confident that the categorical measures of relatedness used in this study are more reliable than variables based on quantitative data such as patents (on the shortcomings of quantitative measures of relatedness, see, e.g. Colombo, 2003).

As for *market-relatedness*, we distinguished merging firms according to whether, before the M&A, they competed in the same product/market or not. M&A between rival firms – firms having the same product lines *and* operating in the same geographical markets – constitute almost the entire class of deals between companies that have the same product mix (10 out of 11). However, the majority of observed pairs of firms did not compete with one another before the merger (21 out of 31 deals), either because their businesses were different, or because they served different customers and geographical markets. In 9 out of the 10 cases, direct competitors were active in the same technological fields.

As for *technology-relatedness*, merging firms were classified as having overlapping technological strengths if, before the deal, they had R&D projects in the same technological fields and had developed capabilities in the same stages of the R&D process. On the other hand, they were considered as having complementary technological strengths if they were in different technological fields, but one's technological knowledge and know-how could be transferred and combined into the other's R&D activities, or even if they were in the same technological fields but had capabilities in different stages of the R&D process (e.g. basic research from one side and development from the other). Note that our sample encompasses M&A between companies that are in the same broadly defined R&D areas (i.e. it does not include M&A between companies that were in entirely unrelated technological areas). This is hardly surprising as we focus on horizontal M&A in this study. Companies that had distinctive capabilities in the same technological fields of the partner account for a 54.8% share (17 out of 31 deals), while complementary technological strengths emerge in 21 out of 31 deals, i.e., 67.7% of the total number of initiatives. In order to avoid double counting in the empirical analysis, seven pairs of merging companies that had both similar and complementary technological capabilities were assigned to the "same technological fields" (STF) category. Therefore, the "complementary technological fields" (CTF) category comprises firms that (a) had strengths in complementary technological fields and (b) had no overlapping technological strengths.[6] Note also that nine pairs of merging firms that were classified

[5] See our full report to the European Commission for the 31 individual case studies.

[6] Some examples help to clarify the definitions adopted in this study. In M&A no. 2 (see Table A.1), the R&D operations of both merging firms focused on cardiovascular instruments; hence the M&A was classified in the "same technological fields" category. By contrast, in M&A no. 22, while both merging firms were in biotechnology, their R&D projects targeted different therapeutic fields; so they were classified in the "complementary technological fields" category. Lastly, in M&A no. 14, the merging firms were in the same technological area (advanced materials) and had both overlapping and complementary R&D operations (while both firms had capabilities in coating technologies, firm A was also in metal forming technologies). In order to avoid double counting, this case was assigned to the "same technological fields" category. Actually, we checked the sensitivity of our results to the assignment of the seven cases that had both overlapping and complementary technological capabilities. In particular, their deletion does not significantly alter the empirical findings that will be illustrated in Section 5.

Table 3
Classification of M&A (number of cases)

	Rivals	Non-rivals	
Same technological fields (STF)	9	8	17
Complementary technological fields (CTF)	1	13	14
	10	21	31

in the “STF” category were rivals before the deal, while the same holds true for only one pair of “CTF” firms. Table 3 classifies the cases according to the relatedness between partners.

In the questionnaire there was a section especially devoted to M&A motives.[7] In line with the results from previous empirical analysis, it is important to make a distinction between *technology-related* and *market-related* motives, as the motives for M&A might affect our constructed measures of technological- and market-relatedness (Ahuja and Katila, 2001). Technology-related motives include motives such as scale and scope economies in R&D, R&D risk spreading, access to technological resources, and reduction of spillovers and of competition in technology markets. Market-related motives comprise traditional motivations of M&A such as increase of market share, rationalisation or entry into new businesses and geographic markets.[8] Each item was assessed by the interviewees on a five-point Likert scale (from 0, “not important at all” to 4 “very important”). Accordingly, we define a deal as “technology-motivated” if one or more of the technology-related items were assigned a score equal to or greater than 3. Due to poor sample stratification, the empirical distribution of motives is not to be assumed as representative of the universe of M&A. With this caveat in mind, it is noteworthy that interviewees described the set of market-related motives as prevailing in the merger decision. In fact, in 15 cases out of 31 (i.e. 48% of sample cases), technology-related motives were reported to have a negligible importance. In the other cases, both market-related and technology-related motives are present. In other words, market-related motives seem to be the main drivers of M&A even in medium- to high-tech industries. This is already suggestive of the importance of what we have labelled as the indirect effects of M&A on R&D running through product market effects.

5. Empirical results on the impact of technology- and market-relatedness

This section discusses the empirical results relating to the effects of M&A on the R&D process. In particular, we are interested in assessing the role played by technology- and market-relatedness of the combining firms. We proceed in two steps in order to convince the reader both of the relevance of these dimensions and the need to analyse the effects of the M&A at the R&D process level directly.

First, we will consider a limited selection of traditional indicators. They capture changes in R&D inputs (i.e. R&D personnel and lab equipment) and performance (i.e. returns to R&D expenditures)[9] that were experienced by merging firms after the deal and that,

[7] In principle, motives represent expectations and preliminary evaluations formulated by the parties before the completion of a deal. Note, however, that there is a possible shortcoming in the approach adopted in this study. In fact, firms’ managers were interviewed *after* completion of the deal, even though they were asked to report about firm’s motivations *before* the deal. Of course, such time lag may have influenced the answers to this question.

[8] More precisely, technology-related motives are captured by nine different items, while technology-unrelated ones add up to 10 items. The following nine technology-related motives were considered: R&D risk spreading, economies of scale in R&D, economies of scope in R&D, restructuring of R&D, access to target’s technological resources, access to technological resources embedded in the target’s environment, get competing technologies under control, reduce the risk of being imitated and set a common standard. The 10 technology-unrelated motives were: rationalisation of production, spread fixed costs of production over larger output, rationalisation of marketing and sales, access to specialised assets and capabilities in production, access to specialised assets and capabilities in commercial activities, access to non-technological resources embedded in target’s environment, increase market share, broaden product mix, entry into a new geographic market and entry into a new business.

[9] Our measure of the impact of M&A on R&D performance is qualitative and to some extent subjective, as it is based on the judgement expressed by informed managers during the interviews. The same consideration applies to other measures of the effects of M&A on firms’ R&D outputs and performance that will be analysed in next section. Hence, the results of the empirical analysis relating to this aspect must be interpreted with caution. There are basically two reasons why we did not use objective indicators of R&D outputs, such as the number of patents or the number of new products introduced into the market. First of all, we were interested in comparing the pre- and post-M&A situations of both merging firms, so as to identify the effects of a specific deal. As in previous studies, the “objective” data necessary for such a comparison at the deal level were not available. Second, a portion of the M&A in our sample was accomplished in

according to the interviewed managers, were directly attributable to the completion of the deal. Answers in the questionnaire concerning such aspects were codified as ordered categorical variables and so they can be used in statistical analyses. Use of such traditional indicators makes it easier to compare our subsequent results with those of previous studies.

Second, as was mentioned earlier, the questionnaire comprises a large number of specific questions relating to changes in R&D inputs, outputs, performance, organisation and mission that were engendered by the specific deal under consideration. We will rely on such information to build a series of (quantitative) synthetic indicators through principal component analyses of five independent groups of individual answers concerning each of the above-mentioned aspects. As we will show, these indicators are much more informative and comprehensive than those that have been used so far to study the impact of M&A on R&D. While it is not possible to eliminate all subjectivity from these measures, the principal component technique extracts information from various questions in the questionnaire simultaneously, somewhat alleviating this problem through the diversity of questions.

Then, we will relate the values taken by both types of indicators – traditional and synthetic – to the technology- and market-relatedness of merging firms. Table 3 classifies M&A deals according to both market- and technology-relatedness. A full split into four types is not possible. Not surprisingly, we have only one case of firms that are rivals and are assigned to the "CTF" category. To sort out the effects of technology-relatedness from market-relatedness as much as possible, we compare the rival (R) and non-rival (NR) firms within the "STF" category. This allows discussing the impact of market relatedness, while controlling for technology relatedness (i.e. STF). To discuss the effect of technology relatedness for a given market-relatedness (i.e. NR), we compare the "STF" and "CTF" categories for the set of non-rival firms. We believe this conditional analysis of the relatedness measures constitutes an important contribution to the existing literature, where the economics based literature focused almost exclusively on the market-relatedness measure, while the technology management literature analysed the effect of the technology-relatedness of the M&A partners, ignoring or in isolation from the market-relatedness dimension.

As a final remark, we are aware that the empirical results that will be presented below suffer from the limited size of our sample and sample selection, as previously illustrated. Nonetheless, we also believe that such results are interesting in their own right; in fact, they considerably extend our understanding of the relationships between M&A and R&D, pointing out the conditioning role played by technology- and market-relatedness. More importantly, they suggest guidelines with respect to data collection for further analyses based on larger, more representative samples.

5.1. R&D inputs and performance

We will first analyse the information directly provided by the case study questionnaires on the effects of M&A on the R&D efforts and the returns to R&D expenditures of the merging firms. For this purpose, we consider answers to individual questions that will not be used in the subsequent principal component analyses.

Interviewees described changes in the amount of physical R&D facilities and in the number of R&D personnel that occurred in both merging companies as a consequence of the completion of the deal on a scale ranging from "100% decrease" to "increase greater than 100%". Furthermore, interviewees described changes in the returns to R&D expenses as ranging from "substantial decrease" to "substantial increase". Answers were codified through three discrete variables, ordered along, respectively, ten- and nine-point Likert scales. For each variable, we computed the mean value in the pertinent M&A categories and assessed differences across M&A categories through *t*-tests. The results are illustrated in Tables 4 and 5.

First of all, Table 4, focusing on non-rival firms only, shows that technology-relatedness matters; in fact, the

the last 5 years. Given the long lead times that generally are necessary for producing patentable results and for commercialising new products, indicators that rely on "objective" data are unlikely to allow detecting evidence of changes in R&D outputs and performance, as such changes become apparent in objective data only after considerable time has elapsed since completion of a M&A. The more subjective indicators we use reflect the perceptions and opinions of firms' informed top managers as to what is going on after the deal in the combining entities; in spite of their subjective nature, they suffer to a lesser extent from the above-mentioned problem and provide interesting variation, i.e. we find both positive and negative outcomes.

Table 4
The effects of M&A on R&D inputs and performance in non-rival firms: the role of technology-relatedness

Variables	Non-rival firms		
	Same technological fields[a]	Complementary technological fields[a]	Confidence level[b]
Changes of physical R&D facilities[c]	−0.188 (1.642)	0.808 (1.625)	*
Changes of R&D personnel[c]	−0.375 (1.544)	0.423 (1.629)	
Changes of the returns to R&D expenditures[d]	1.750 (1.438)	2.385 (1.472)	

[a] Mean values; standard errors in parentheses.
[b] *t*-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.
[c] Answers codified through a 10-point Likert scale, ranging from −5 (100% decrease) to +4 (increase greater than 100%). 0 means no change.
[d] Answers codified through a nine-point Likert scale, ranging from −4 (substantial decrease) to +4 (substantial increase). 0 means no change.

impact of M&A upon merging firms' R&D effort differs according to the technological characteristics of merging firms. If firms were in the same technological fields (STF) before the deal, changes in R&D effort were considerably more negative (or less positive) than if firms were in complementary technological fields (CTF). In the former category, changes relating to both R&D facilities and personnel turned out to be negative, while they were positive in the latter one. The difference between the "STF" and "CTF" categories relating to R&D facilities is statistically significant at conventional levels; the one relating to R&D personnel is insignificant. In addition, the mean value of the "changes in R&D performance" variable is smaller in the "STF" category than in the "CTF" one, but, in line with most existing studies, these results are not significant.

In Table 5 attention is focused on firms in the same technological fields (STF). We examine differences of changes in R&D inputs and performance according to whether before the deal the merging firms directly competed with each other or not. In general, rival firms exhibit a larger decrease of R&D effort and lower returns to R&D expenses than non-rival firms. However, only the difference relating to the latter variable turned out to be statistically significant at conventional levels.

At face value these results indicate that M&A between firms in the same technological fields have a negative impact on R&D inputs and performance compared to partners in complementary technological fields. Similarly, non-rivals merging have a more positive impact on R&D performance relative to merging rival firms. Our classification on the basis of ex-ante-relatedness seems to have some bite at the aggregate level. However, to really understand what is driving these aggregate results on the effects of M&A on R&D, we need to delve deeper into the R&D process itself, a task we perform next.

5.2. *Synthetic indicators of consequences of M&A on R&D process*

In addition to the three individual questions considered in Section 5.1, another 50 questions in the case study questionnaire concern R&D activities. Such a richness of descriptive elements was necessary to cope with the variety of the observed impact of M&A on R&D and the complexity and multi-dimensional na-

Table 5
The effects of M&A on R&D inputs and performance: the role of market relatedness

Variables	Same technological fields		
	Rival firms[a]	Non-rival firms[a]	Confidence level[b]
Changes of physical R&D facilities[c]	−0.556 (0.856)	−0.188 (1.642)	
Changes of R&D personnel[c]	−0.833 (1.150)	−0.375 (1.544)	
Changes of the returns to R&D expenditures[d]	0.556 (1.947)	1.750 (1.438)	**

[a] Mean values; standard errors in parentheses.
[b] *t*-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.
[c] Answers codified through a 10-point Likert scale, ranging from −5 (100% decrease) to +4 (increase greater than 100%). 0 means no change.
[d] Answers codified through a nine-point Likert scale, ranging from −4 (substantial decrease) to +4 (substantial increase). 0 means no change.

Table 6
Principal components and individual questions

Principal component	Questions (load factor)
R&D inputs	
A1: Increase of R&D effort	Hiring of R&D personnel (0.809)
	Increase of R&D expenditures (0.841)
	More funds internally available to finance R&D projects (0.618)
A2: Decrease of R&D effort[a]	Cut of R&D personnel (0.875)
	Closure of R&D laboratories (0.742)
	Less funds internally available to finance R&D projects (0.557)
	Decrease of R&D expenditures (0.549)
A3: R&D rationalisation	Termination of non-concurrent R&D programs (0.797)
	Termination of concurrent R&D programs (0.744)
	Loss of key researchers (voluntary abandonment) (0.558)
A4: New R&D fields and sources	Launch of new R&D programs in technological fields new to the company (0.800)
	Increase of the use of external R&D sources (0.732)
	Launch of new R&D programs in technological fields already covered by the company (0.554)
A5: Critical mass in R&D	Achievement of critical mass in technological fields that were new to the company (0.565)
	Achievement of critical mass in technological fields already covered by the company (0.540)
	Decrease of the use of external R&D sources (0.533)
	Opening of new R&D laboratories (0.499)
	Increase of the scale of the typical R&D project (0.468)
	Decrease of the scale of the typical R&D project (−0.399)
R&D outputs	
B1: Increase of R&D output	Greater speed in developing technological knowledge (0.756)
	Greater speed in introducing new production processes (0.737)
	More patents granted (0.739)
	Improvement of existing technological competencies (0.725)
	Greater speed in introducing new products (0.675)
	Development of new technological competencies (0.668)
B2: Better exploitation of technological competencies	Application of the target's existing technological competencies in the acquiring firm's product markets (0.941)
	Application of the acquirer's existing technological competencies in the target firm's product markets (0.910)
B3: Less technological competition	Decreased danger of being imitated (0.846)
	Elimination of competing product standard (0.837)
R&D performance	
C1: Increase of R&D productivity	More productive R&D personnel (0.909)
	Increase of returns to R&D expenditures (0.780)
	Improved management of the R&D process (0.609)
C2: Organisational problems in R&D	Greater complexity, less focus and/or slower decision making in R&D (0.862)
	Less motivated R&D personnel (0.795)
	Decrease of returns to R&D expenditures (0.498)
R&D organisation and management	
D1: R&D specialisation and knowledge transfer	Getting knowledge (patents, methods, other blueprints) from the other company (0.847)
	Creation of joint teams (0.793)
	Mutual specialisation of the R&D tasks (0.643)
D2: R&D restructuring	Re-organisation of R&D teams (0.829)
	Top management of the R&D function replaced (0.715)
	R&D projects run in parallel by independent R&D teams (0.464)
D3: R&D resource redeployment	Transfer of R&D technical personnel from the other company (0.805)
	Transfer of R&D physical equipment from the other company (0.817)

Table 6 (*Continued*)

Principal component	Questions (load factor)
R&D mission	
E1: Broadening of R&D mission	Greater emphasis on research as opposed to development (0.719)
	Extension of the typical time horizon of R&D projects (0.655)
	Broadening of the scope of R&D (0.601)
E2: Focussing of R&D mission	Shorting of the typical time horizon of R&D projects (0.778)
	Focussing of R&D on specific technological fields (0.760)
	Greater emphasis on development as opposed to research (0.641)

[a] A negative value for the A1 indicator is compatible with either a reduction of R&D effort or no change, while a negative value for A2 may indicate either an increase of R&D effort or no change. If both indicators are negative, the deal is very likely to have had a negligible net impact on the amount of resources devoted to R&D by the firms under scrutiny. Such situation occurred for 20 firms out of 62.

ture of the R&D process. We decided to extract principal components from the original questions to provide a more parsimonious description of the phenomena at hand. Answers from the questionnaires were codified through binary or discrete ordered variables. In order to obtain meaningful indicators, we subdivided the whole set of questions into five groups relating to R&D inputs, outputs, performance, organisation and mission, respectively, and ran a principal component analysis for each group. The results of these principal component analyses are summarised in Table 6. The first column indicates the name of the principal component while the second column groups the individual questions that loaded onto this principal component, with the load factor between brackets.

5.3. *Results from the synthetic indicators*

In Section 5.1 we showed that the effects of M&A on R&D inputs and the returns to R&D expenditures depend on merging companies' technology- and market-relatedness. In this section, we tackle the effects in a broader perspective, taking advantage of the quite complete representation of R&D activities yielded by the synthetic indicators.

Again, we follow a similar methodology to the one adopted in Section 5.1. First, merging firms are subdivided into mutually exclusive categories. In particular, we compare (a) the "STF" and "CTF" categories for non-rival firms, i.e. technology-relatedness and (b) within the "STF" category, rival ("STF-R") and non-rival ("STF-NR") firms, i.e. market-relatedness. Then, mean values of the synthetic indicators are computed for each category and the differences between mean values are assessed through *t*-tests. In Table 7 we consider technology-relatedness, while Table 8 presents the results for market-relatedness.

5.3.1. *Technology-relatedness*

The results of Table 7 confirm that firms in the "CTF" category increased R&D effort after completion of a merger or an acquisition to a larger extent than those in the "STF" category, but the difference is not significant at conventional confidence levels. The "STF" category also exhibits poorer performance, in terms of R&D productivity, even though the difference relating to the corresponding indicator (C1) again is statistically insignificant. Analysis of the individual answers[10] reveals that firms with overlapping technological strengths never opened a new research laboratory after the deal, an event that occurred for 11% of the firms with complementary technological specialisation. In addition, they more often decreased R&D expenditures (31% against 15%) and cut R&D personnel (19% against 11.5%, Table A.2). In spite of their declaration of a better profit outlook after the deal, 12% of "STF" firms mentioned a decrease of the internal funds available for R&D financing; no firm in the "CTF" category mentioned such occurrence (Table A.5).

The data of Table 7 also help to further explore why firms with overlapping technological strengths

[10] Tables A.2–A.6 in the Appendix report the results for the individual answers of our questionnaire. As one can note, many of the differences in means on individual questions are not significant, which reinforces the need to aggregate the results into synthetic indicators. Nevertheless, by reporting the difference for individual answers the reader gets a feel for the depth and breadth of our data. Table 6 indicates which individual questions (and weighting) make up the different synthetic indicators.

Table 7
The effects of M&A on R&D synthetic indicators in non-rival firms: the role of technology-relatedness

Factors	Non-rival firms		
	Same technological fields[a]	Complementary technological fields[a]	Confidence level[b]
A1: Increase of R&D effort	0.199 (2.016)	0.332 (2.095)	
A2: Decrease of R&D effort	−0.145 (2.207)	−0.708 (1.357)	
A3: R&D rationalisation	0.762 (2.005)	−0.728 (1.121)	**
A4: New R&D fields and sources	0.406 (1.568)	0.219 (1.636)	
A5: Critical mass in R&D	−0.081 (0.706)	0.545 (1.949)	
B1: Increase of R&D output	0.623 (2.051)	0.600 (3.621)	
B2: Better exploitation of technological competencies	0.349 (2.054)	0.211 (1.412)	
B3: Less technological competition	0.600 (1.598)	−0.696 (1.306)	**
C1: Increase of R&D productivity	0.253 (1.686)	0.568 (1.889)	
C2: Organisational problems in R&D	0.476 (1.871)	−0.568 (0.763)	**
D1: R&D specialisation and knowledge transfer	0.589 (0.682)	−0.501 (2.009)	**
D2: R&D restructuring	0.355 (1.590)	−0.215 (1.486)	
D3: R&D resource redeployment	−0.158 (1.663)	0.331 (1.274)	
E1: Broadening of R&D mission	0.175 (1.210)	0.279 (1.615)	
E2: Focussing of R&D mission	0.717 (1.360)	−0.615 (1.324)	***

[a] *t*-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.
[b] Mean values; standard errors in parentheses.

performed quite poorly. As predicted, such firms turned out to rely on the rationalisation of R&D activity to a much larger extent than firms with complementary technology specialisation, as is highlighted by the larger mean value of the A3 indicator; the difference between the two categories of firms is statistically significant at 95%. In particular, termination of concurrent and non-concurrent R&D projects was mentioned by 50 and 56% of "STF" firms, respectively. Again these values are significantly larger than those of "CTF" firms (35 and 11%, Table A.2). In addition, firms with similar technological strengths seem to have been looking for faster returns to R&D expenses by focusing the mission of R&D. In fact, the difference between the mean value of the E2 indicator in the "STF" and "CTF" categories is large and statistically significant at 99%. Consideration of the individual answers shows that 50 and 38% of firms with overlapping technological specialisation mentioned that the merger or the acquisition resulted in greater emphasis being placed on development as opposed to research and in the shortening of the typical time horizon of R&D projects. The corresponding values for firms with complementary technological strengths were 8 and 15% (Table A.3).

In turn, the rationalisation and the focusing of R&D often lead key researchers to voluntarily abandon the firm, an event that was mentioned by almost 31% of "STF" firms, while it was never mentioned by firms in the "CTF" category (Table A.2). In addition, organisational problems engendered by the merger or the acquisition, especially those associated with the motivation of R&D personnel, were found to be more serious for firms with the same rather than complementary technological capabilities; again the difference in the mean value of the C2 indicator between the "STF" and "CTF" categories is significant at 95%.

In contrast, M&A between firms with complementary technological specialisation were often a vehicle for the technological diversification of merging firms. Even though this aspect is not immediately apparent from the synthetic indicators, the individual answers reveal that the "achievement of critical mass in technological fields new to the firm" and the "development of new technological competencies" were assigned quite high importance scores by managers of "CTF" firms; the mean values in this category equal 2.62 and 2.69 on a five-point Likert scale (from 0 to 4) and were found to be significantly greater than those reported by managers of firms with overlapping technological strengths (1.13 and 2.00, respectively; see Table A.6).

The indicators on R&D organisation indicate that firms in the same technological fields tend to specialise significantly more and transfer codified technology. Firms in complementary technological fields seem to rely rather on resource redeployments, although the effect is not significant. We would expect these resource redeployments to consist of transfer of non-codifiable technology. In line with the more pronounced organisational problems, R&D restructuring (D2) is higher for same technology firms, but this effect is not significant.

Lastly, it is noteworthy that M&A between firms with overlapping technological knowledge are more often associated with a reduction of competition in technology markets than those between firms with complementary strengths. Note the large difference in the mean values of B3, which is statistically significant at the 95% confidence level. In fact, the interviewed managers of "STF" firms, when asked about the technological implications of the deal, attributed quite high scores to the "elimination of a competing product standard" and the "decrease of the danger of being imitated" (the mean values are equal to 1.25 and 2.00, respectively). In contrast, the importance of such aspects was considered to be negligible by managers of "CTF" firms (average scores equal 0.69 and 0.62, respectively). These differences are again significant at 99% (Table A.6).[11]

Overall, we do find support for our hypotheses on the conditioning effect of technology relatedness of the firms on the effect of the M&A on the R&D process. Firms active in "STF" are likely to have a more negative impact on R&D inputs. This is particularly apparent through the R&D rationalisations that occur as a result of this type of M&A. Furthermore, as conjectured, the mission of R&D is affected in opposite directions, depending on the technology-relatedness of combining firms. For both types of firms we expected R&D output and performance to increase. However, it is interesting to note that the process for generating these positive results is different. "STF" firms specialise their R&D process and reduce technological competition, in addition to the prevalent rationalisation. "CTF" firms redeploy resources across the new entity to create critical mass in technological fields new to the firm and to develop new competencies.

5.3.2. *Market-relatedness*

Table 8 focuses on the market-relatedness dimension. Again remarkable differences emerge between rival (R) and non-rival (NR) firms that share the same technologies. First, rival firms exhibit an even greater post-deal reduction of R&D effort than non-rival ones. In the "STF-R" category, the A1 and A2 indicators have smaller and greater mean values, respectively, than in the "STF-NR" category, even though the differences are not significant at conventional confidence levels. Turning to individual answers, we observe statistically significant differences between the two categories as to the frequency with which firms mentioned having closed R&D facilities (38.9% against 12.5%) and having fired R&D personnel (44.4% against 18.8%). In addition, M&A between direct competitors very rarely led combining firms to explore new technological fields and benefit from new external technology sources; the mean value of the A4 indicator is negative for "STF-R" firms, but positive for "STF-NR" firms, with the difference significant at 90%. In particular, 81.3% of the "STF-NR" firms launched new R&D projects relating to the technological fields in which they had previously developed distinctive capabilities; the corresponding share of rival firms was as low as 27.8%, with the difference significant at 99% (Table A.2).

Second, firms that directly competed between each other seem to exhibit poorer performance after the deal in terms of both R&D outputs and productivity, as is witnessed by the lower mean values of the B1, B2 and C1 indicators, all statistically significant at conventional confidence levels. Of course, the qualitative nature of the indicators suggests some caution in interpreting the results. Individual answers highlight the significantly lower propensity to patent of rival firms, the lower speed in introducing new production processes and developing new technological knowledge,

[11] The negative effect on competition between firms in deals with a substantial technological overlap is confirmed when one considers the economic implications of the sample deals. In fact, the "decrease of the pressure from competitors and new entrants" and the "decrease of input prices", which signals greater market power in backward vertical markets, were assigned by the interviewed managers of "STF" firms average scores equal to 1.53 and 2.23, respectively. The corresponding scores were as low as 0.66 and 1.36 in the "CTF" category, with the differences significant at conventional levels.

Table 8
The effects of M&A on R&D synthetic indicators: the role of market relatedness

Factors	Same technological fields		
	Rival firms[a]	Non-rival firms[a]	Confidence level[b]
A1: Increase of R&D effort	−0.493 (1.315)	0.199 (2.016)	
A2: Decrease of R&D effort	1.097 (2.485)	−0.145 (2.207)	
A3: R&D rationalisation	0.534 (1.510)	0.762 (2.005)	
A4: New R&D fields and sources	−0.592 (1.423)	0.406 (1.568)	*
A5: Critical mass in R&D	−0.515 (1.500)	−0.081 (0.706)	
B1: Increase of R&D output	−1.344 (3.120)	0.623 (2.051)	**
B2: Better exploitation of technological competencies	−0.792 (1.841)	0.349 (2.054)	*
B3: Less technological competition	0.421 (1.236)	0.600 (1.598)	
C1: Increase of R&D productivity	−0.701 (1.337)	0.253 (1.686)	*
C2: Organisational problems in R&D	0.517 (2.181)	0.476 (1.871)	
D1 R&D specialisation and knowledge transfer	0.092 (2.060)	0.589 (0.682)	
D2: R&D restructuring	−0.137 (1.276)	0.355 (1.590)	
D3: R&D resource redeployment	−0.146 (1.209)	−0.158 (1.663)	
E1: Broadening of R&D mission	−0.430 (1.018)	0.175 (1.210)	
E2: Focussing of R&D mission	0.380 (1.995)	0.717 (1.360)	

[a] *t*-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.
[b] Mean values; standard errors in parentheses.

and the lower capacity to combine their own capabilities with those of the partner so as to obtain synergistic gains.

By contrast, there were no significant differences between "STF-R" and "STF-NR" firms as to changes of the organisation and the mission of R&D in the merged entity. More interestingly, the negative implications for technology competition of M&A between firms with overlapping technological capabilities seem not to depend on whether the firms were direct competitors or not. The B3 indicator takes a large positive mean value for both the "STF-R" and "STF-NR" sub-categories, and the difference is insignificant at conventional levels.

In conclusion, we confirm our hypotheses on the conditioning effect of market-relatedness of the firms on the effect of M&A on the R&D process. M&A between rival firms have a more negative effect on R&D inputs, R&D outputs and R&D performance than other horizontal M&A. While this was not necessarily expected, a possible explanation is that these M&A happen for non-innovation-related motives and that the indirect effect on the R&D process is quite pronounced in these cases.

6. Conclusions and discussion

The results of the preceding section confirm our hypothesis that the ex-ante-relatedness between merger partners matters and that market- and technology-relatedness have important *separately identifiable* consequences for the impact of a M&A on the new entity's R&D and innovation process. To uncover these different consequences one needs to examine the impact of a specific M&A deal on the R&D process at a sufficiently disaggregate level. At this point, the main contribution of the paper is opening the black box of M&A effects on the R&D process and carefully separating the technology-relatedness and market-relatedness effects. We show that the underlying drivers of the aggregate effects on R&D inputs, outputs and performance can be quite different depending on the ex-ante-relatedness of partners. When merged entities are technologically complementary, they increase their R&D efficiency, while merged entities which are technologically substitutive decrease their R&D inputs after the M&A. Furthermore, if the same technology firms were rivals in the product market prior to their merger, the reduction of R&D is more pronounced than if they were non-rival. This suggests that rival firms reap little technology gains from mergers.

We see two important issues for further research. While our measures of market- and technology-relatedness seem to capture some effects, refining these relatedness concepts is in order. In particular, our measure of technology-relatedness could be separated into knowledge-relatedness, on the one hand, and technology-relatedness, on the other. Technology-relatedness would capture the technology that is already in operation before the M&A, such as production technology. Knowledge-relatedness would capture the potential for future technology development due to existing knowledge in both partners. The effect of M&A on the former is more likely to lead to scale and scope in production when technologies are similar. The latter relatedness concept is more likely to trigger scale and scope economies in R&D when new knowledge and technology is developed. Currently, our measure of technology-relatedness captures both of these forms of relatedness, maybe amalgamating some direct and indirect effects of M&A on the R&D process. Furthermore, one could distinguish between disembodied technology, such as patents, blueprints, etc., and embodied technology, such as technology residing in equipment or researchers. Capturing benefits from disembodied technology after a M&A might be easier than when technology is embodied in researchers on whom the M&A might have countervailing effects.

While our research has made clear the importance of considering how M&A affect the R&D process, a second issue for further research is the need to study this R&D process more carefully. Our questionnaire identifies which decisions would be more relevant to study depending on the ex-ante-relatedness of the partners. On the one hand, true case studies about a specific deal would allow managers more discretion to detail the actual decisions they made and how they affected the R&D process. On the other hand, our questionnaire suggests some helpful guidelines with respect to data collection for further analyses based on larger, more representative samples. We hope that this paper spurs more research into the promising intersection of M&A and innovation research.

For management, the implications of our research are quite straightforward. First, in our sample of high- and medium-tech industries, non-innovation-related motives for M&A seemed to prevail, but the absence of pure innovation motives for M&A does not imply that there are little or no effects on R&D from the deal. Quite on the contrary, our results show that there are considerable differences in the nature, direction and size of the effects on R&D, depending on the type of relatedness between partners. These results have implication both for the selection of appropriate partners for M&A and for the post-M&A integration. Both market- and technological-relatedness have their implications for the innovation process of the merged entity. Whenever the primary concern of the merger is market-related, selecting partners with differences in the technological dimension has its implications for the innovation process and ultimately the (long-term) success or failure of the M&A. Once the partner is selected, a clear understanding of the pressures of the M&A on the R&D process will help management with the integration of new companies, whether or not these M&A were driven by innovation-related motives.

While the case study methodology allows us to zero in on the effects of M&A on the R&D process, we should take into consideration the limitations of such a methodology as well. First, the limited number of deals restricts the type of analysis feasible. Other relevant variables for assessing the effect of M&A on the R&D process might be omitted from the analysis. One variable we did control for in the questionnaire, but did not use in this study, is whether the M&A deal was mainly financed through debt. We have eight cases of highly leveraged deals, seven of which took place between partners in the same technological fields. As discussed in the literature survey, leverage could drive the negative effect on R&D inputs and shorten the horizon of R&D projects. Whenever leverage of the company is highly correlated with the fact that the partners are active in the same technological fields, part of our findings could be explained by this event. Nevertheless, 10 out of 17 cases of mergers between partners in the same technological fields have no debt financing, leading to a relatively low correlation between these characteristics. Yet, this reinforces the need to carefully relate the managerial decisions to their effect on the R&D process.

When re-considering the theoretical effects and their consequences for the R&D process that we developed, it is worth stressing that in order to provide a robust empirical test of these hypotheses, a multivariate analysis based on a larger-scale sample representative of the target population of M&A is needed. Therefore, the results presented here are to be considered preliminary and await further corroboration. This notwithstanding, we contend that they already extend our understanding of the impact of the M&A phenomenon on innovation substantially, where we need to control simultaneously for the ex-ante technology-relatedness and market-relatedness between partners when evaluating their impact on the R&D and innovation process.

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Appendix A. Appendix

For an overview of the different cases and their classification, see Tables A.1–A.6.

Table A.1
Overview of M&A and firms included in the sample

Merger no.	Industry	Country		Market-relatedness	Technology-relatedness	Scientific and technological fields	
		Firm I	Firm II			Firm I	Firm II
1	Aerospace	UK	UK	NR	CTF	Aircrafts and avionic platforms	Avionics components
2	Biomedical instruments	IT	US	R	STF	Cardiovascular surgery and cardiac devices	Cardiovascular surgery and cardiac devices
3	Chemicals	US	UK	NR	CTF	Polyolefins, catalysts and catalysis process	Polymer chemistry
4	Chemicals	DE	DE	NR	STF	Specialty chemical processes	Specialty chemical processes
5	Chemicals	ES	ES	NR	CTF	Commodity chemicals	Plastics, petrochemicals
6	Electrical machinery	CH	CH	R	STF	Building control systems	Building control systems
7	Electrical machinery	FR	FR	NR	STF	Control systems for industrial processes	Control systems for industrial processes
8	Electrical machinery	BE	CA	R	STF[a]	Transformers	Large power transformers
9	Electrical machinery	IT	US	NR	STF	Automation systems for automotive	Automation systems for automotive
10	Electronics	BE	US	NR	CTF	Analog electronics	Digital electronics
11	Electronics	IT	FR	NR	CTF	Semiconductor: power devices	Semiconductor: small signal devices
12	Energy production	UK	US	NR	STF[a]	Nuclear engineering: fuel process and decommissioning	Nuclear engineering: fuel process and energy systems

Table A.1 (*Continued*)

Merger no.	Industry	Country		Market-relatedness	Technology-relatedness	Scientific and technological fields	
		Firm I	Firm II			Firm I	Firm II
13	Farm machinery	IT	US	R	STF	Design, engineering and testing of mechanical components and systems	Design, engineering and testing of mechanical components and systems
14	Household appliances	IT	FR	NR	CTF	Mechanical and electronic engineering: free-standing white goods	Mechanical and electronic engineering: built-in white goods
15	Industrial materials	BE	US	NR	STF[a]	Metal forming and coating technologies	Coating technologies
16	Instruments	BE	NL	NR	CTF	Software for testing systems	Data acquisition systems, image processing software
12	Instruments	IT	US	NR	STF	Transport signalling systems	Transport signalling systems
18	Motor vehicles	DE	US	NR	CTF	Engines, new concept vehicles	Development of specialised mass-market vehicles
19	Non-ferrous metals	BE	CA	R	STF[a]	Cutting tool powders, zinc powders for batteries	Cutting tool powders, nickel powders for batteries
20	Pharmaceuticals	CH	CH	NR	STF[a]	Cardiovascular and central nervous systems, inflammatory disorders, allergies, infections, oncology	Immunology and transplantations, central nervous system, oncology, dermatology, chronic pains
21	Pharmaceuticals	SE/US	US	NR	CTF	Central nervous system, oncology, infectious diseases, metabolic disorders, large biotech proteins	Inflammation, arthritis, small chemicals for therapeutic use, agricultural chemistry and biotechnology, nutritional products
22	Pharmaceuticals	BE	US	NR	CTF	Allergies, central nervous system diseases	Inflammatory diseases
23	Plastics	BE	DE	NR	STF	Vinyls	Vinyls
24	Rubber	AU	US	NR	CTF	Natural rubber	Synthetic rubber
25	Specialty chemicals	UK	NL	R	CTF	Specialty chemicals	Natural, polymer and synthetic chemistry
26	Specialty chemicals	NE	NL	NR	CTF	Chemical processes, materials	Ferments and enzymes
27	Specialty chemicals	BE	FR	NR	CTF	Development of natural and synthetic organic chemicals, inorganic chemicals, plastics	Process technology of high-performance compound materials
28	Specialty chemicals	CH	DE	R	STF[a]	Development of dyes, pigments, additives, masterbatches, textile and leather chemicals, paper chemicals	Materials, pigments, additives, masterbatches, environment-friendly process technologies
29	Specialty chemicals	DE	CA	R	STF	Metal chemicals, detergent and adhesives	Metal chemicals
30	Steel	UK	NE	R	STF[a]	Process control, environment-friendly technologies	Metallurgy processes
31	Textile machinery	IT	IT	R	STF	Computer-aided manufacturing systems	Computer-aided manufacturing systems

R: rivals; NR: non-rivals; STF: same technological fields; CTF: complementary technological fields; a: STF/CTF, classified in the STF category.

Table A.2
Individual questions

Variables[a]	Non-rival firms			Same technological fields		
	Same technological fields[b]	Complementary technological fields[b]	Confidence level[c]	Rival firms[b]	Non-rival firms[b]	Confidence level[c]
Closure of R&D laboratories	0.125 (0.342)	0.154 (0.368)		0.389 (0.502)	0.125 (0.342)	*
Opening of new R&D laboratories	0.000 (0.000)	0.115 (0.326)		0.000 (0.000)	0.000 (0.000)	
Cut of R&D personnel	0.188 (0.403)	0.115 (0.326)		0.444 (0.511)	0.188 (0.403)	
Hiring of R&D personnel	0.188 (0.403)	0.269 (0.452)		0.056 (0.236)	0.188 (0.403)	
Loss of key researchers (voluntary abandonment)	0.313 (0.479)	0.000 (0.000)	***	0.278 (0.461)	0.313 (0.479)	
Termination of concurrent R&D programs	0.500 (0.516)	0.346 (0.485)		0.722 (0.461)	0.500 (0.516)	
Termination of other (non-concurrent) R&D programs	0.563 (0.512)	0.115 (0.326)	***	0.278 (0.461)	0.563 (0.512)	*
Launch of new R&D programs in technological fields						
(a) New to the company	0.438 (0.512)	0.462 (0.508)		0.333 (0.485)	0.438 (0.512)	
(b) Already covered by the company	0.813 (0.403)	0.577 (0.504)		0.278 (0.461)	0.813 (0.403)	***
Scale of the typical R&D project						
(a) Decreased	0.000 (0.000)	0.000 (0.000)		0.056 (0.236)	0.000 (0.000)	
(b) Increased	0.500 (0.516)	0.462 (0.508)		0.500 (0.514)	0.500 (0.516)	
Dependence on external R&D sources						
(a) Decreased	0.188 (0.403)	0.154 (0.368)		0.056 (0.236)	0.188 (0.403)	
(b) Increased	0.250 (0.447)	0.269 (0.452)		0.111 (0.323)	0.250 (0.447)	

The effects of M&A on the structure of R&D function: the role of market- and technology-relatedness.
[a] Answers codified through binary variables. 0 means no change.
[b] Mean values; standard deviations in parentheses.
[c] χ^2-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.

Table A.3
Individual questions

Variables[a]	Non-rival firms			Same technological fields		
	Same technological fields[b]	Rival firms[b]	Rival firms[b]	Rival firms[b]	Complementary technological fields[b]	Confidence level[c]
Greater emphasis on:						
(a) Research as opposed to development	0.125 (0.342)	0.231 (0.430)		0.111 (0.323)	0.125 (0.342)	
(b) Development as opposed to research	0.500 (0.516)	0.077 (0.272)	***	0.333 (0.485)	0.500 (0.516)	
The typical time horizon of R&D projects has been:						
(a) Extended	0.313 (0.479)	0.308 (0.471)		0.111 (0.323)	0.313 (0.479)	
(b) Shortened	0.375 (0.500)	0.154 (0.368)		0.556 (0.511)	0.375 (0.500)	
Focussing of R&D on specific technological fields	0.813 (0.403)	0.577 (0.504)		0.556 (0.511)	0.813 (0.403)	
Broadening of the scope of R&D	0.500 (0.516)	0.423 (0.504)		0.278 (0.461)	0.500 (0.516)	

The effects of M&A on the R&D mission and objectives: the role of market- and technology-relatedness.
[a] Answers codified through binary variables. 0 means no change.
[b] Mean values; standard deviations in parentheses.
[c] χ^2-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.

Table A.4
Individual questions

Variables[a]	Non-rival firms			Same technological fields		
	Same technological fields[b]	Complementary technological fields[b]	Confidence level[b]	Rival firms[b]	Non-rival firms[b]	Confidence level[c]
Top management of the R&D function replaced	0.563 (0.512)	0.308 (0.471)		0.222 (0.428)	0.563 (0.512)	**
Re-organisation of R&D teams	0.688 (0.479)	0.615 (0.496)		0.667 (0.485)	0.688 (0.479)	
R&D projects in the same technological fields run in parallel by independent R&D teams	0.125 (0.342)	0.077 (0.272)		0.167 (0.383)	0.125 (0.342)	
Mutual specialisation of the R&D tasks	0.750 (0.447)	0.769 (0.430)		0.778 (0.428)	0.750 (0.447)	
Creation of joint R&D teams	1.000 (0.000)	0.769 (0.430)	**	0.889 (0.323)	1.000 (0.000)	
Transfer of R&D physical equipment from the other company	0.438 (0.512)	0.462 (0.508)		0.278 (0.461)	0.438 (0.512)	
Transfer of R&D technical personnel from the other company	0.500 (0.516)	0.769 (0.430)	*	0.667 (0.485)	0.500 (0.516)	
Getting knowledge (e.g. patents, methods, other blueprints) from the other company	1.000 (0.000)	0.769 (0.430)	**	0.889 (0.323)	1.000 (0.000)	

The effects of M&A on the R&D organisation and management: the role of market-and technology-relatedness.
[a] Answers codified through binary variables. 0 means no change.
[b] Mean values; standard deviations in parentheses.
[c] χ^2-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.

Table A.5
Individual questions

Variables[a]	Non-rival firms			Same technological fields		
	Same technological fields[b]	Complementary technological fields[b]	Confidence level[c]	Rival firms[b]	Non-rival firms[b]	Confidence level[c]
R&D expenditures						
(a) Increased	0.313 (0.479)	0.308 (0.471)		0.278 (0.461)	0.313 (0.479)	
(b) Decreased	0.313 (0.479)	0.154 (0.368)		0.556 (0.511)	0.313 (0.479)	
Funds internally available to finance R&D projects						
(a) Less	0.125 (0.342)	0.000 (0.000)	*	0.111 (0.323)	0.125 (0.342)	
(b) More	0.563 (0.512)	0.538 (0.508)		0.278 (0.461)	0.563 (0.512)	*

The effects of M&A on the R&D efforts and financing: the role of market- and technology-relatedness.
[a] Answers codified through binary variables. 0 means no change.
[b] Mean values; standard deviations in parentheses.
[c] χ^2-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.

Table A.6
Individual questions

Variables[a]	Non-rival firms			Same technological fields		
	Same technological fields[b]	Complementary technological fields[b]	Confidence level[c]	Rival firms[b]	Non-rival firms[b]	Confidence level[c]
More patents granted	1.125 (0.806)	1.385 (1.577)		0.556 (0.705)	1.125 (0.806)	**
Decreased danger of being imitated	2.000 (1.461)	0.615 (1.023)	***	1.333 (0.840)	2.000 (1.461)	
The elimination of competing product standard	1.250 (1.238)	0.692 (1.158)		1.667 (1.372)	1.250 (1.238)	
Achievement of critical mass in technological fields						
(a) New to the company	1.125 (1.310)	2.615 (1.813)	***	0.778 (1.353)	1.125 (1.310)	
(b) Already covered by the company	3.000 (0.516)	2.923 (1.412)		3.111 (0.900)	3.000 (0.516)	
Improvement of existing technological competencies	2.625 (0.719)	2.846 (1.047)		2.556 (0.856)	2.625 (0.719)	
Development of new technological competencies	2.000 (1.265)	2.692 (1.289)	*	1.667 (1.283)	2.000 (1.265)	
Application of the acquirer's existing technological competencies in the target firm's product markets	2.250 (1.438)	1.846 (0.967)		1.333 (1.283)	2.250 (1.438)	*
Application of the target's existing technological competencies in the acquiring firm's product markets	2.000 (1.461)	2.231 (1.275)		1.333 (1.283)	2.000 (1.461)	
Greater speed in						
(a) Introducing new products	2.500 (1.366)	1.923 (1.719)		2.000 (1.609)	2.500 (1.366)	
(b) Introducing new production processes	2.875 (1.088)	2.000 (1.697)	**	1.778 (1.592)	2.875 (1.088)	**
(c) Developing technological knowledge	2.875 (0.957)	2.769 (1.336)		1.667 (1.455)	2.875 (0.957)	***
Improved management of the R&D process	2.000 (0.730)	2.462 (1.303)		1.667 (0.970)	2.000 (0.730)	
More productive R&D personnel	2.000 (1.033)	1.615 (1.525)		1.444 (1.199)	2.000 (1.033)	
Greater complexity, less focus and/or slower decision making in R&D	0.750 (1.125)	0.538 (0.859)		0.889 (1.323)	0.750 (1.125)	
Less motivated R&D personnel	1.125 (1.310)	0.077 (0.272)	***	0.667 (0.970)	1.125 (1.310)	
Returns to R&D expenditures:						
(a) Increased	1.750 (1.438)	2.385 (1.472)		1.000 (1.085)	1.750 (1.438)	
(b) Decreased	0.000 (0.000)	0.000 (0.000)		0.444 (1.294)	0.000 (0.000)	

The effects of M&A on technological performances: the role of market- and technology-relatedness.
[a] Answers codified through a five-point Likert scale, ranging from 0 (not important at all) to 4 (very important).
[b] Mean values; standard deviations in parentheses.
[c] *t*-Test of the difference between mean values. ***Confidence level > 99%. **Confidence level > 95%. *Confidence level > 90%.

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