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Technological similarity, post-acquisition R&D reorganization, and innovation performance in horizontal acquisitions

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ABSTRACT

This paper aims to disentangle the mechanisms through which technological similarity between acquiring and acquired firms influences innovation in horizontal acquisitions. We develop a theoretical model that links technological similarity to: (i) two key aspects of post-acquisition reorganization of acquired R&D operations – the rationalization of the R&D operations and the replacement of the R&D top manager, and (ii) two intermediate effects that are closely associated with the post-acquisition innovation performance of the combined firm – improvements in R&D productivity and disruptions in R&D personnel. We rely on PLS techniques to test our theoretical model using detailed information on 31 horizontal acquisitions in high- and medium-tech industries. Our results indicate that in horizontal acquisitions, technological similarity negatively affects post-acquisition innovation performance and that this negative effect is not mediated by the reorganization of the acquired R&D operations. However, replacing the acquired firm's R&D top manager leads to R&D productivity improvements that positively affect innovation performance.

1. Introduction

The impact of firm acquisition on innovation has received considerable attention in the economics and management literature. Early studies found that for the acquiring firm it lowers research and development (R&D) expenses (Hall, 1990) and innovation output (Hitt et al., 1991, 1996). Later studies suggest that the effect of acquisition on innovation performance depends on the characteristics of acquiring and acquired firms (e.g., Desyllas and Hughes, 2010). This stream of research identifies the *technological similarity* of the acquiring and acquired firms as an important predictor of the innovation impact resulting from acquisitions (Ahuja and Katila, 2001; Cloodt et al., 2006; Ornaghi, 2009). In their study of *horizontal acquisitions* (i.e., acquisitions of firms in the same industry as the acquiring firms), Cassiman et al. (2005) show that the more similar the technological resources and capabilities of acquired and acquiring firms, the more likely that the acquisition will result in a reduction in the combined R&D effort and the efficiency of R&D operations. Makri et al. (2010) find that technological (and scientific) similarity appears to have no positive effect on innovation performance in the post-acquisition period – in terms of quantity, quality, and novelty of the patents awarded to acquiring firms.

Although these findings are interesting, our understanding of their underlying rationale is fairly limited. A popular view inspired by qualitative studies of the acquisition implementation process (Haspeslagh and Jemison, 1991; Jemison and Sitkin, 1986; Pablo, 1994), posits that in order to realize the efficiency gains that can arise from combining similar resources and capabilities, the operations of the newly combined firm need to be reorganized (Capron, 1999; Capron et al., 1998, 2001; Karim and Mitchell, 2000). However, reorganization efforts can result in collateral damage in the form of conflicts, and disruption among firms' personnel that ultimately can destroy the potentially beneficial effects of the acquisition of a similar firm. It might be assumed that these arguments hold also for R&D operations. However, the *chain of links* through which firms' technological similarity influences post-acquisition innovation performance in horizontal acquisitions has not been adequately explored. This is a serious weakness in the acquisition literature and this gap in the research is a source of causal ambiguity (King, 2007; King and Zeithaml, 2001; Lippman and Rumelt, 1982). Cording et al. (2008) argue that intrafirm linkage ambiguity, a type of casual ambiguity related to lack of understanding about the link between an action and its performance

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outcome within a focal firm (King and Zeithaml, 2001), is a source of problems for managers involved in acquisition implementation because it limits their ability to accurately predict the outcome of specific implementation decisions which in turn harms post-acquisition performance. Along similar lines, we maintain that a lack of understanding of these links between technological similarity and post-acquisition innovation performance severely limits managers' abilities to predict how the reorganization of R&D operations following a horizontal acquisition might differently influence innovation performance depending on the degree of similarity of the technological resources and capabilities of the combining firms. The aim of this paper is to address this weakness.

This study is inspired by studies that apply a process view to understand the relationship between the product and market relatedness of acquiring and acquired firms, and acquisition performance of the newly combined firm (Larsson and Finkelstein, 1999; Zollo and Singh, 2004). Thus, we apply a similar type of process investigation to the R&D and innovation contexts. We highlight the links between the technological similarity of acquiring and acquired firms and post-acquisition R&D reorganization actions; the effects of these reorganization actions on R&D operations; and ultimately, the links between these intermediate effects and post-acquisition innovation performance. In other words, the complex chain leading from the technological similarity of R&D operations to post-acquisition innovation performance is broken down into more manageable segments, and the underlying structure of actions and their effects is exposed. In so doing, we highlight the innovation impact of technological similarity mediated by R&D reorganization, and the impact that is generated by the direct (i.e., non-mediated) link between technological similarity and post-acquisition innovation performance.

Our empirical analysis is based on data gathered through face-to-face interviews with firms' top managers, conducted within in-depth case studies of 31 horizontal acquisitions of European firms that operate in the medium and high-tech industries.[1] We test our model using partial least squares (PLS) techniques. The results of the empirical analysis indicate that technological similarity between acquiring and acquired firms has a large and direct negative effect on post-acquisition innovation performance, and that the effect mediated by a reorganization of the acquired R&D operations – notably, productivity improvements achieved by replacing the R&D top manager – is positive but of small economic magnitude. These results provide an original contribution to the literature on the innovation impact of acquisitions by looking into the black box of the R&D reorganization process. They also offer fresh new insights for managers of acquiring firms which may help their identification of acquisition targets and improve the implementation of acquisition activities.

The paper proceeds as follows. In Section 2, we discuss the theoretical background and provide an overview of the model. Section 3 develops our hypotheses and in Sections 4 and 5 we describe the methodology for the empirical analysis and present our results. The findings are discussed in Section 6 where we highlight our contribution to the acquisition literature. We conclude by summarizing our findings, and indicating the limitations of our paper and directions for future research in Section 7 which also highlights some implications of our findings for managers.

2. Overview of the theoretical model

In this paper, we consider horizontal acquisitions. Therefore, the R&D operations of acquiring and acquired firms generally are in the same broadly defined technological area. However, there may be different *degrees of overlap* in these operations. At one extreme there are acquiring and acquired firms with completely overlapping R&D operations, that is R&D operations in the same narrowly defined technological fields (e.g., in the same 3-digit USPTO patent classes). This would refer for example, to two firms conducting R&D on medical devices used in cardiovascular surgery. In this case acquiring and acquired firms would exhibit a high degree of technological similarity. At the other extreme, although the two firms may operate in the same broadly defined area of R&D operations (e.g., their R&D operations are in the same 2-digit patent sub-categories; see Hall et al., 2001), they specialize in different, narrowly defined technological fields. For example, between two firms that conduct R&D related to semiconductors, one firm might specialize in power devices and the other in small signal devices. In this case, the R&D operations of acquiring and acquired firms are associated with a low degree of technological similarity. The distinction between the presence and the absence of overlapping R&D operations is not clear-cut. There can be intermediate situations where parts of the firms' R&D operations are overlapping and parts are not.[2]

Fig. 1 presents an overview of our model. Our model suggests that the degree of technological similarity of acquiring and acquired firms affects the post-acquisition innovation performance of the combined firm both directly and indirectly through different post-acquisition reorganization actions and intermediate effects. First, taking inspiration from insights offered by studies of the acquisition implementation process (Haspeslagh and Jemison, 1991; Jemison and Sitkin, 1986; Pablo, 1994), we suggest that in order to realize the innovation potential of an acquisition, managerial actions are needed in the post-acquisition period to reorganize the acquired R&D operations. As clearly stated by Zollo and Singh (2004, p. 1236), post-acquisition reorganization "involves the degree to which pre-existing resources within the acquired firm are replaced with the equivalent resources of the acquirer, or are simply dismissed." In particular, we consider the following two R&D reorganization actions: (i) rationalization of the R&D operations of acquired firms by reducing R&D personnel, terminating duplicate R&D projects, and closing R&D laboratories, and (ii) the replacement of acquired firms' R&D top manager. Second, we consider two intermediate effects of these reorganization actions which are viewed as crucial determinants of post-acquisition innovation performance: (i) improvements in the productivity of the R&D personnel in the newly combined entity relative to the productivity of the two independent entities, and (ii) disruptions to the R&D personnel in the newly combined entity.

Several studies show the importance of rationalizing acquired operations and replacing acquired firms' top managers post-acquisition. Post-acquisition rationalization of manufacturing, sales, distribution, and logistics activities, in the form of the disposal or sale of physical assets, closing of facilities, and reductions to the workforce, have been examined extensively in previous studies (e.g., Capron, 1999; Capron et al., 2001). Analyzing 1483 acquisitions of US target firms in the period 1981–2000, Maksimovic et al. (2011) show that out among 12,893 acquired plants, 18.6%

[1] These case studies were conducted within the FP5 project "Mergers and Acquisitions and Science and Technology Policy" funded by the European Commission, DG Research (Contract No. ERBHPV2-CT-1999-13). Part of the output of the project has been published in the following work: European Commission (2003), Cassiman et al. (2005) and Cassiman and Colombo (2006).

[2] It is a matter of judgment as to whether the R&D operations of acquiring and acquired firms are or are not overlapping. As will become clear in Section 4, we devoted considerable effort to establish the degree of technological similarity of our sample firms in the course of the interviews conducted with firms' top managers, and through careful examination of firms' published and internal documents.

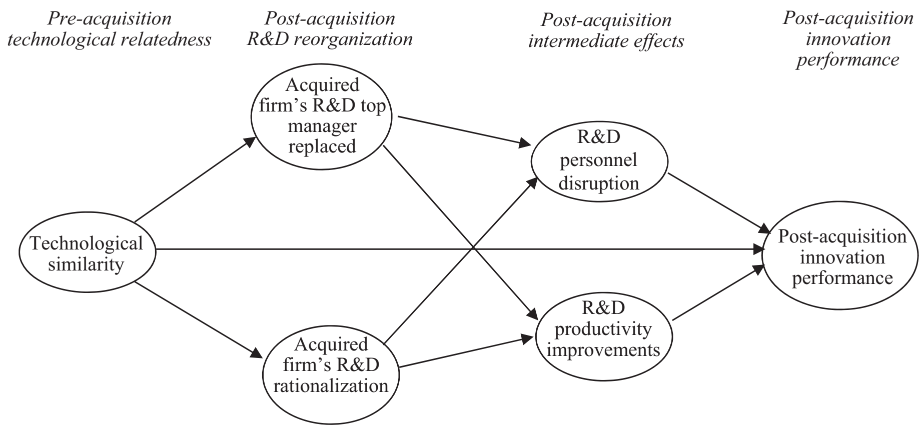

Fig. 1. Theoretical model.

were closed and 27.0% were sold off within three years of their acquisition. In the year following acquisition, 46.0% of the acquiring firms examined by O'Shaughnessy and Flanagan (1998) announced layoffs associated with the acquisition. Within the same time horizon, Krishnan et al. (2007) identified announcements of workforce reduction in the combined entity averaging 3.5% of the total workforce. Moreover, if the acquiring and acquired firms are in similar lines of business the likelihood of lay-off announcements and the extent of the workforce reductions are considerably greater. It is a stylized fact in the acquisition literature that acquisitions are followed also by high turnover of acquired executives. In a sample of acquisitions in the 1970s, Walsh and Ellwood (1991) show that the cumulative rate of turnover of acquired top managers by the end of the second year after an acquisition is 38.6%, significantly higher than in the control group of non-acquired firms. Similar data are provided by Hambrick and Cannella (1993). Data provided by Krishnan et al. (1997) and Wulf and Singh (2011) relating, respectively, to acquisitions made in the 1980s and 1990s, show even higher turnover rates among acquired top managers. Also, the degree of relatedness between acquiring and acquired companies is likely to influence the turnover of acquired managers, although the evidence on this is mixed.[3]

Whether the above mentioned post-acquisition reorganization actions positively or negatively influence post-acquisition performance is uncertain. On the one hand, rationalization of acquired operations is often necessary for the synergies associated with an acquisition to materialize. In addition, following the seminal works of Manne (1965) and Jensen and Meckling (1976), from a market for corporate control perspective, the departure of acquired executives may be evidence that acquisitions discipline entrenched ineffective managers and restore efficiency (e.g., Martin and McConnell, 1991). On the other hand, the rationalization of acquired operations and the departure of acquired top managers can be disruptive for firms' personnel, with negative implications for post-acquisition performance. In addition, the managerial rent perspective (Castanias and Helfat, 1991, 1992) argues that managerial talent is one of the most valuable resources obtained through an acquisition (see also Buchholtz et al., 2003). Therefore, loss of these resources is likely to have a negative effect on post-acquisition performance. In line with these arguments, the empirical evidence in studies on the performance effect of post-acquisition workforce reductions is mixed (for positive and negative effects, respectively, see e.g., Conyon et al., 2002; Krishnan et al., 2007). In relation to turnover of senior managers in the acquired firm, while the departure of the most senior executives (i.e., CEO, Chairman, President) has been found to harm post-acquisition performance, departure of other executives does not have a significant effect (Cannella and Hambrick, 1993).

In this paper, we extend the arguments proposed by these studies to the sphere of R&D and innovation. We expect that if acquiring and acquired firms have very similar R&D operations, the reorganization of R&D consisting of rationalization of acquired R&D operations and replacement of acquired R&D top manager will be more likely. Moreover, to the extent that the rationalization of acquired R&D operations allows better exploitation of economies of scale and scope, and that replacement of acquired R&D top managers is by more effective managers, these reorganization actions will likely result in productivity gains in the R&D function of the combined entity and will lead eventually to improved innovation performance. However, since R&D is a human capital intensive activity, such reorganization might be disruptive to R&D personnel. If key scientists and engineers leave the combined entity and the remaining R&D personnel become demoralized, post-acquisition innovation performance could deteriorate. Lastly, on the basis of the extant acquisition literature (e.g., Ahuja and Katila, 2001; Cassiman et al., 2005), we acknowledge that the technological similarity of the R&D operations of acquiring and acquired firms may influence post-acquisition innovation performance independent of the R&D reorganization actions considered here. In our model, this effect is captured by a direct link between technological similarity and post-acquisition innovation performance.

We examine the decisions related to reorganization of the R&D operations of *acquired firms* not acquiring firms. Previous studies show that the organizational changes that follow an acquisition occur primarily within the acquired firm (e.g., Datta, 1991; Pablo, 1994). Acquiring managers are often confident about their managerial capabilities, enjoy more powerful positions than their acquired peers, and are tempted to colonize the acquired firm by providing managerial assistance and reconfiguring its operations. Moreover, it is politically easier for the acquiring firm to impose divestiture measures on the acquired business than on its own business. The available empirical evidence confirms that acquired R&D operations are more affected by post-acquisition reorganizations than the R&D operations of acquiring firms. Capron (1999) shows that divestitures of R&D assets, and cuts to R&D personnel are three to five times more likely in acquired than in acquiring firms. Data on post-acquisition turnover rates among R&D managers are not

[3] Buchholtz et al. (2003) analyze tender offers and show that CEO departure is more likely if there is a perfect match between the 4-digit primary SIC codes of acquiring and acquired firms. Walsh (1989) provides evidence of a positive relation between relatedness and turnover of acquired executives, while Hambrick and Cannella (1993) find the opposite effect in a sample that also includes friendly mergers. Wulf and Singh (2011) study of acquired CEO retention, shows that relatedness (at the 3-digit SIC code level) has no significant effect.

available. However, the general evidence indicates that turnover rates among top managers are dramatically higher in acquired than in acquiring firms.[4]

3. Development of hypotheses

3.1. Technological similarity and innovation performance: a direct link

The main aim of this study is to investigate whether technological similarity has an indirect effect on the post-acquisition innovation performance of the combined firm, mediated by the reorganization of the acquired R&D operations. However, we would acknowledge that technological similarity is also likely to have a direct (i.e., non-mediated) effect on post-acquisition innovation performance. On the basis of previous studies we expect this effect to be negative.

The acquisition of firms with related but dissimilar R&D operations can generate benefits over and above those arising from the acquisition of firms with similar R&D operations, for several reasons. First, when acquiring and acquired firms have related but dissimilar R&D operations, an acquisition can allow them to share indivisible R&D inputs (e.g., laboratory equipment and specialized technical expertise) across different types of R&D outputs at no additional cost. Therefore, they can capture economies of scope (Henderson and Cockburn, 1996). Second, the resource-based view argues that the ability of firms to create a unique bundle of resources and capabilities is a key source of sustainable competitive advantage (e.g., Barney, 1991). Acquisitions between firms that have non-overlapping R&D operations in the same broad technological areas can be instrumental to this end. These firms are likely to have complementary technological resources and capabilities. They are also likely to have a shared language and compatible cognitive structures, which are recognized as crucial pre-conditions for mutual learning (Lane and Lubatkin, 1998). Therefore, the two firms can easily understand the value of each other's technological resources and capabilities, exchange and integrate their different knowledge, and leverage their respective technological strengths (Ahuja and Katila, 2001; Makri et al., 2010). At the same time, combination of their complementary knowledge bases creates an opportunity to exploit knowledge spillovers among complementary R&D projects through the cross-fertilization of ideas (see again Henderson and Cockburn, 1996). In accordance with the theory of recombinant invention (Fleming, 2001), this combination also enhances the ability of the combined firm to find novel, creative solutions to technical problems.

Accordingly, when considering horizontal acquisitions, we expect the impact of acquisition on innovation to be greater the smaller the overlap between the R&D operations of the acquiring and acquired firms. This effect is *not* related to the reorganization of the acquired R&D operations. On this basis, we derive the following benchmark hypothesis:

Hypothesis 1. In horizontal acquisitions, there is a negative link between the technological similarity of the R&D operations of acquiring and acquired firms, and the innovation performance of the combined firm. This link is not mediated by reorganization of the acquired R&D operations.

3.2. Technological similarity, reorganization of acquired R&D operations, and R&D productivity improvements

If the R&D operations of acquiring and acquired firms are similar, an acquisition can pave the way to capturing "economies of sameness" (Larsson and Finkelstein, 1999, p. 6). Combination of two previously independent firms can increase the size of R&D operations, allowing economies of scale (e.g., through task specialization) and increasing R&D output per unit of R&D input. Redundancies in R&D can be eliminated, thereby reducing R&D input per unit of R&D output (Henderson and Cockburn, 1996). In order to realize these economies, R&D operations need to be reorganized. Duplicate R&D projects must be terminated, redundant R&D equipment disposed of, and laboratories that duplicate specializations closed. Moreover, in order to capitalize on the increased scale, the R&D operations of the acquiring and acquired firms need to be combined, leading to the redeployment of R&D facilities and personnel. These rationalization actions, which are more likely to affect acquired rather than acquiring firms (e.g., Capron, 1999), lead to improvements in the productivity of the R&D personnel in the combined entity.

In addition, technological similarity enables acquiring firms to improve R&D productivity by replacing the acquired R&D top manager. In this regard, the literature on market for corporate control argues that acquisitions offer a mechanism through which incompetent or self-serving managers can be replaced with managers who can enhance performance (see also Walsh and Ellwood, 1991) Similarity between firms facilitates this move since acquiring managers will have a good understanding of the specificities of the acquired operations.[5] However, the managerial rents view (Cannella and Hambrick, 1993; Castanias and Helfat, 1991, 1992) claims that managerial talent is one of the most valuable resources firms can obtain through an acquisition. According to this view, better acquisition performance is associated with retention rather than replacement of acquired managers. However, when the R&D operations of the combining firms are similar, the background and experience of the R&D managers of the two firms are likely also to be similar. Even if the acquired R&D top manager possesses impressive skills, the value this will contribute to the combined entity is clearly more limited than where the two firms' areas of expertise are less similar. In sum, in the former situation, replacing of the acquired firm's R&D top manager will have a more positive (or less negative) effect on the R&D productivity of the combined entity than in the latter situation.

Based on the above reasoning, we derive the following hypotheses.

Hypothesis 2a. Technological similarity is positively related to the post-acquisition rationalization of the acquired R&D operations.

Hypothesis 2b. Technological similarity is positively related to the post-acquisition replacement of the acquired R&D top manager.

Hypothesis 3. Rationalization of the acquired R&D operations is positively related to post-acquisition productivity improvements in the combined R&D operations.

Hypothesis 4. Replacement of acquired R&D top manager is positively related to post-acquisition productivity improvements in the combined R&D operations.

[4] Walsh and Ellwood (1991) show that the cumulative turnover rate of acquiring top managers by the end of the second year after an acquisition was only 17.5% and was not significantly different from the turnover rate in the control group.

[5] Previous studies show that strategic similarity between acquiring and acquired firms leads to the redeployment of resources to acquired firms, in turn, making divestiture of acquired resources more likely (Capron et al., 2001). Replacement of acquired managers with personnel from acquiring firms is part of this resource reconfiguration process.

Hypothesis 5. Productivity improvements in the combined R&D operations are positively related to post-acquisition innovation performance.

3.3. Technological similarity, reorganization of acquired R&D operations, and R&D personnel disruption

In Section 3.2, we suggested that the higher the technological similarity between acquiring and acquired firms, the greater the likely extent of the rationalization of the acquired R&D operations. Moreover, replacement of acquired R&D top manager is also more likely if acquiring and acquired firms are technologically very similar. In the following, we show that these post-acquisition reorganization actions can generate serious collateral damage that favors the voluntary departure of key inventors and harms R&D employees' motivation. The ensuing negative effects on post-acquisition innovation performance may balance or even outweigh the positive effects described in Section 3.2.

Work on the acquisition implementation process suggests several reasons why the rationalization of acquired R&D operations is likely to create disruption, and feelings of resentment, and dissatisfaction among R&D employees (Larsson and Finkelstein, 1999; Puranam et al., 2006; Ranft and Lord, 2002). First, rationalization is often accompanied by the absorption of acquired R&D operations into the acquiring firm's organization. To the extent that structural integration implies a reduction in the autonomy and social status of acquired scientists and engineers, and increased uncertainty about career prospects, these individuals will suffer from lower intrinsic motivations (Osterloh and Frey, 2000) and often will "mentally disengage" (Haspeslagh and Jemison, 1991, p. 179). In line with this view, Paruchuri et al. (2006) find that when acquired firms are structurally integrated into the acquiring firm's organization, the knowledge workers who demonstrate the most severe decline in productivity are those who lose the most social status and centrality. Second, even if there is no change in intrinsic motivations or psychological attitudes, the grouping together of formerly separate R&D operations in larger units makes it more difficult to link rewards to the individual performance of scientists and engineers. The increased noise in the performance indicators negatively affects the extrinsic motivations of acquired scientists and engineers, and especially the most talented (Zenger, 1994). Third, the reshaping of R&D operations involves organizational changes that alter the work context and organizational routines of previously separate firms (Ranft and Lord, 2002; Zollo and Singh, 2004). This creates stress and a sense of loss among R&D personnel (Buono and Bowditch, 1989).

The disruption to R&D personnel engendered by the rationalization of acquired R&D operations is damaging to post-acquisition innovation performance. If talented employees leave the newly combined firm, there is a loss of human and social capital (Ernst and Vitt, 2000). In fact, key inventors' knowledge "cannot be specified and communicated independent from the possessor of the knowledge" (Winter, 1987, p. 168). Moreover, acquired knowledge assets also include socially complex knowledge that "resides primarily in specialized relationships among individuals and groups" (Badaracco, 1991, p. 79) within and across organizations. These relationships may be irreparably damaged if key R&D staff leave the firm (Dougherty and Bowman, 1995).

Previous studies indicate that these negative effects are severe, especially among acquired R&D personnel (Kapoor and Lim, 2007). Acquired R&D top managers who are retained can help to limit this damage through "mobilizing and mitigating actions" (Graebner, 2004, p. 752) that make the departure of talented inventors less likely. Mitigating actions are aimed at proactively sharing information among acquired employees, addressing employees' acquisition-related career concerns, and protecting employee autonomy from excessive interference from the acquiring firm's personnel. Mobilizing actions include setting challenging but realistic goals for acquired inventors, and favoring coordination with their peers in the acquiring firm. Acquired R&D top managers are ideally placed to implement these measures because of their knowledge of the acquired R&D employees, and their long-standing relationships with them.

Conversely, if the acquired R&D top manager is fired or voluntarily leaves the firm, we expect the combined firm to find it difficult to retain acquired R&D personnel since they may interpret the departure of their most senior R&D manager as indicating underlying problems related to the acquisition, and become alarmed about their own future prospects (Cannella and Hambrick, 1993). As discussed above, the replacement of the acquired R&D top manager is more likely when acquiring and acquired firms have more similar R&D operations.

Accordingly, we derive the following hypotheses.

Hypothesis 6. Rationalization of acquired R&D operations is positively related to post-acquisition disruption to R&D personnel in the combined firm.

Hypothesis 7. The replacement of the acquired R&D top manager is positively related to post-acquisition disruption to R&D personnel in the combined firm.

Hypothesis 8. Disruption to R&D personnel in the combined firm is negatively related to post-acquisition innovation performance.

4. Methods

4.1. Data

The data used for the empirical analysis were collected as part of a research project promoted by the DG Research of the European Commission and based on a multiple-case design. The EC project was aimed at understanding the impact of mergers and acquisitions on employment, economic performance, and innovation in European companies and examined 31 horizontal acquisitions[6] that occurred in Europe in 1987–2001. These acquisitions involved 62 companies, all of which were active in medium and high-tech industries.

Prior research suggests that various factors, such as firm's industry, location, size, age, and acquisition experience, the motive for the acquisition and the method of payment, all play a role in acquisition outcomes (e.g., Capron, 1999; Krug and Hegarty, 1997; Larsson and Finkelstein, 1999). Therefore, in order to increase the generalizability of the findings, the sample includes acquisitions where acquiring and acquired firms were located in different countries, operated in different industries, and varied in size and age, and where the reasons for the acquiring firms' acquisition activities were either innovation-related or non-innovation-related. Table 1 provides an overview of the characteristics of the 31 acquisitions included in the sample, and of the firms involved in these deals. The sample, although fairly small, is relatively heterogeneous, so that it combines the richness of in-depth case studies with the breadth typical of large-sample empirical investigations. As suggested by Larsson and Finkelstein (1999, p. 3), "[t]he combination

[6] Selection of the 31 cases was based on the 1993 "EU Market Share Matrix (MSM)": a firm-level database of all "leading firms" in EU industry, and all manufacturing sectors. In the year *t* a firm is a "leading firm" if it is one of the five largest EU producers in at least one EU 3-digit industry in that year. The original MSM database contained information on 294 firms. Taking into account the sectors of interest of the EU project on Mergers and Acquisitions (i.e., medium and high-tech industry), 73 firms remained in the listing. Removing 14 acquiring firms from outside the EU, the final sample consisted of 59 firms, 31 of which agreed to participate in the study (response rate of approximately 52%).

Table 1
Overview of acquisition deals and firms included in the sample.

Deal	Country		Company sales (USD millions)		Acquisition characteristics				Scientific and technological fields		
	Firm I	Firm II	Firm I	Firm II	Year	Hostile	Financed by debt	Industry	Firm I	Firm II	Technology similarity
1	UK	UK	14,270	4,977	1999	1	0	Aerospace	Aircrafts and avionic platforms	Avionics components	1
2	IT	US	1,324	2,249	1999	0	1	Biomedical instruments	Cardiovascular surgery and cardiac devices	Cardiovascular surgery and cardiac devices	3
3	US	UK	1,000	2,000	1995	0	0	Chemicals	Polyolefin, catalysts, and catalysis process	Polymer chemistry	1
4	DE	DE	11,592	3,303	2000	1	0	Chemicals	Specialty chemical processes	Specialty chemical processes	3
5	ES	ES	430	949	1989	0	0	Chemicals	Commodity chemicals	Plastics, petrochemicals	1
6	CH	CH	352	907	1995	0	1	Electrical machinery	Building control systems	Building control systems	3
7	FR	FR	3,261	765	1988	0	0	Electrical machinery	Control systems for industrial processes	Control systems for industrial processes	3
8	BE	CA	139	33	1994	0	1	Electrical machinery	Transformers	Large power transformers	2
9	IT	US	791	800	1999	0	1	Electrical machinery	Automation systems for automotive	Automation systems for automotive	3
10	BE	US	232	7	1990	0	0	Electronics	Analog electronics	Digital electronics	1
11	IT	FR	309	309	1987	1	0	Electronics	Semiconductor: power devices	Semiconductor: small signal devices	1
12	UK	US	2,196	1,100	1998	0	0	Energy production	Nuclear engineering: fuel process and decommission-ing	Nuclear engineering: fuel process and energy systems	2
13	IT	US	5,697	5,738	1999	0	1	Farm machinery	Design, engineering, and testing of mechanical components and systems	Design, engineering, and testing of mechanical components and systems	3
14	IT	FR	400	104	1990	0	0	Household appliances	Mechanical and electronic engineering: free-standing white goods	Mechanical and electronic engineering: built-in white goods	1
15	BE	US	1,625	51	2001	0	0	Industrial materials	Metal forming and coating technologies	Coating technologies	2
16	BE	NL	48	8	1996	0	0	Instruments	Software for testing systems	Data acquisition systems, image-processing software	1
17	IT	US	1,001	197	1991	0	0	Instruments	Transport signaling systems	Transport signaling systems	3
18	DE	US	71,519	61,147	1998	1	0	Motor vehicles	Engines, new concept vehicles	Development of specialized mass-market vehicles	1
19	BE	CA	4,385	47	1997	0	1	Non-ferrous metals	Cutting tool powders, zinc powders for batteries	Cutting tool powders, nickel powders for batteries	2
20	CH	CH	13,766	10,138	1996	1	0	Pharmaceuticals	Cardiovascular and central nervous systems, inflammatory disorders, allergies, infections, oncology	Immunology and transplantations, central nervous system, oncology, dermatology, chronic pain	2

Table 1 (*Continued*)

Deal	Country		Company sales (USD millions)		Acquisition characteristics				Scientific and technological fields		
	Firm I	Firm II	Firm I	Firm II	Year	Hostile	Financed by debt	Industry	Firm I	Firm II	Technology similarity
21	SE/US	US	6,758	7,237	1999	1	0	Pharmaceuticals	Central nervous system, oncology, infectious diseases, metabolic disorders, large biotech proteins	Inflammation, arthritis, small chemicals for therapeutic use, agricultural chemistry and biotechnology, nutritional products	1
22	BE	US	1,692	10	1998	0	0	Pharmaceuticals	Allergies, central nervous system diseases	Inflammatory diseases	1
23	BE	DE	433	357	1999	0	0	Plastics	Vinyl	Vinyl	3
24	AU	US	250	250	1989	0	0	Rubber	Natural rubber	Synthetic rubber	1
25	UK	NL	16,424	20,834	1997	0	1	Specialty chemicals	Specialty chemicals	Natural, polymer, and synthetic chemistry	1
26	NL	NL	6,355	1,154	1998	0	0	Specialty chemicals	Chemical processes, materials	Ferments and enzymes	1
27	BE	FR	1,217	38	1991	0	0	Specialty chemicals	Development of natural and synthetic organic chemicals, inorganic chemicals, plastics	Process technology for high-performance compound materials	1
28	CH	DE	1,892	5,308	1997	1	1	Specialty chemicals	Development of dyes, pigments, additives, master batches, textile and leather chemicals, paper chemicals	Materials, pigments, additives, master batches, environmentally friendly process technologies	2
29	DE	CA	9,815	122	1996	0	0	Specialty chemicals	Metal chemicals, detergent and adhesives	Metal chemicals	3
30	UK	NL	11,513	5,452	1999	0	0	Steel	Process control, environmentally friendly technologies	Metallurgy processes	2
31	IT	IT	836	0.03	1992	0	0	Textile machinery	Computer-aided manufacturing systems	Computer-aided manufacturing systems	3

Technology similarity: 1 = low (non-overlapping R&D operations); 2 = medium (part of the two firms' R&D operations is overlapping); 3 = high (perfect overlap of R&D operations).

of idiographic and nomothetic research is particularly well-suited to the study of complex organizational activities such as M&A processes because it can capture a broad range of relatively detailed phenomena without the severe limits on the number of observations that are inherent in case study methods (cf. Lee, 1991; Luthans and Davis, 1982)."

We rely on qualitative data and perceptual measures based on interviewed managers' judgments. Specifically, the data were collected during face-to-face interviews with top managers in the acquiring firms who were in charge of or actively participated in the implementation of the acquisition process (in most cases the Vice-President for strategy or corporate development and the Vice-President for R&D or the Chief Technology Officer), and as a result were the most knowledgeable individuals about the reorganization triggered by the acquisition and its impact on the combined entity, including the impact on innovation. A detailed case study protocol was developed for the interviews, which were conducted by trained researchers during the period 2001–2002. Interviews lasted around 2 h on average. Open-ended and closed-ended questions were posed. For the closed question, measurement scales were developed that encompassed the relevant constructs from the economic and management literatures. During the interviews, the respondents were administered the open-ended and closed-ended questions by two interviewers (usually two experienced researchers) who took notes to ensure accurate recording of responses. The qualitative information obtained from the interviews was cross-checked with data from several secondary information sources: (i) documents provided by the informants about the acquisitions and the firms involved (e.g., annual reports, balance sheets, R&D investment/project descriptions); (ii) archival data, including business publications and firm websites; and (iii) data from official registries, such as those maintained by the US Patent and Trademark Office (USPTO) and the European Patent Office (EPO). The information collected during the interviews was coded independently by the two researchers. Conflicts in the coding and/or inconsistencies in the information collected from primary and secondary sources were resolved through follow-up phone calls to the managers interviewed. In most cases, brief meetings or phone calls were held with other relevant managers for follow-up and clarification purposes. In a very few cases, managers of acquired firms were also interviewed. This information was used to cross-check the information gathered from the acquiring firm. We see the type of data collected and the data collection tools and procedures implemented by the EC project to fit very nicely with the empirical needs of our work. Although there are well-developed constructs and relationships between these constructs that have been already established with precision by a variety of scholars in the field of post-acquisition reorganization, in this article we suggest that there is a need for a better understanding of the complex chain that links all these constructs and relationships in one process. The combination of qualitative and quantitative data is a research design that efficiently allows to analyze how a process model works and unfolds (e.g., Edmondson and McManus, 2007). Open-ended research questions can help us refining key variables (e.g., technological relatedness) and the specific knowledge about the phenomenon. Quantitative data allow for generalizability via the application of a rigorous test of hypothesis. To this end we apply PLS that is an appropriate estimation technique given the small size of our sample, and has the advantage over a qualitative method of allowing for a formal statistical test of our theoretical hypotheses.

Each case study covered the following issues: description of acquiring and acquired firms (products and markets, history, sales, R&D activities and strategy, acquisition behavior); description of the acquisition (motives, market and technology relatedness between the acquiring and acquired firms); analysis of post-acquisition reorganization, notably of R&D operations; and evaluation of the impact of the acquisition on employment, economic performance, and innovation performance. In line with the extant acquisitions literature, the effects on the focal acquisition were assessed for a three-year window following completion of the acquisition (with the exception of two cases where acquisitions were completed in 2000 and 2001, making this time window smaller). With regard to the specific aim of the present paper, the interviewees' responses to the open-ended questions provided in-depth information on the post-acquisition reorganization of R&D operations, the effects of the acquisition on R&D inputs and outputs, including disruption to R&D personnel, and several indicators reflecting the ultimate impact on innovation of the acquisition. This type of fine-grained information is not available from secondary data sources.

Another advantage of these data is their level of analysis – individual acquisitions – which provides a unique opportunity to isolate the impact of a given acquisition from other confounding factors (Capron, 1999; Cassiman et al., 2005; Datta, 1991). This is very important since some firms may be involved in several acquisitions in a given year. Moreover, the acquired assets may be only a portion of an acquired firm's assets, and acquisitions are often followed by partial divestiture of acquired assets. Accordingly, firm-level data available from surveys or published annual statistics (e.g., R&D expenses, patents), offer a view that is too aggregated. Our informants (managers) had deep knowledge of the focal acquisition, and their informed judgment about the effects that were triggered by the acquisition reduced the problems typically encountered in studies that use secondary data to study the impacts of acquisitions.

Thus, despite the small number of observations, we are confident that our data set allows us accurately to assess the effect of technological similarity on the post-acquisition reorganization of R&D operations, and ultimately, post-acquisition innovation performance.

This type of in-depth data collection is demanding of managers' time, so we allowed our interviewees to select the individual acquisitions to be analyzed. Since firm managers are likely to choose large deals which they regarded as being successful, this selection procedure could be a source of bias. Nonetheless, we believe that this procedure does not invalidate our argument that our data set is a suitable sample for analyzing the hypothesized relationships since the selection of acquisitions is likely based on factors other than managers' perceptions of post-acquisition innovation performance. As noted above, the aim of the case studies was to collect these data as part of a broader investigation into the impact of acquisitions on employment, and economic and innovation performance, and any of these variables may have driven the case selection. Consistent with this argument, our sample includes acquisitions with positive and negative impacts on innovation. Moreover, the relationships between R&D reorganization, innovation performance, economic performance, and employment evolution are ambiguous. Thus, the fact that most managers selected successful acquisitions is unlikely to have created a unidirectional bias in our data between R&D reorganization actions and post-acquisition innovation performance.

4.2. Measures

Table 2 presents details of the indicators obtained from the closed-ended questions and used to operationalize the various constructs. Wherever possible, multiple indicators were considered and key informants' responses were codified and checked using interviewees' responses to the open-ended questions and secondary data.

The construct *post-acquisition innovation performance* is measured using three indicators that capture the extent to which the acquisition positively affects different dimensions of the innovation performance of the combined firm (i.e., patenting activity, development of new technological competencies, and speed in developing technological knowledge). Qualitative information on the impact of the acquisition on patenting activity was checked against USPTO and EPO data.

In terms of the distribution of acquiring and acquired firms' R&D operations across technological fields, in none of the deals were the firms' R&D operations in unrelated technological fields. This is not surprising since our sample includes only horizontal acquisitions. Following Cassiman et al. (2005), the variable *technological similarity* captures the extent to which the R&D operations of the acquiring and acquired firms are overlapping. From the closed-ended questions we know (yes/no) whether the target and the acquiring firms had strengths in: (1) "the same technological fields (i.e., they have largely overlapping technological capabilities)"; (2) "different but complementary technological fields". From the transcripts of the open-ended questions we have the evaluations of technological relatedness made by the Vice-Presidents for R&D or Chief Technology Officers interviewed, and validated using documentation on the acquisitions, provided by the firms involved in the deal (for a description of the technological fields in which acquiring and acquired firms operate, see Table 1). Based on this original information we operationalize the variable *Technological similarity* as an index that takes the value 3 (maximum value) if acquiring and acquired firms had R&D operations in the same narrowly defined technological fields, thus overlapping perfectly. An example is acquisition no. 17. In this case acquiring and acquired firms had perfectly overlapping technological expertise in transport signaling systems. The variable takes the value 1 (minimum value) if acquiring and acquired firms had no overlapping R&D operations. Examples are acquisitions nos. 24 and 26. In the former case, a manager of the acquiring firm declared in interview that "Firm 2 had a strong position in producing gloves that were chemically resistant, while Firm 1 produced mainly gloves for heavy industries. [. . .] the technology of Firm 1 was based on synthetic polymers. The technology of Firm 2 was primarily based on natural rubber." In the case of the latter acquisition, the responding Chief Technology Officer declared that "Firm 2 was specialized in biotechnology in

Table 2
Construct measurement.

Latent construct	Indicator	Individual item reliability	Composite reliability
Technological similarity			1.00
	The extent of technological similarity between acquiring and acquired firms. It equals: 1 = if the acquiring and the acquired firms operated in related technological fields but *did not* have any overlapping R&D operations (i.e., R&D operations in the same narrowly defined technological fields) 2 = if the acquiring and the acquired firms operated in related technological fields and had *both* overlapping and non-overlapping R&D operations 3 = if the acquiring and the acquired firms operated in related technological fields and had perfectly overlapping R&D operations	1.00	
Acquired firm's R&D rationalization			0.77
	- Extent of cut in acquired R&D personnel (1 = 0–10%; 2 = 11–50%; 3 = 51–100%)[a]	0.75	
	- Extent of cut in acquired physical R&D facilities (1 = 0–10%; 2 = 11–50%; 3 = 51–100%)[a]	0.75	
	- Extent of rationalization of the acquired R&D operations (1 = no change; 2 = termination of concurrent R&D projects; 3 = closure of R&D laboratories)	0.69	
Acquired firm's R&D top manager replaced			1.00
	Whether the top manager of the acquired R&D function was replaced just after the acquisition ("yes"; "no")	1.00	
R&D productivity improvements of the combined firm			1.00
	- Extent of the increase in the productivity of R&D personnel due to the acquisition (1 = negligible; 5 = very large)	1.00	
R&D personnel disruption in the combined firm			0.81
	- Extent of loss of R&D personnel due to voluntary abandonment in the acquired firm after the acquisition (1 = 0%; 2 = 1–10%; 3 ≥ 11%)[b]	0.87	
	- Extent of loss of R&D personnel due to voluntary abandonment in the acquiring firm after the acquisition (1 = 0%; 2 = 1–10%; 3 ≥ 11%)[b]	0.77	
	- Impact of the acquisition in generating less motivated R&D personnel in the combined firm (1 = negligible; 3 = large)	0.63	
Post-acquisition innovation performance of the combined firm			0.82
	Impact of the acquisition on the following technological performance of the combined firm (1 = negligible; 5 = very large): - More patents granted	0.77	
	- Development of new technological competencies	0.85	
	- Greater speed in developing technological knowledge	0.72	

[a] The original scale was made of the following six classes: 0; 1–10; 11–50; 51–90; 91–99; 100. Given lack of variation in the classes at the two ends of the scale, we regrouped the classes into three new ones: 0–10; 11–50; 51–100.
[b] The original scale was made of the following six classes: 0; 1–10; 11–50; 51–90; 91–99; 100. Given lack of variation in the classes at the right end of the scale, we regrouped the classes into three new ones: 0; 1–10; ≥11.

enzymatic routes and fermentation processes. These technologies were complementary with Firm 1's organic chemistry technologies. Both companies were active in antibiotics or the intermediates necessary for the production of those antibiotics.... Technological strengths were complementary as Firm 2 and Firm 1 had, respectively, strong positions in biotechnology and chemical processes." In intermediate situations where acquiring and acquired firms had overlapping and non-overlapping R&D operations, the variable takes the value 2. An example is acquisition no. 19; from the case study we know that Firm 1 and Firm 2 were both in the cutting-tool powders and battery materials businesses. The interviewed managers told us that in relation to the powder business, the two firms operated in the same technological field (engineered cobalt powder), while in battery material their R&D operations were non-overlapping: Firm 1 was specialized in lithium-ion batteries and Firm 2 in nickel hydroxide and mixed nickel/cobalt batteries.

Similar to Zollo and Singh (2004), interviewed managers were asked to indicate whether the top manager responsible for the acquired R&D function was replaced after the acquisition. Based on this information, we operationalized the single-item dummy variable *acquired firm's R&D top manager replaced*. Following Capron (1999), we define the construct *acquired firm's R&D rationalization* as the extent of rationalization of the acquired R&D operations triggered by the acquisition in terms of reductions in R&D personnel, disposal of physical R&D facilities, and rationalization of R&D activities.[7] With regard to the intermediate effects of acquisitions, we measure *R&D personnel disruption* based on the interviewed managers' indications of the extent of voluntary resignation of R&D personnel (Ernst and Vitt, 2000) and reduction in the motivation of R&D employees (Cartridge and Cooper, 1993) in the combined firm as a result of the acquisition.[8] The single item construct *R&D*

[7] The rationalization of R&D activities is measured through the variable "Extent of rationalization of the acquired R&D operations" (Table 2) that is an index taking values ranging from 1 to 3 depending on the answers that the interviewed managers provided to the following questions: (1) Did the acquisition lead to the termination of concurrent R&D projects (yes/no)? (2) Did the acquisition lead to the closure of R&D laboratories (yes/no)? The variable "Extent of rationalization of the acquired R&D operations" equals 3 if R&D laboratories were closed, 2 if there was no closure of R&D laboratories but R&D projects were terminated, and 0 if no such events occurred.

[8] The construct "acquired firm's R&D rationalization" includes cuts to the R&D workforce that occurred in the post-acquisition period. The construct "R&D personnel disruption" includes *voluntary* resignation of R&D personnel. Disruption to R&D personnel can be very high even if there are no changes to R&D workforce numbers (e.g., because scientists and engineers who left were replaced). This situation is exemplified by acquisitions nos. 12 and 20. In the former case, around 100 people from the acquired firm worked for the central R&D organization. During the 9 months between announcement and signing of the acquisition contract, it was not clear for this group of R&D workers what a post-acquisition reorganization would imply. This created uncertainty among the R&D staff in the acquired firm resulting in between 11% and 50% of the staff leaving the firm voluntarily and the cuts to

productivity improvements is captured as the extent of the improvements in the productivity of the R&D personnel in the combined entity resulting from the acquisition, relative to the productivity of the two independent entities.

To test our theoretical model we consider several control variables. First, previous studies indicate that acquisitions that do not have any technological motivations will likely have little or no effect on the innovation routines of the firm and thus little or no impact on post-acquisition innovation performance (for a further discussion, see Ahuja and Katila, 2001). Accordingly, we include the dummy variable *non-innovation related motives* among the controls. It takes the value of 1 if the acquisition was motivated primarily by non-innovation related reasons such as expansion in a foreign market, product diversification, or market share increase. Second, and again following previous studies (see e.g., work by Capron and colleagues), we control for the relative size of the target firm to the acquirer firm measured as real sales in the year preceding the acquisition. Anand et al. (2005) indicate that controlling for the relative size is important because the larger the target relative to the acquirer the more likely it will be that (i) the acquisition will be an important economic event for the acquirer, (ii) the acquisition will have the potential to generate synergies, and (iii) the acquisition implementation process will be complex. Third, we consider the home countries of acquiring and acquired firms. *Cross-border acquisition* is a dummy variable indicating whether the acquiring and acquired firms come from different countries (Bertrand and Zuniga, 2006; Haleblian and Finkelstein, 1999). Fourth, the control dummy variable *previous link* equals 1 if acquiring and acquired firms have experienced one or more (technological or non-technological) alliances with one another before the focal acquisition.[9] These alliances may have enabled mutual learning and development of trust, thereby facilitating implementation of the acquisition (e.g., Agarwal et al., 2006; Porrini, 2004). Fifth, as our sample includes acquisitions in both medium- and high-tech industries, we control for the target firm's industry by including the dummy variable *high tech* which equals 1 for high-tech industry and 0 otherwise. Sixth, the acquisitions analyzed in the study occurred during the period 1987–2001. Post-acquisition strategies and procedures possibly varied over this period making the time between acquisition and the ensuing integration process a potentially important omitted variable. We control for the time between year of acquisition and year in which data were collected using the variable *year*. Finally, we acknowledge that post-acquisition reorganization includes other aspects (such as those related to the *acquiring* firms' R&D operations) than those considered here. For example, technological similarity might be expected to have a direct (i.e., non-mediated) effect on the two identified intermediate effects. For this reason, the model includes a direct link between *technological similarity* on the one side, and *R&D productivity improvements* and *R&D personnel disruption* on the other. Should these links prove not to be significant, we can assume that the links between *technological similarity* and the two intermediate effects under investigation are fully mediated through rationalization of the acquired R&D operations and replacement or retention of the acquired R&D top manager. We control also for the possible link between *R&D personnel disruption* and post-acquisition *R&D productivity improvements*. If the most talented inventors decide to leave the combined firm, it might be difficult to find immediate replacements for skilled personnel. Also, the knowledge-based capabilities that enable the firm to continue to generate innovations are often embedded in complex social relations and the departure of key inventors can disrupt this social texture and lower the productivity of the combined entity's R&D operations.

4.3. Testing procedure

To estimate the structural model (i.e., the relations among the constructs) and the measurement model (i.e., the relations between the variables and the constructs they represent), we apply the PLS method using Smart-PLS (Ringle et al., 2005). This technique maximizes the variance explained in latent and endogenous variables. In other words, its primary objective is to minimize errors (Hulland, 1999). The PLS is a well-established method, and has been used in strategic management research and other business disciplines (Birkinshaw et al., 1995; Cording et al., 2008; Dierickx and Cool, 1989; Hulland, 1999). Compared to other structural model testing methods, such as LISREL, PLS estimation imposes substantially fewer conditions. It requires no assumptions about the distribution of variables, nor does it pose identification problems, and is better suited to relatively small samples (Hair et al., 2011). With PLS, a model with 27 variables can be appropriately estimated with only 10 observations (Lohmöller, 1989); each causal subsystem sequence of paths is estimated separately (Anderson and Gerbing, 1988). For example, scholars in management research have estimated models with 36 businesses (Johansson and Yip, 1994) and 21 banks (Cool et al., 1989) using PLS. For these reasons, we believe that PLS is the appropriate testing procedure for our study. Also, our sample fulfills the PLS requirement of the number of observations being equal to or larger than ten times the largest number of structural paths directed at a particular latent construct in the structural model (Hair et al., 2011).

4.4. Common method bias

Since it was not possible to obtain measures for the dependent and the independent variables from different key informants, data collection was designed following a set of procedural remedies to reduce potential common method bias. First, we separated measurement of the dependent and independent variables. In the face-to-face interviews, this was accomplished by creating a temporal separation in the form of a time lag between measurement of the two sets of variables (Podsakoff et al., 2003). Second, although it could be argued that use of Likert scales with similar anchors makes it easier for respondents to complete questionnaires, Podsakoff et al. (2003, p. 884) suggest that "this may also increase the possibility that some of the covariation observed among the constructs examined may be the result of the consistency in the scale properties rather than the content of the items." Accordingly, we used different scale endpoints and formats for the different variables. We would expect these precautions to reduce method bias due to common scale endpoints and anchoring effects.

In addition to the procedural precautions implemented during data collection, we follow Podsakoff et al.'s (2003) recommendation to conduct a statistical post hoc test to control for the

the acquired R&D workforce (imposed by the management) being negligible. Similarly, in acquisition no. 20 cuts to R&D personnel in both acquired and acquiring firms were small (most redundancies were in production not R&D). The R&D staff (between 11% and 50%) who left the company voluntarily did so because of the change in culture and management style, or because they did not obtain the positions they wanted. Among the remaining researchers there was huge reduction in motivation. In other cases, there may be no personnel disruption in spite of substantial cuts to the R&D workforce. For instance, in acquisition no. 23 both acquiring and acquired companies experienced cuts in R&D personnel. In the former a 20% reduction and in the latter about 30%. However, the motivation of the remaining R&D personnel improved because the vinyl business became the major focus of the new combined firm.

[9] The original information available from the project data indicates whether the target and the acquiring company had established or not (yes/no) any of the following co-operative agreements before the acquisition: (1) technological agreement in the form of (a) minority shareholding, (b) equity joint venture, (c) license agreement, and (2) non-technological agreement in the form of (a) minority shareholding, (b) equity joint venture, and (c) license agreement.

Table 3
Correlation of constructs and discriminant validity.

	Construct	R^2	(1)	(2)	(3)	(4)	(5)	(6)
(1)	Post-acquisition innovation performance	0.33	*0.78*[a]					
(2)	Technological similarity		−0.45					
(3)	Acquired firm's R&D rationalization	0.20	−0.31	0.38	*0.83*			
(4)	Acquired firm's R&D top manager replaced	0.11	−0.06	0.33	0.11			
(5)	R&D productivity improvements in the combined firm	0.19	0.26	0.17	0.28	0.40		
(6)	R&D personnel disruption in the combined firm	0.18	0.01	0.29	0.38	0.31	0.19	*0.76*

[a] For multiple-item constructs, figures on the diagonal represent the square root of the average variance extracted. Number of observations = 31.

effects of unmeasured latent methods factors. In particular, as Liang et al. (2007) suggest, we use PLS to examine a model in which items are allowed to load on their theoretical constructs and on a latent common-method-variance factor. The squared values of the method-standardized factor loadings (i.e., the percentage of method based indicator variance) was substantially lower than the squared standardized loadings linking the substantive latent constructs with their indicators (i.e., percentage of substantive variance). This allows us to conclude that common method bias is unlikely to be a serious concern in our study (Williams et al., 2003).

5. Results

5.1. Reliability and validity of measures

The measurement model enables us to analyze individual item reliability, internal consistency, discriminant validity, and constructs correlation. Thus, we are able to evaluate whether the constructs are measured with satisfactory accuracy. Table 2 reports the individual item reliability and the composite reliabilities, which are assessed using a measure suggested by Fornell and Larcker (1981). All the composite reliability values exceed the minimum threshold of 0.70 (Nunnally, 1967), indicating convergent validity for all of our measures. With regard to individual item reliability, the individual factor loadings are all greater than 0.6, and, therefore, are well over the minimum threshold of 0.4. This first set of results indicates a high degree of individual item reliability (Birkinshaw et al., 1995; Hulland, 1999).

Table 3 presents the correlation matrix for all the constructs and single-item measures used in the empirical analysis. The diagonal elements show the square roots of the average variance extracted (AVE) for the corresponding construct. All AVE values are higher than the 0.50 threshold recommended by Fornell and Larcker (1981). Our model shows adequate discriminant validity (i.e., each construct shows more common variance with its measures than with other constructs); the diagonal elements are all greater than the off-diagonal elements in the corresponding rows and columns (Hulland, 1999). Finally, although there are no overall goodness-of-fit statistics for PLS models, the models are evaluated on the basis of strong indicator loadings, R^2 values for the dependent (endogenous) constructs, and significance of the structural paths (Cording et al., 2008; Hulland, 1999). The R^2 values reported in Table 3 show that our model explains 33% of the variance in the innovation performance of the new combined firm.

5.2. Tests of the hypotheses

Fig. 2 reports the estimated path coefficients of the theoretical model. As a preliminary observation, notice that none of the control variables are statistically significant. Moreover, their inclusion in or exclusion from the model does not change the sign or statistical significance of the hypothesized relationships.[10] Similarly, the direct link between *R&D personnel disruption* and *R&D productivity improvements* in the combined entity, and the links between *technological similarity* and these two intermediate effects are not significant and we dropped them from the final model (see Appendix Figs. A1–A3). Given the small number of observations, we present a conservative model without controls or insignificant control paths (Fig. 2).

First, in line with hypothesis H1, the similarity of the R&D operations of the acquiring and acquired firms has a statistically significant, *direct* negative impact on post-acquisition innovation performance ($\beta = -0.53$, $p < 0.01$).

In relation to the indirect impact of *technological similarity*, we first consider the relation between this variable and the R&D reorganization actions under investigation. We find statistically significant, positive links between technological similarity and both rationalization of the acquired R&D operations ($\beta = 0.45$, $p < 0.01$) and replacement of the acquired firm's R&D top manager ($\beta = 0.33$, $p < 0.10$). These results support hypotheses H2a and H2b, and show that these reorganization actions are more likely in the context of acquiring and acquired firms with higher levels of technological overlap.

Second, the results in Fig. 2 show that the productivity improvements in the R&D operations of the combined firm are explained mostly by replacement of the acquired firm's R&D top manager ($\beta = 0.34$, $p < 0.05$), while the link between these improvements and the rationalization of the acquired R&D operations, although positive ($\beta = 0.19$), is not statistically significant. Thus, our analysis supports hypothesis H4 but not hypothesis H3. Our results show also that R&D productivity improvements in the combined firm are positively correlated with post-acquisition innovation performance ($\beta = 0.33$, $p < 0.05$), which supports hypothesis H5.

Our findings do not support hypotheses H6, H7, and H8; we find no statistically significant relation between the variable *R&D personnel disruption* and rationalization of the acquired R&D operations or replacement of the acquired firm's R&D top manager. Surprisingly, we also found no evidence of a negative link between R&D personnel disruption and post-acquisition innovation performance.

In sum, our analysis indicates that in horizontal acquisitions, similarity of the R&D operations of acquiring and acquired firms triggers a reorganization of the R&D function which involves a rationalization of the acquired R&D operations and replacement of the acquired R&D top manager. The latter action leads to R&D

[10] Given the small number of observations in our sample, we evaluated the effect of the control variables on our estimations as follows: First, we defined a baseline model including the control variables *non innovation-related motives*, *cross-border acquisition* and *relative size*, which are generally considered important in studies on the relationship between acquisition and innovation performance (see Fig. A.3 in Appendix). Second, we included the other control variables one by one, and eventually retained only those that had a statistically significant effect. None of the control variables included showed a significant relationship. We changed the baseline model by using other combinations of the control variables; the results were largely unchanged.

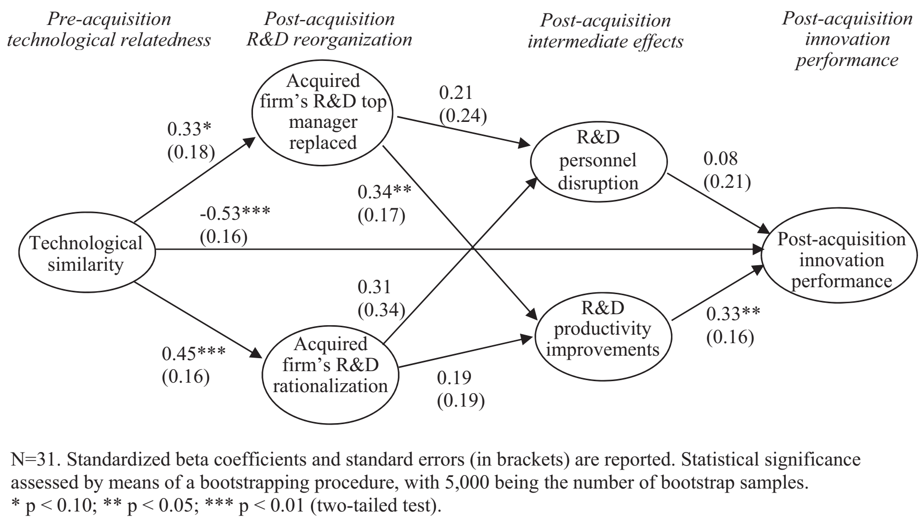

Fig. 2. Path estimation.

productivity improvements in the combined entity which, in turn, positively affects post-acquisition innovation performance. However, the magnitude of this effect (0.037) is considerably smaller than the magnitude of the *negative* direct effect (0.53 in absolute value) between technological similarity and post-acquisition innovation performance. At the same time, the effect of the reorganization in the form of disruption to R&D personnel does not appear to affect post-acquisition innovation performance negatively.

6. Discussion

This study makes an original contribution to work on the effect of acquisitions on innovation. This stream of research focuses on the technological relatedness between acquiring and acquired firms and shows that acquisitions exhibit better innovation performance if the firms involved have related but non-overlapping R&D operations (Ahuja and Katila, 2001; Cassiman et al., 2005; Cloodt et al., 2006; Makri et al., 2010; Ornaghi, 2009). Our study confirms this finding and goes a step further by investigating the effects of reorganization of the acquired R&D operations. Disentangling the *direct* and *mediated* links in the chain between technological similarity and post-acquisition innovation performance helps to explain some of the previous results.

In particular, we found no evidence of a negative innovation impact of technological similarity mediated by either rationalization of acquired R&D operations or replacement of the acquired firm's R&D top manager. Conversely, the *mediated* impact on innovation of technological similarity is *positive* although small in economic magnitude, and originates from the productivity improvements achieved through change of leadership in the acquired R&D operations. This is a novel contribution to the acquisition literature.

Previous studies argue that acquisitions engender disruption among R&D employees which in turn, damages post-acquisition innovation performance (Ernst and Vitt, 2000; Kapoor and Lim, 2007; Ranft and Lord, 2002). However, most of this work focuses on acquisitions of small technological firms and documents the problems frequently generated by absorption of the acquired firm within the organization of the acquiring firm ("structural integration"), an action that is generally associated with extensive rationalization of acquired R&D operations (Paruchuri et al., 2006; Puranam et al., 2006; Puranam and Srikanth, 2007). Our study suggests that generalizing these findings to other types of acquisitions (e.g., acquisitions of large firms or firms that operate in medium-tech industries) is questionable. Our results do not indicate the presence of this "dark side" of the rationalization of the R&D operations of acquired firms.

Our study contributes also to the stream of literature that examines the replacement or retention of acquired top executives, and the implications of these actions for acquisition performance. The strategy literature claims that, in acquisitions of technology-intensive firms, the retention of acquired leaders is instrumental in the implementation of mitigating and mobilizing actions designed to protect and energize acquired personnel (Graebner, 2004). Conversely, departure of acquired leaders involves a loss of managerial talent for the combined firm (Castanias and Helfat, 1991) and increases unease among the R&D personnel (Buono et al., 1985). Cannella and Hambrick (1993) find that personnel turnover among acquired management is negatively related to acquisition performance but that these negative effects arise exclusively from the departure of the most senior executives. The interesting issue of whether the departure of *acquired functional managers* is detrimental to post-acquisition performance *in their function* has not been investigated. To the best of our knowledge, this paper is the first to focus on the *acquired R&D top manager*. We found no compelling evidence that the departure of these managers, which is more likely when acquiring and acquired firms have very similar R&D operations, leads to disruption to R&D personnel in the post-acquisition period and harms innovation performance. Conversely, in accordance with the market for corporate control perspective on replacement of acquired top executives (Jensen and Meckling, 1976; Manne, 1965), we find that the replacement of the acquired R&D top manager engenders R&D productivity improvements which in turn, positively affect innovation performance, even though the economic magnitude of this effect is small.

Lastly, we found a strong *negative direct link* between technological similarity and post-acquisition innovation performance, a link that is *not* mediated by the post-acquisition reorganization of acquired R&D operations. This result is in line with popular argument in studies inspired by the resource-based view (e.g., Capron et al., 1998; Harrison et al., 1991; King et al., 2008), that the synergistic combination of different resources and capabilities represents a fundamental source of gains in the context of acquisitions. Hence, the greater the overlap between the R&D operations of the acquiring and acquired firms, the lower will be the potential for synergistic combinations of firms' resources and capabilities. Cassiman et al. (2005) show that acquisitions of technologically similar firms have a smaller impact on innovation than acquisitions of technology-related but dissimilar firms. Our findings indicate that this lack of potential for synergistic combination is the main explanation for their results. The disruption to R&D personnel engendered by the reorganization of R&D operations does not play a substantive role.

7. Conclusions

The aim of this paper was to extend our understanding of the multiple links between the technological similarity of acquiring and acquired firms and the impact on innovation of horizontal acquisitions. Specifically, it aimed to disentangle the direct effects among these variables from the indirect effects mediated by the reorganization of acquired R&D operations. We applied PLS techniques to test a theoretical model using detailed information obtained from interviews with firms' top managers conducted in the course of 31 case studies of horizontal acquisitions of European firms in high- and medium-tech industries. Our results confirmed the negative effect of technological similarity on post-acquisition innovation performance that is highlighted in previous studies. Interestingly, this effect is *not* mediated by the reorganization of acquired R&D operations. Conversely, reorganization and, notably, the replacement of an acquired firm's R&D top manager leads to R&D productivity improvements that have a positive effect, though of small economic magnitude, on post-acquisition innovation performance.

Clearly, this study has some limitations. First, the sample of acquisitions is fairly small. This may explain why some of the links examined were found not to be significant. Moreover, King et al.'s (2004) meta-analysis indicates that there are "unidentified moderators" that explain heterogeneity in acquisition performance. In line with their suggestions, in this paper we considered several controls that may affect post-acquisition innovation performance. However, the small sample size prevented us from more thorough examination of the effects of these controls in our model. In particular, we could not investigate whether the hypothesized links are moderated by these controls. For example, we did not detect any negative effect from the reorganization of acquired R&D operations on post-acquisition innovation performance, mediated by disruption to R&D personnel. Previous studies indicate that these effects are likely to be relatively more important in acquisitions of small high-tech firms. Our sample size was too small to investigate whether there were any differences across acquired firms of different sizes in relation to the links between technological similarity, R&D reorganization actions, and post-acquisition innovation performance. Similar reasoning can be applied to the motivations (innovation- or non-innovation related) for the acquisitions. A larger sample might have allowed an investigation of the moderating effect of these and other variables on the links considered here.

Second, in line with arguments inspired by the resource-based view, we detected a negative, and of large magnitude, direct link between technological similarity and post-acquisition innovation performance. A more comprehensive understanding of this link would be useful. For instance, it might be possible to analyze whether superior innovation performance among technologically related but dissimilar acquisitions was due to the existence of economies of scope in R&D captured through more efficient use of fungible physical assets (e.g., Henderson and Cockburn, 1996), or to superior creativity in explorative search engendered by combining complementary human capital resources (Wulf and Singh's (2011)). It would be interesting also to assess which specific R&D reorganization actions (if any) need to be implemented to reap these benefits. In other words, this link might be mediated by R&D reorganization actions that differ from those examined here, such as the establishment of inter-organizational teams, the introduction of loci of social interaction between the R&D personnel in the acquiring and acquired firms, or other coordination arrangements.

Despite these limitations, our study makes a valuable contribution to the acquisition literature and proposes a methodological approach that improves our understanding of the links between the technological similarity of acquiring and acquired firms, the reorganization actions of acquired R&D operations, their intermediate effects on the R&D activities of the combined entity, and eventual post-acquisition innovation performance. Our study has some important implications for managers in acquiring firms, relating to the selection of acquisition targets and implementation of acquisitions. If acquiring managers aim to use acquisitions as a mechanism for technology in-sourcing, or if innovation performance improvement is an important motive of their acquisitions, these managers should understand that the innovation impact of acquiring a firm with R&D operations that are similar to those of the acquiring firm is likely to be less positive than in the case of an acquisition of a firm that operates in the same broadly defined technological area as the acquiring firm but has dissimilar R&D operations (i.e., R&D operations in different narrowly defined technological fields). Of course, acquiring managers may decide to acquire target firms with similar R&D operations in the expectation of substantial benefits in other functional areas. If acquiring managers decide to pursue this type of acquisition, our results indicate that they should not hesitate to reorganize the R&D function, and that replacing the acquired R&D top manager is likely to be a positive move. Indeed, our study shows that in absence of such reorganization, post-acquisition innovation performance will likely decrease.

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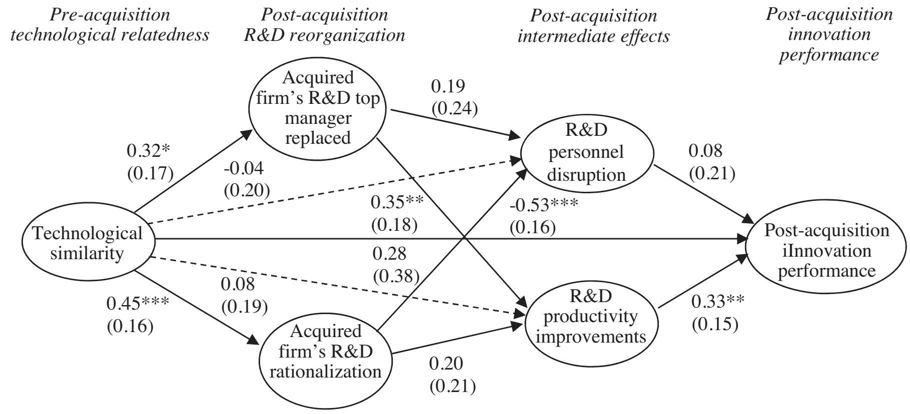
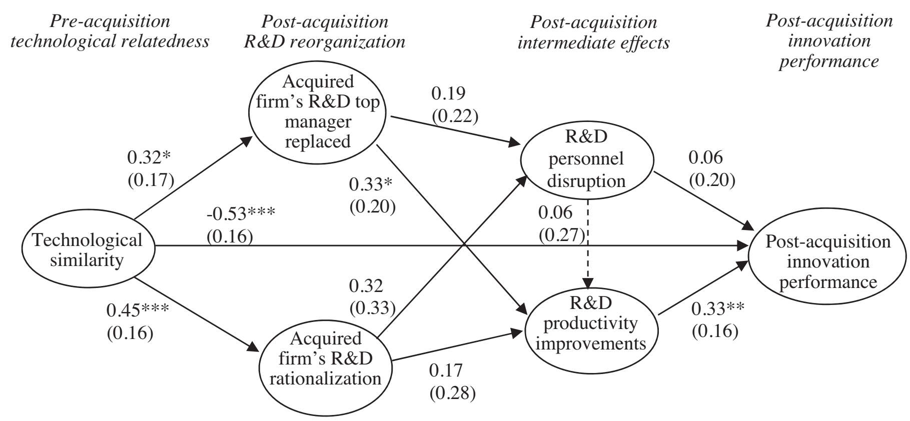
Appendix.

See Figs. A1–A3.



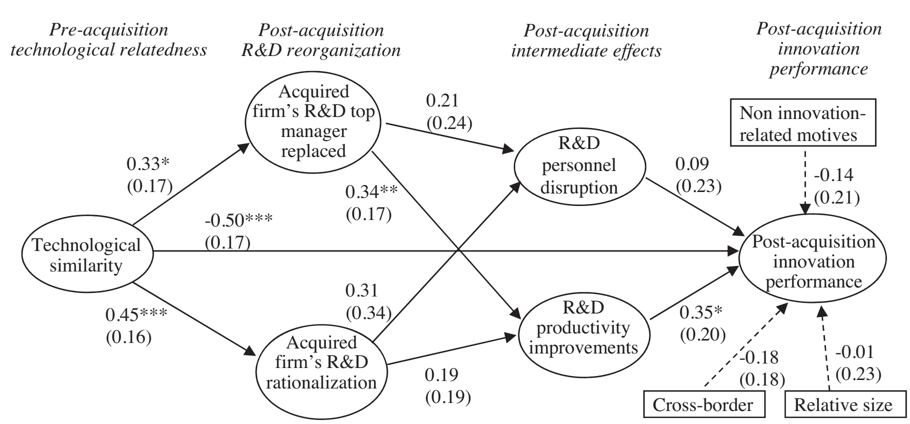
N=31. Standardized beta coefficients and standard errors (in brackets) are reported. Statistical significance assessed by means of a bootstrapping procedure, with 5,000 being the number of bootstrap samples.
* p < 0.10; ** p < 0.05; *** p < 0.01 (two-tailed test).

Fig. A1. Path estimation: controlling for direct effect from technological similarity to intermediate effects.



N=31. Standardized beta coefficients and standard errors (in brackets) are reported. Statistical significance assessed by means of a bootstrapping procedure, with 5,000 being the number of bootstrap samples.
* p < 0.10; ** p < 0.05; *** p < 0.01 (two-tailed test).

Fig. A2. Path estimation: controlling for direct effect from R&D personnel disruption to R&D productivity improvements.



N=31. Standardized beta coefficients and standard errors (in brackets) are reported. Statistical significance assessed by means of a bootstrapping procedure, with 5,000 being the number of bootstrap samples.
* p < 0.10; ** p < 0.05; *** p < 0.01 (two-tailed test).

Fig. A3. Path estimation: controlling for relative size, cross-border acquisitions and non-innovation related motives.

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