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ACQUIRED INVENTORS? PRODUCTIVITY AFTER HORIZONTAL ACQUISITION: MANAGING THE R&D INTEGRATION PROCESS

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Abstract

Effective integration of the R&D functions of the acquired and acquiring firms is essential for knowledge recombination after acquisition. However, prior research suggests that the post-acquisition integration process often damages the inventive labor force. We argue that an examination of the multifaceted nature of the integration process further enhances our understanding of which conditions will be more or less detrimental for corporate inventors. We focus on R&D teams which are the immediate organizational context in which inventors operate and drawing on insights from learning theory and evolutionary economics we posit and find that the reorganization of R&D teams after acquisition harms acquired inventors? innovative performance. Though, the implementation of other integration decisions can mitigate or aggravate this negative effect.

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ABSTRACT

Effective integration of the R&D functions of the acquired and acquiring firms is essential for knowledge recombination after acquisition. However, prior research suggests that the post-acquisition integration process often damages the inventive labor force. We argue that an examination of the multifaceted nature of the integration process further enhances our understanding of which conditions will be more or less detrimental for corporate inventors. We focus on R&D teams which are the immediate organizational context in which inventors operate and drawing on insights from learning theory and evolutionary economics we posit and find that the reorganization of R&D teams after acquisition harms acquired inventors' innovative performance. Though, the implementation of other integration decisions can mitigate or aggravate this negative effect.

INTRODUCTION

Horizontal acquisitions—i.e., acquisitions of firms that operate in the same industry as the acquiring firm—are an important mechanism firms use to grow and increase their competitive advantage. A consolidated stream of studies has examined the economic and financial performance of horizontal acquisitions (for a review, see Haleblian *et al.*, 2009). This literature shows that the realization of synergies that could arise from combining resources and capabilities of the acquiring and acquired firms strongly depends on the post-acquisition integration process (e.g., Capron, 1999; Larsson and Finkelstein, 1999; Ranft and Lord, 2002; Zollo and Singh, 2004). Integration involves "changes in the functional activity arrangements, organizational structures and systems, and cultures of combining organizations to facilitate their consolidation into a functioning whole" (Pablo, 1994: 806), and poses serious challenges to managers in the newly created firm. Indeed, failures and poor performance of horizontal acquisitions are often associated to an ineffective implementation of the integration process (e.g., Jemison and Sitkin, 1986; Shrivastava, 1986; Haspeslagh and Jemison, 1991; Larsson and Finkelstein, 1999). The attention toward the integration process becomes paramount also in relation to an increasing consideration of scholarly work on the *innovation impact* of horizontal acquisitions (e.g., Capron, 1999; Ahuja and Katila, 2001; Cassiman *et al.*, 2005). Research shows that the interdependence between firms' technology strategy and the post-acquisition integration process explains firms' ability to be innovative and reap synergistic technological gains after the acquisition (Graebner, 2004; Puranam, Singh, and Zollo, 2006; Colombo and Rabbiosi, 2014).

In line with an evolving stream that calls for exploring the micro-foundations of firm-level studies (Felin and Foss, 2005; Felin and Hesterly, 2007), parallel work has started examining the relationship between horizontal acquisitions, integration and innovation at the *individual level* of analysis (Paruchuri, Nerkar, and Hambrick, 2006; Kapoor and Lim, 2007; Paruchuri and Eisenman, 2012). The focus is on a specific discrete integration decision—structural integration—consisting in the absorption of the acquired operations within the organization of the acquiring firm as opposed to keeping the acquired operations as a separate subsidiary. The main finding is that structural integration negatively affects the post-acquisition innovation productivity of acquired inventors (Puranam *et al.*, 2006). These studies have enriched our understanding of the effects of integration on innovative performance at the individual level in the very important context of the acquisitions of small-technology-based firms. However, horizontal acquisitions often involve larger firms where post-acquisition integration hinges on a broader set of different decisions which are likely to affect the innovative behavior of acquired individuals. These decisions aim at physical integration like changes of the organization structure (structural integration is one possible decision, others are the divestiture of assets and the elimination of redundancies), technological integration such as changes of the research scope or reallocation of R&D resources, and managerial integration like changes of responsibilities and decision-making power (Shrivastava, 1986; Haspeslagh and Jemison, 1991; Pablo, 1994; Capron, Mitchell, and Swaminathan, 2001). Post-acquisition integration is complex, nonetheless, how these complexity influences the innovation performance of acquired individuals' behavior and productivity is still unclear.

We contribute to addressing this research gap by looking at how different integration decisions, implemented in isolation or in combination, impact the post-acquisition innovation productivity of individual acquired inventors. First, we consider integration through the *reorganization of R&D teams* in the period that immediately follows the acquisition. More precisely, integration occurs if inventors of the acquiring and acquired firms are transferred across the two firms and organized into new teams. R&D teams are the immediate organizational context in which inventors operate. Recombining R&D teams is a powerful decision to facilitate the transfer of knowledge embedded in individual inventors, foster inter-personal communication and coordination, and integrate the two firms' technological capabilities (Ranft and Lord, 2000; Ranft and Lord, 2002). However, the reorganization of teams puts pressure on individual inventors to develop new or modify existing working routines (Nelson and Winter, 1982; Szulanski, 1996; Edmondson, 2002). We posit that the benefits of knowledge recombination on inventor productivity stemming from the reorganization of R&D teams are overcome by the costs the same reorganization raises challenging the collective learning process occurring at the team level. Second, given the complexity of the integration process we argue that hardly an integration decision works in isolation while it is likely to be contingent on situation created by other decisions. Accordingly, we focus on three additional post-acquisition integration decisions occurring at the physical-, technological-, and managerial level of integration which we expect to indirectly influence inventors' collective learning. These decisions are the divestiture of acquired R&D laboratories, the launch of R&D programs in technological fields new to the acquired firm, and the replacement of the acquired R&D top manager. We posit that the negative effect of R&D team reorganization is aggravated when acquired R&D laboratories are closed and projects in technological fields new to the acquired inventors are launched after the acquisition. On the other hand, we suggest that favoring unlearning of existing routines the replacement of the acquired R&D top manager mitigates the negative effects on inventor productivity induced by R&D team reorganization.

Our empirical analysis is based on the patenting activity of 3,693 acquired inventors who continue to work within the new firm after the acquisition (Paruchuri *et al.*, 2006; Kapoor and Lim, 2007) and 25 horizontal acquisitions of sizable firms in medium- and high-tech industries. In each acquisition, the R&D function is a component of the acquired firm's assets and the R&D operations of acquiring and acquired firms are in the same broadly defined technological area. We construct our sample implementing the coarsened exact matching (CEM) technique and empirically test our arguments applying a difference-in-differences setup in a longitudinal data setting.

Our study contributes to extend the work on post-acquisitions integration at the individual-level of analysis. Scholars tend to confirm that the decline in the patenting activity after acquisition observed at the firm-level (Hitt *et al.*, 1991) is associated with a decline in patenting at the individual level (Kapoor and Lim, 2007) and the negative effect on inventor productivity is worsened by structural integration when small technology-based firms are acquired (Paruchuri *et al.*, 2006). In the context of horizontal acquisitions of sizable firms, our findings suggest that interdependencies between different integration decisions can help explaining the differential effects of post-acquisition integration on inventors. Moreover, our work adds value to the general literature on post-acquisition integration studying how this process occurs through the reorganization of R&D teams that are the organizational context where knowledge recombination is more likely to take place. Finally, we theoretically argue and empirically corroborate that through further integration decisions firms can mitigate or aggravate the negative effect of R&D team reorganization on inventors' innovation productivity. Accordingly, we contribute to capture the multifaceted and complex nature of post-acquisition integration.

POST-ACQUISITION INTEGRATION PROCESS

Value creation as reflected in the combination's potential of synergistic assets and resources that have initially motivated the acquisition are often not realized. Research on post-acquisition implementation highlights that this is often the case because of the poor and ineffective process through which resources are integrated (e.g., Jemison and Sitkin, 1986; Datta, 1991; Pablo, 1994). When two previously separated firms come together under the same corporate structure, the realization of synergies depends on integration through the rationalization, reconfiguration, and coordination of resources and assets of the acquiring and acquired firms (Haspeslagh and Jemison, 1991). Integration can be of different intensity (from low to high) and involve different decisions. Post-acquisition integration can be low and consists in minor changes like the standardization of basic processes and systems, or more widespread including changing in physical and knowledge-based resources like the consolidation of product lines and R&D projects, and the redeployment of resources (e.g., Shrivastava, 1986; Napier, 1989; Pablo, 1994; Capron, Dussauge, and Mitchell, 1998; Larsson and Finkelstein, 1999; Capron *et al.*, 2001; Ranft and Lord, 2002; Graebner, 2004; Zollo and Singh, 2004).

A broad set of studies at the firm-level of analysis point to several important post-acquisition integration decisions and discuss their effects on innovation. For instance, the redeployment of resources of the acquired and acquiring firms enhances product features (e.g., product cost, product quality) (Capron and Hulland, 1999) and improves the overall organizational innovation capabilities (Capron, 1999). Graebner (2004) highlights that if the acquired top management remains in place after the acquisition the success of the integration of acquired and acquiring firms' resources is more likely. The implementation of rich communication systems like "cross-fertilized" teams of managers and formal and informal events facilitating face-to-face interactions is also essential to establish a favorable climate between acquired and acquiring employees and facilitate two-way flows of knowledge and integration of technologies and capabilities (Ranft and Lord, 2002).

At the individual level of analysis, the understanding of the effect of integration on innovative performance is limited to the role played by post-acquisition structural integration. Structural integration tends to decrease individual inventor productivity because it reduces the autonomy of employees, harms their motivations, increases uncertainty about career prospects and creates a sense of dislocation and anxiety (Paruchuri *et al.*, 2006). While structural separation can be considered a proper strategic option in the case of acquisitions of small-technology-based firms, when larger firms are acquired structural integration is more likely to take place and precede the implementation of a broader set of additional integration decisions (Pablo, 1994). In the attempt to understand the effect of organizational integration on inventor productivity, in this study we consider four integration decisions which are presented in the next sections.

A look at the complexity of R&D post-acquisition integration

We expect that the integration of physical, technological, and managerial resources provides new opportunities for knowledge combination and the conditions for different and better use of R&D resources which, ultimately, can enhance individual inventors' productivity. However, as we discuss later in the paper, integration decisions taken to combine two previously separated R&D functions also generate costs which, ultimately, can abate the potential positive effect of integration.

Physical integration of resources and assets involves the decision to eliminate common inputs (e.g., reduction of R&D personnel, closure of R&D laboratories) (Shrivastava, 1986; Bowman and Singh, 1993; Capron *et al.*, 2001; Colombo and Rabbiosi, 2014). A situation typical of horizontal acquisition is that assets of the acquiring and acquired firms in part overlap and in part are complementary and mutually exclusive. This relatedness forms the basis for mutual understanding and realization of potential synergies (Ahuja and Katila, 2001). However, the same relatedness gives raise to redundancies and duplications. The rationalization of some R&D activities and the redeployment of others might be necessary to achieve synergy-based benefits from the acquisition. Technological integration involves decisions affecting the scale of typical R&D projects, the focus on specific technological fields, the specialization or diversification of R&D tasks, the re-design of research teams. After the acquisition, research projects that were not feasible before become feasible through the exchange of resources. Thus, technological integration allows for new combination of different R&D inputs to potentially realize knowledge and outputs that did not exist before or achieve efficiencies that could not be achieved previously or only at prohibitive costs (Ahuja and Katila, 2001; Cassiman *et al.*, 2005). Finally, as part of the integration process, managerial integration involves a complex combination of decisions related to the selection and transfer of managers after acquisition (Shrivastava, 1986). The turnover of the acquired top management is often seen in relation to the integration process because managers represent repositories of potentially valuable knowledge that can be exploited during integration (e.g., Graebner, 2004; Cording, Christmann, and King, 2008).

We capture the complexity of post-acquisition R&D integration analyzing four integration decisions. To take into account physical integration, we study the divestiture of acquired R&D laboratories after the acquisition while we capture managerial integration with the decision to maintain or replace the acquired R&D top manager. In the case of technological integration, we focus on two decisions that are the reorganization of the R&D teams and the launch of R&D programs that are new relating to the technological fields in which the acquired firm had previously developed distinctive capabilities. These four decisions are all crucial for R&D integration. However, as we argue in the next section, the reorganization of R&D teams is paramount while we expect the other decisions to amplify or reduce the direct effect of R&D team reorganization on inventor productivity.

R&D post-acquisition integration: the reorganization of R&D teams

The knowledge-based view of the firm plays a central role in explaining how knowledge recombination can occur and synergies be realized after acquisition. Taking its intellectual roots in the behavioral theory of the firm (Cyert and March, 1963) and evolutionary economics (Nelson and Winter, 1982), the knowledge-based view identifies firms as generators, repository, and integrators of knowledge (e.g., Kogut and Zander, 1992; Grant, 1996). Post-acquisition resource recombination's potential can be seen as result of a knowledge-based process in which acquiring and acquired firms learn how to transfer, teach and utilize each other' existing tangible and intangible resources and create new knowledge (e.g., Kogut and Zander, 1993). This learning process is facilitated by the superior coordination provided by having people, practices and intellectual property embedded in the same organizational entity (Kogut and Zander, 1993;

Grant, 1996; Kogut and Zander, 1996) and by the fact that acquiring and acquired firms share related prior knowledge and contextual understanding (Cohen and Levinthal, 1990).

Organization's knowledge is encapsulated in individual skills and organizational routines: skills refer to knowledge and abilities held by employees (i.e., firm resources) while routines can be described as recurrent interaction patterns (Nelson and Winter, 1982). Routines involve multiple resources linked by interactions and are collective phenomena. Specifically, routines capture the joint use of knowledge held by individuals organized in activities (e.g., teams), which, however, is more than the sum of the knowledge held by the single individuals (Becker, 2004). Routines are a result of path-dependent actions taken over time and bound by the firm's existing technological base and knowledge (e.g., Dosi, 1982; Dierickx and Cool, 1989).

Research outputs such as patented innovations reside in the interlinked and mutually reinforcing skills of individuals with the organizational routines connecting these individuals (Nelson and Winter, 1982). Knowledge recombination relies on an intricate, path-dependent context in which inventors search locally and (implicitly) apply routinized tasks (e.g. information filters, communication and problem-solving strategies) to give rise to innovation, and requires individual to communicate and coordinate to create new routines, thereby participating in a collective process (Nelson and Winter, 1982; Henderson and Clark, 1990). Given the collective nature of knowledge recombination, we identify the decision to reorganize R&D teams in the period that immediately follows the acquisition as a key decision the newly created firm can implement after acquisition to integrate the previously separate R&D functions and facilitate synergistic value creation. More precisely, integration occurs if inventors of the acquiring and acquired firms are transferred across the two firms and organized into new teams.

How that team reorganization is such an important integration decision for individual inventors? We expect an inventor's ability to unlock the post-acquisition innovative potential stemming from the realization of synergies to depend on the capacity of his/her R&D team to encourage the coordinated exchange of knowledge, materials, and reciprocal inputs and to work interactively to complete research tasks. Since we are interested in the effect of post-acquisition integration at the individual-level of analysis, the focus on R&D team reorganization allows to observe the effect of the integration process in the context in which dialogue, discussion, experimentation, and reflection between knowledge-workers take place (Senge, 1990). Teams hold together set of individuals who share responsibilities and assumptions, acquire, share, and combine knowledge, and carry out activities that leave outcomes (Alderfer, 1987; Hackman, 1987; Argote, Gruenfeld, and Naquin, 2001). Teams learn though their team members' ability to share information, seek for feedback and ask questions, talk about errors and reflect on results (Edmondson, 1999). At the same time, team learning also benefits the members who compose the team in a way that learning in teams helps developing the knowledge and skills of team members (Edmondson and Nembhard, 2009). Post-acquisition R&D team reorganization facilitates each inventor to access not only self-contained knowledge and skills from her organization's knowledge base but also inventors' skills and the organizational knowledge base of the other firm. As a result, the team and its members become embedded in multiple, non-redundant resources which transfer and use can manifest through research output like patents.

THEORY AND HYPOTHESES

The effect of R&D team reorganization on inventors' productivity after acquisition

The reorganization of teams is a powerful integration decision because it creates the necessary conditions for different inventors to engage in face-to-face communication and share their knowledge (Ranft and Lord, 2000; Ranft and Lord, 2002). Since the acquired and acquiring firms share resources that are similar or complementary—i.e. they are related—and relevant within each other's context the recombination of knowledge will be eased (Haspeslagh and Jemison, 1991; Ahuja and Katila, 2001). In other words, shared industry experiences and related technical and knowledge bases of inventors of the acquiring and acquired firms provide a contextual understanding that facilitates the communication and sharing of inventors' specific knowledge among team members (Cohen and Levinthal, 1990). However, although inventors may share organized knowledge structures and routines stemming from the relatedness in their technical and scientific skills, the reorganization of R&D teams can also damage team-level collective learning.

With team reorganization team members are reshuffled to include inventors of both the acquired and acquiring firms. Thus, reorganized inventors face a pressure to develop new or alter existing routines—or shared mental models (Edmondson, 2003).[1] With post-acquisition integration existing routines of the acquiring (acquired) inventors need to come together with those routines of the acquired (acquiring) inventors. Knowledge recombination requires intense team members' interdependence—"the extent to which team members cooperate and work interactively to complete tasks" (Stewart and Barrick, 2000: 137). Interactions develop strong ties, members' cohesion, team identity and coordination that facilitate informal learning among team-members (Mudrack, 1989; Manz and Newstrom, 1990). However, coordination routines will suffer from the reorganization of teams: while keeping team members together facilitates communication and coordination and enables the development of routines that support new task

[1] The team literature describes mental models as organized knowledge structures that allow individuals to describe, explain, and predict actions in their environment (Klimoski and Mohammed, 1994). When individuals share mental models they select actions that are consistent and coordinated with those of the other team members (Mathieu *et al.*, 2000). Team research shows that the functioning and performance of teams are related to shared mental models in teams (for a review, see Mohammed, Ferzandi, and Hamilton, 2010).

learning (e.g., Levine, Richard, and Moreland, 1999) the reorganization of teams dismantles team routines and negatively affects team performance (Lewis, Lange, and Gillis, 2005). Moreover, the way how team inputs are transformed into outputs are influenced by team routines (Kraiger and Wenzel, 1997). In particular, team members who share mental models work toward common objectives, easily coordinate their actions, and exhibit effective team processes, which subsequent positively affect team performance (Mathieu *et al.*, 2000; Rentsch and Klimoski, 2001). However, facing new unfamiliar work environments team members cannot apply existing routines and need to learn new ones to succeed (Rico *et al.*, 2008).

Although R&D team reorganization fosters communication and coordination among acquired and acquiring inventors, these inventors may have difficulty in interact with each other's given their different routines. They may also underestimate the amount of extra learning necessary to effectively take on the new shared mental models, indeed the convergence on new routines develops out of salient shared experiences (Nelson and Winter, 1982). Therefore, we posit that integration through team reorganization will prove frustrating, demobilizing and inefficient for inventors who will have to invest more effort in learning and aligning with the dominant (or new) routines of the team.

Hypothesis 1: The patenting performance of acquired inventors will decrease more after acquisition if post-acquisition integration involves the reorganization of R&D teams of the acquired and acquiring firms.

Moderating effects: looking at the complexity of post-acquisition R&D integration

The first integration decision we expect to moderate the effect of R&D team reorganization on inventors' productivity is the divestiture of acquired R&D laboratories which captures physical integration. Horizontal acquisitions are often characterized by overlapping activities and redundancies which gives the opportunity to downsizing and redeploy the remaining resources into a more efficient recombination (Capron, 1999; Capron *et al.*, 2001). We suggest that when the reorganization of R&D teams is concurrent with the divestiture of acquired R&D laboratories, the negative effect of team reorganization on the acquired inventors' productivity will be worsen by the sense of disruption acquired inventors will experience.

The achievement of synergistic benefits after the acquisition not only requires integration but also to maintain morale and gain the commitment of people to the new goals (Shrivastava, 1986; Ranft and Lord, 2000). Closing down R&D laboratories has a direct impact on the morale of the retained employees. Although people might feel relief about their retained jobs, they also become emotionally aroused about their negative expectations regarding the future. Specifically, resource redeployment after rationalization is often accompanied by geographical relocation or changes of the internal affiliation. Accordingly, after divestitures employees will feel uncertain about their status and career and concerned of losing their identity (e.g., Walsh, 1989; Paruchuri *et al.*, 2006). In addition, divestiture of acquired R&D assets is also likely to exacerbate the feeling of submission and inferiority of acquired employees (e.g., Hambrick and Cannella, 1993). Asset divestiture builds up sense of disruption, resentment, and hostility that aggravates the working conditions of acquired inventors who will express their uncertainty and feeling of dislocation in subversive behavior and reduced productivity (Shrivastava, 1986; Ernst and Vitt, 2000; Ranft and Lord, 2000). Thus, we expect the loss of motivation and disruption induced by rationalization to worsen the negative effect of team reorganization of inventor productivity.

Hypothesis 2: The closure of acquired R&D laboratories aggravates the negative effect of post-acquisition R&D team reorganization on acquired inventors' patenting performance after the acquisition.

Building on the literature of team mental models we distinguish between task- and team-related routines to examine the moderating effect of the two remaining integration decisions. Team researchers proposed the existence of multiple and simultaneous mental models (Cannon-Bowers, Salas, and Converse, 1993), which can be reflected into two major conceptually distinct types, one related to task work and one related to team work (Mathieu *et al.*, 2000). The former refers to the ability of team members to understand the technology and equipment with which they are interacting and their sharing of knowledge about how the task is realized (e.g., knowledge of immunology held by team developing immunotherapy drugs; knowledge of photolithographic aligners held by team developing semiconductor devices). We refer to these aspects as task-related routines. On the other hand, team work mental models types relate with team members sharing knowledge about team interactions (e.g., roles and responsibilities in the team, communication channels, information sources) and team models (e.g., knowledge about what to expect from team members). We refer to these aspects as team-related routines.

We posit that when the reorganization of R&D teams is concurrent with the launch of R&D projects in technological fields new to the acquired firm, the negative effect of team reorganization on the acquired inventors' productivity will be worsen by the supplementary challenges the exposure to research tasks in new technological fields induces on acquired inventors' team-related routines. This expectation is consistent with the fact that R&D programs in new technological fields require existing inventors' routines to deal with the use and understanding of new equipment and technology which change team members' tasks, and make the previously developed routines not sufficient anymore (Edmondson, 2003). It is well recognized that new technologies lead to changing established task-related routines at different levels—organizational, team, and individual—and that this process is not without a struggle (e.g., Orlikowski, 1993; Edmondson, Bohmer, and Pisano, 2001). Moreover, previous work suggests that teams whose members maintain tasks in the same domain are more likely to develop routines relevant to the task domain—a critical factor for learning (Lewis *et al.*, 2005). Task knowledge is also necessary for the recognition of members' task-relevant expertise that is found to improve a team's task performance (Stasser, Stewart, and Wittenbaum, 1995). Finally, team members' differences in task-related routines result in ineffective team processes and, therefore, in a reduction of team members' performance (Mathieu *et al.*, 2000). Based on this reasoning, we suggest that:

> *Hypothesis 3: The launch of projects in technological fields new to the acquired inventors aggravates the negative effect of post-acquisition R&D team reorganization on acquired inventors' patenting performance after the acquisition.*

The idea that top management turnover can be used to force the unlearning of old routines and overcome the inertia of organizational change finds its roots in pioneering work in strategic management (e.g., Nystrom and Starbuck, 1984; Tushman and Romanelli, 1985; Wiersema and Bantel, 1993). Top managers tend to stick to existing cognitive structure, practices, and procedures which inhibit the exploration of alternative routines, rules, goals, etc. (Wiersema and Bantel, 1993). Because top managers can directly influence and shape organizational norms and values, top managers' replacement disconfirms past programs, interrupts ongoing activities and interrelationships and is a way to break inertial factors which operate to maintain the status quo (Tushman and Romanelli, 1985). As the replacement of top managers is needed to overcome inertia and accomplish the adaptation to changing contexts (Wiersema and Bantel, 1993), we suggest the replacement of acquired R&D top managers as an important managerial integration decision to overcome acquired inventors' inertia to change and enforce the adoption of new team-related routines.

Team-related routines rely on sharing of knowledge about how inputs are transformed into outputs by team members. These routines stem from interaction patterns involving individual knowledge about team interactions and team expected behaviors. Examples are team members' shared understanding of the amount and quality of knowledge, the information sources and flows necessary to satisfy the communication dimension, the coordination of actions, roles and responsibilities directed to predict the nature of team interactions and strategy, the attributes directed at tailoring what to expect in terms of team cooperation. Given their "how to do" nature, it is reasonable to expect that team-related routines of team members will share similarities with managers' routines. In confirmation of this, Klein and Posey (1986) find that supervision tends to improve if managers and teams share the same team-related routines. Our expectation is supported also by the fact that team researchers suggest organizational culture and environment in which teams operate to influence team mental models about how to encode, store, retrieve, and communicate information (Kraiger and Wenzel, 1997; Arrow, McGrath, and Berdahl, 2000). However, also managers' routines are influenced by their social and cultural environment (Huff, 1982). In addition, managers directly participate to social interaction with other individuals within the organization and this social interaction results in shared organized knowledge structures among the individuals involved—e.g., managers and team members (Klimoski and Mohammed, 1994). Finally, organizational activities are driven by routines developed in a given environmental configuration and adaptations to fit the external changes are dominated by top managers' idea and cognitive schema (e.g., Nystrom and Starbuck, 1984). Therefore, managers play a unique role to create, shape and reinforce organizational routines which in general are implicitly internalized by the other individuals in the firm.

To the extent that manager's cognitions and routines are similar to team-related routines shared by inventors, responses of inventors to organizational stimuli that are not aligned with meeting a target will not be organizationally sanctioned. However, routines that are not associated with failures will continue to be perceived acceptable and persist in the organization (Cyert and March, 1963). Accordingly, the likelihood that acquired inventors will adapt faster to the new team-related routines will depend on the organization's ability to associate acquired existing routines with failure. This is difficult to achieve when acquired R&D top managers are retained given their shared understanding of acquired inventors' team-related routines. Only by removing the acquired R&D top manager the organization can clearly signal the separation from the acquired team-related routines and elicit the acquired inventors to adjust or substitute their team-related routines with the new dominant ones. In other words, the replacement of the acquired R&D top manager will allow for the unlearning of the old team-related routines facilitating the discovery of their inadequacies in the new research context.

Hypothesis 4: The replacement of the acquired R&D top manager alleviates the negative effect of post-acquisition R&D team reorganization on acquired inventors' patenting performance after the acquisition.

METHOD

The test of the effect of post-acquisition R&D team reorganization on inventor performance requires a methodology that takes into account selection effects and unobserved heterogeneity. First, we need to account for the fact that characteristics related to the inventors in the pre-acquisition period could trigger the decision to reorganize teams. For example, if inventors with inherent low patenting performance are more likely to be in firms that reorganize R&D team, then their post-acquisition performance vis-à-vis to inventors that did not go through a process of reorganization would be naturally lower. Therefore, a cross-section estimation of the post-acquisition period would not be an appropriate alternative. Second, inventors exhibit a life cycle in their innovation productivity (Levin and Stephan, 1991; Kapoor and Kwanghui, 2007), with the rate at which they produce innovations varying with the experience that they accumulate. Therefore, it is not enough to estimate the effect of R&D team reorganization solely based on pre and post individuals' performance because this approach would provide no indication of abnormal deviations from what is expected to be observed for an individual within a similar trajectory. Finally, previous work shows the negative effect of acquisitions on inventor productivity (e.g., Paruchuri *et al.*, 2006; Kapoor and Kwanghui, 2007). Accordingly, to estimate the effect of R&D team reorganization on inventor's patenting performance, we first need to account for the expected decline in inventors' productivity triggered by the acquisition itself. Not accounting for this effect could lead to an overestimation of the negative effect of post-acquisition integration through R&D team reorganization.

In the attempt to overcome these endogeneity issues, we apply a difference-in-differences setup in which we compare the patenting performance of acquired inventors involved in R&D team after acquisition (*treatment group*) with inventors which were not exposed to R&D team reorganization after acquisition (*control group*). For both groups we observe the longitudinal changes in their performance based on the pre- and post-acquisition periods. In order to implement this empirical strategy, we rely on the Coarsened Exact Matching (CEM) technique to estimate the ATT (average treatment effect on the treated) concerning inventors patenting performance. This matching technique is based on the improvement of the balance between treatment and control groups making their joint distributions in terms of the covariates more similar (Iacus, King, and Porro, 2011; 2012).

Sample and data

The sample consists of 3,693 acquired inventors working in 25 firms resulting from horizontal acquisitions undertaken in medium and high-tech industry by large firms headquartered in the European Union (EU). We identify these horizontal acquisitions based on data collected as part of a research project promoted by the DG Research of the European Commission.[2] Using the 1993 EU Market Share Matrix (MSM), the project identified 59 acquiring leading firms—the five largest EU producers in EU 3-digit medium and high-tech industry in that year—headquartered in EU. 31 firms out of 59 (response rate of approximately 52%) agreed to participate in the study based on a multiple-case design and provided detailed information about 31 acquisitions occurred during the 1987-2001 period. Some acquisitions were domestic, other cross-border and involved firms located in other EU countries as well as in North America. The choice of selecting acquisitions from the DG research project was dictated by the fact that is usually very difficult to have access to detailed information about post-acquisition integration processes. The DG project data were collected during face-to-face interviews with 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). This research design allowed for collecting specific data about post-acquisition decisions aimed at integrating the R&D functions of the acquired and acquiring firms. We use this information to operationalize the integration decisions examined in our study.

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[2] 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).

The innovation productivity of each acquired inventor is defined using the *Patent Network Dataverse* database that builds on the United States Patent and Trademark Office (USPTO) and includes information regarding the identification of disambiguated names of individual inventors registered at the U.S. utility patents for the period 1975−2010 (Li *et al.*, 2014). Focusing on a single large patent office ensures data consistency and avoids potential noise created by cross-offices differences in terms of procedures and practices regarding the way patent applications are managed. Moreover, the U.S. market represents one of the world's largest markets for global firms in medium- and high-tech industry like those included in the DG project research. The following steps describe the construction of our dataset. First, based on the identification of the company name we identified all patents filed at the USPTO by the 31 acquired firms in the 5 years prior the acquisition. We removed from the sample five firms with no patenting activity. Second, in some cases the acquisition involved only specific businesses of the acquired firm. Accordingly, we scrutinize the patent data of the remaining 26 acquired firms to retain only information pertaining to the business units and their inventors directly involved in the acquisition[3]. However, in one case the complex structure of the assets of both the acquired and acquiring firms involved in the acquisition did not allow us to uniquely identify businesses and inventors that undoubtedly were part of the acquisition. We removed this case from our sample and remained with 25 deals involving 4,785 unique inventors that actively patented during the pre-acquisition period—i.e., active inventors. Third, we accounted for inventors mobility across firms (Singh and Agrawal, 2011; Younge, Tong, and Fleming, 2014).

[3] For example, in the acquisition of Westinghouse by British Nuclear Fuels Limited (BNFL) only the nuclear business of Westinghouse was acquired. To identify the inventors that were part of the acquisition, we scrutinized the abstracts and content of all patents filled by Westinghouse and select only those inventors involved in the nuclear business. Similarly, in the acquisition of CytoMed by UCB the deal involved activities of CytoMed in the fields of allergy, asthma and central nervous system. Using the same approach, we selected only CytoMed inventors related to the patents that were part of the deal.

Specifically, we removed inventors who had patented in a different firm within the five years before and after the acquisition was concluded—the assignee name differs from the name of the acquired firm. After removing these inventors, the final sample consists of 3,978 active acquired inventors.

Measures

Consistent with prior research on inventors patenting performance (e.g., Paruchuri *et al.*, 2006; Kapoor and Kwanghui, 2007; Singh and Agrawal, 2011), we measure our dependent variable *patenting performance* as total number of granted patents filed by an inventor with the acquired firm during the pre- and post- acquisition periods. Our dependent variable is computed based on two time windows. The first window captures the cumulative number of patents that an inventor produced within the five years before the acquisition and the second window refers to the cumulative number of patents in the five years after the acquisition.

Our explanatory variables capture the implementation of post-acquisition integration decisions relying on information gathered by the DG research project and are defined as follows. The variable *R&D team reorganization* is a dummy that takes value 1 if R&D teams of both the acquiring and the acquired firms have been reorganized after acquisition, which imposes the transfer of inventors across the two firms and organized them into new teams. The dummy variable *divestiture* equals 1 if acquired R&D laboratories have been closed after the acquisition. The variable *R&D program diversification* takes value 1 if R&D programs that are new relating to the technological fields in which the acquired firm had developed distinctive capabilities prior the acquisition are launched after the acquisition. Finally, the turnover of top managers responsible for the acquired R&D function after the acquisition is captured by the dummy *acquired R&D top manager replaced*. All these four variables are measured at the deal level and subsequently shared by inventors working in the same firm.

We control for a number of acquisition- and individual-level characteristics. The first set of controls concerns acquisition-specific characteristics. We control for the acquired firm's industry by including the dummy variable *high tech* which equals 1 for high-tech industry and 0 otherwise. This variable absorbs part of the cross-industry differences that could explain differences in inventors' propensity to patent. We also control for *cross-border* acquisitions by using a dummy variable that indicates whether the acquiring and acquired firms are from different countries. The variable *hostile* takes value 1 if the acquisition is the product of a hostile takeover and 0 otherwise. Differently motivated acquisitions can implement more or less invasive integration processes. During the DG research project, interviewed people were asked to assess the importance of the following innovation related motives, on a five-point Likert scale ranging from "not important at all" to "very important": (1) economies of scale in R&D; (2) economies of scope in R&D; (3) restructuration of the R&D process, elimination of duplicative; (4) obtain access to assets, skills and capabilities of technological nature of the merging companies; (5) obtain access to knowledge and other technical resources embedded in the environment of the merging companies; (6) spread the risks of the R&D portfolio; (7) reduce the risk of being imitated. Based on this information, we compute the variable *innovation related motives* as a single composite measure based on the loadings from a principal component factor analysis[4] of the seven indicators of innovation related motives (Cronbach's alpha = 0.95). The existence of previous interactions or relationships between the acquired and the acquiring firm should supposedly lower the uncertainties among R&D personnel in the acquired firm.

[4] Factor loadings: item 1 = 0.97; item 2 = 0.97; item 3 = 0.97; item 4 = 0.94; item 5 = 0.69; item 6 = 0.97; item 7 = 0.96; Eigenvalue = 6.04; variance explained = 0.87 %.

Therefore, we control for the variable *technological links* that equals 1 if acquiring and acquired firms have experienced one or more technological alliances (i.e., equity joint ventures, license agreements, minority shareholding) with one another before the focal acquisition. We also control for the technological similarity that refers to the extent to which acquiring and acquired firms operate in the same technological fields. The variable *technology similarity* is defined using the index proposed by Makri, Hitt and Lane (2010)[5]. Using a five-year window regarding the pre-acquisition period, we compute the ratio between the total number of patents filed by the acquired and acquiring firms within the same 3-digit patent classes multiplied by the total number of patents accumulated by the acquirer in all common classes, and the acquirer total patents within this period. We also control for the *relative size* of the acquired firm using the ratio between the total sales of the acquired and acquiring firm. Finally, we added year dummies regarding the year in which the acquisition was concluded to control for differences in patenting inventors' behaviour originating from year trends.

The second set of controls concerns individual-specific characteristics. Specifically, we control for the variable *inventor tenure* that is the number of years between the date of the first patent that the inventor produced with the acquired firm as the assignee and the acquisition date. We also control for the inventors *search depth* (Katila and Ahuja, 2002) in the five years prior to the acquisition by computing the ratio between repeated citations and the total citations observed in their patenting output. Finally, we control for the familiarity of the acquired inventor with the acquirer's expertise. Similar to a measure proposed by Parachuri et al. (2006) we first identify all patents that had been produced by the acquirer firm within the five years before the acquisition. Then, we observe the main class related to each of those patents in order to identify the field in

[5] Our measure differs from Marki et al. (2010) in terms of the time widow used to compute it (i.e., five years), their original measure was based on a single year and we consider the patents accumulated over five years

which the acquirer has been mostly active prior to the acquisition. Subsequently, we look at the patents that each inventor in the acquired firm has produced and compute the ratio between the inventor's patents concentrated within the acquirer's main technological area and the total patents produced within the same period.

Coarsened exact matching

We use the CEM procedure to create the treatment and control sample with balanced characteristics in terms of several pre-treatment covariates (Iacus *et al.*, 2011; 2012). This matching technique works through a process of data pruning in which the CEM algorithm creates a set of strata that must contain at least one treatment and control observation, which allows to subsequently running the analysis in the original (pruned) data (Blackwell *et al.*, 2009). The outcome of this matching process ensures a reduction in the overall imbalance between treated and control groups in terms of the matching characteristics while relaxing several assumptions that are required to produce unbiased estimates of the treatment effects (Iacus *et al.*, 2011; 2012; Aggarwal and Hsu, 2014).

To run the CEM algorithm we first split the 3,978 acquired inventors in terms of treatment and control groups. It is interesting to note that in the case of 15 merged firms—2,083 (52.36%) inventors—the R&D team reorganization is implemented after acquisition while it does not occur in 10 merged firms—1,895 (47.64%) inventors. In order to prune the data, we match inventors in the treatment and control groups using the following five pre-treatment observables pertaining to inventor-level characteristics, which we expect to be correlated with the treatment. The first variable is *inventor's technological diversity* which measures the heterogeneity of the knowledge inventors have accumulated in different technological fields within the five year prior to the acquisition. It is computed based on a Herfindahl index (HI) calculated using the main technological fields (3-digit class) to which the inventor patents are assigned (Hoisl, 2007). Second, because the status of an inventor before the acquisition can also affect his post-deal performance, we also match both groups using a dummy variable indicating if an individual is a *star inventor*. We identify as start inventors those individuals for which the pre-acquisition patenting productivity is one standard deviation above the mean of the other inventors observed within the same firm. The third variable is *inventor's last patenting* calculated as the number of years passed since the last time the focal inventor patented before the acquisition (Paruchuri *et al.*, 2006). Fourth, to ensure that the treatment and control group are similar in terms of their performance in the pre-acquisition period, we also consider the variable *number of pre-patents* which is the total number of patents each inventor produced within the five years prior to the year that his/her firm was acquired. This last variable increases the confidence that the deviations in the trajectory between individuals in the treatment and control group are likely to be due to the treatment, as their ex-ante performance should be comparable. Finally, we use three period dummies to match the inventors in the treatment and control groups around the same years that their firms were acquired.

The CEM matching produced a significant improvement of the imbalance in our data, with the overall imbalance provided by the *L1* statistics moving from *L1*=0.33 to *L1*= 0.11 (for a detailed discussion on the interpretation of the L1 statistic, see Iacus *et al.*, 2011). The improvement in the overall level of imbalance between the two groups is the most important statistics of the CEM outcome, because although the marginal distribution of the five variables used in the matching procedure could be similar their joint distribution could still be imbalanced (Blackwell *et al.*, 2009). During the matching process, 285 inventors (approximately 7% of the original sample) were removed from the sample because the CEM algorithm was not able to match those observations in a strata including at least one inventor from the treatment and one for the control group. By dropping these dissimilar observations between inventors that experienced the treatment and the ones that did not, CEM reduced the sample to 3,693 observations that will serve as the sample in which we will test our hypotheses. Among those observations, 1,857 belong to the treatment group and 1,836 to the control group. Given that we are not using a one-to-one matching solution we employ *CEM weights* to compensate for the differential strata size (Blackwell *et al.*, 2009).

A difference-in-differences approach for examining the effect of R&D team reorganization

The difference-in-differences approach exploits the fact that we observe the productivity of inventors not just in the post-acquisition but also in the period that precedes it. Although the post-acquisition differences in the treatment and control groups confound inherent differences between the two groups, we can partially disentangle these effects by reducing the imbalance between the two groups based on "observables" and tracking them in the pre- and post-acquisition periods. Furthermore, although we make both groups comparable in terms of their performance before the acquisition, we still look at pre-acquisition differences in patenting performance for both groups and use it as a benchmark to examine the post-acquisition differences and identify the part of the second difference that can be attributed to the reorganization of teams itself. We use the following equation to implement this logic:

$$\textit{Patenting activity}_{j,t} = f\,(\psi_R \textit{treatment group}_j + \psi_{R\,P} \textit{treatment group}_j \times \textit{post-acquisition}_{j,t} + \psi_P\, \textit{post-acquisition}_{j,t} + \psi_X X_j + \delta_{t-\textit{pre-acquisition}\,(j)} + e_{j,t})$$

For each inventor j whose R&D teams are reorganized after acquisition, the dummy variable *treatment group* takes value 1 and value 0 if the inventors belong to the control group. In this model, ψ_R captures the systematic differences between the treatment and control groups that exist before the acquisition. The interaction term *treatment* × *post-acquisition* should capture the net effect (net of the average acquisition effect) that the treatment has on the treated group. Based on our theoretical argumentation, the coefficient of interest $\psi_{R\,P}$, should be negative and significant. The final variable *post acquisition* takes value 1 for both the treatment and control groups only when observed in the post-acquisition period. Therefore, ψ_P consists of the *counterfactual* in the patenting productivity for the post-acquisition period in the case R&D team reorganization had not happened.

Following previous studies (e.g., Meyer, 1995; Younge *et al.*, 2014), we test our hypothesized moderating effects by extending the basic difference-in-differences model using three-way interactions between the term *treatment* × *post-acquisition* with each variable of interest.

Results

Table 1 reports the means, standard deviations, minimum, maximum and Pearson correlation coefficients for all variables used in the study, based on the CEM-matched sample of 3,693 unique inventors observed across two period (pre- and post-acquisition) and forming a total of 7,386 observations. We observe that the variable *relative size* is correlated with some of our variables of interest. To test if those correlations are biasing our results, we tested the stability of the coefficients by removing *relative size* from the models and the results remained the same.

[*Insert Table 1 here*]

Apart from the dependent variable and the variable *post-acquisition* the others variables are time invariant, and vary within the sample only when interacted with the *post-acquisition* variable.

We start our analysis with a simple difference-in-differences estimation based on the CEM sample and including no further explanatory variables. This estimation presents the basic intuition behind our idea to use the pre- and post-acquisition performance to measure the effect that the reorganization of R&D teams has on inventors patenting activity. Table 2 reports the means for the dependent variable *Patenting performance* based on four subsamples: R&D team reorganization (treatment) pre-acquisition, R&D team reorganization (treatment) post-acquisition, control group pre-acquisition and control group post-acquisition. Based on Table 2, we observe that in the pre-acquisition period the patenting performance of inventors in the treatment (3.039) and control group (2.954) is not statistically significant. When we consider the relative changes from the pre- to the post-acquisition period, it is possible to observe that the inventors of both groups had a substantial decline in their patenting productivity. Indeed, the inventors in the control group presented an average decline in the order of 46% (i.e., 1 − (1.586/2.954)) in the post-acquisition period, while for the treatment group this decline was in the order of 69% (i.e., 1 − (0.913/3.039)). This finding is in line with previous studies that have reported a negative average effect of acquisitions on the acquired inventors. Furthermore, it also confirms the suitability of using as a control sample a group of inventors that also went through an acquisition process in order to have a more conservative counterfactual for the effect of R&D team reorganization on patenting performance.

[*Insert Table 2 here*]

The post-acquisition mean values for the patenting productivity in the treatment and control inventors indicate a statistically significant difference ($p<0.01$) between the two groups, with the control group reporting a mean value of 1.212 patents while the treatment 0.913 patents. If we subtract from the mean value observed for the treatment the counterfactual provided by the control group we observe a second difference in the order of −0.673 (0.913 − 1.212). Given that the in the pre-acquisition period both groups are not statistically different, the mean comparison of the post-acquisition values would provide an indication of the negative effect that team reorganization has on inventor patenting productivity. Nevertheless, following the difference-in-difference logic, we proceed and obtain the final estimates by subtracting the second difference from the first ($-0.673 - 0.085 = -0.758$). Those estimates indicate that when we subtract the pre-acquisition differences from the second difference, the remaining value is negative and statistically significant ($p<0.01$).

To test our hypotheses, we estimate a negative binomial model using a difference-in-differences setup (see Table 3). The variable *post-acquisition* × *R&D team reorganization* is used to estimate the treatment on the treated observations; around 25% of the observations across the two periods have a positive outcome for this variable. Our analyses are conducted at the inventor-period level. As such, each inventor is observed and recorded both in the pre- and the post-acquisition period. We model unobserved heterogeneity at the inventor level with random effects. Finally, while we match the treatment and control groups on inventor level characteristics, the additional set of control variables used in the main analysis helps removing undesirable residual heterogeneity that could remain in the sample after the matching process. We include an indicator for the treatment group *R&D team reorganization*, and indicator for *post-acquisition* and the interaction capturing the effect of the treatment on treated *post-acquisition* × *R&D team reorganization*. Model 1 reports the controls and the variables of interest before the interaction testing their effect in the post-acquisition period. The effect for the variable *post-acquisition* is negative and highly significant ($p<0.001$), this result is closely aligned with previous studies. Model 2 introduces the interaction between *post-acquisition* × *R&D team reorganization.* In line with Hypothesis 1 this effect is negative and significant ($p<0.001$). Model 3 introduces the set of interaction terms testing the moderating effect of *divesture* on *R&D team reorganization*, the results for the three-way interaction *divestiture* ×

post-acquisition × *R&D team reorganization* is negative and significant (p<0.001), confirming Hypothesis 2. Model 4 tests the moderating effect for *R&D program diversification*. As we predicted by Hypothesis 3, the coefficient of the interaction *R&D program diversification* × *post-acquisition* × *R&D team reorganization* is also negative and significant (p<0.001). Finally, testing Hypothesis 4, Model 5 enters the moderating effect *acquired R&D top management replaced*. In line with our expectations, the results for the term *acquired R&D top management replaced* × *post-acquisition* × *R&D team reorganization* is positive and significant (p<0.001). To test the stability of the coefficients in Model 6 we enter the main effect together with the three moderating coefficients. Our findings are largely confirmed with the only exception of the moderating effect of technological integration through the launch of R&D programs in technological fields new to the acquired firm which effect becomes insignificant.

Robustness checks, available from authors upon request, are not shown here because of space limitation. First, in order to test if our results are biased by omitted time-invariant individual level characteristics we estimate the same models with inventor level fixed effects. The results of a negative binomial with fixed effects are similar to the ones reported above. Second, as potential unobserved heterogeneity at the deal (acquisition) level could also be a source of bias, we estimated the models using deal dummies. Those dummy variables absorb time-invariant characteristics that relate to the acquisition itself. Those estimations were also equivalent to the reported negative binomial model with random effects. The fixed effects estimators were not our preferred choice because they do not allow time invariant variables to be included in the models. However, given that our main results remain qualitatively unchanged, we found no evidence of omitted variables biasing our estimates.

DISCUSSION AND CONCLUSIONS

Discrete intangible and tacit resources are difficult to exchange in the market due to market failures. Accordingly, the strategic literature often proposes horizontal acquisitions as a choice to access such resources that otherwise are not easily transferable (e.g., Bowman and Singh, 1993; Karim and Mitchell, 2000). However, reaping the synergistic benefit of the strategy behind these acquisitions requires that the resources of both acquiring and acquired firms are reconfigured, realigned, and rationalized, that is integration decisions are implemented (Capron, 1999; Karim and Mitchell, 2000; Cording *et al.*, 2008).

In relation to the effect of horizontal acquisitions on innovative performance, research shows that the post-acquisition integration, although necessary to realize synergistic benefits, imposes several challenges on the inventive labor force of the acquiring and acquired firms which, ultimately, can harm innovation (Ernst and Vitt, 2000; Ranft and Lord, 2000; Ranft and Lord, 2002; Puranam *et al.*, 2006). In particular, when acquired firms are formally integrated under the corporate umbrella of the acquiring firms (structural integration), horizontal acquisitions harm knowledge-workers' motivation and create disruption, expose firms' R&D personnel to feelings of resentment and dissatisfaction which result in reduced inventor productivity (Paruchuri *et al.*, 2006). We contribute to this work about the relationship between integration and inventors' innovation performance, addressing the complexity of post-acquisition integration and going beyond structural integration and the categorization of integration with single types of decisions. Specifically, to better disentangle the effect of the complex post-acquisition integration process on inventor productivity, we focus on the decision of reorganizing R&D teams and its interdependencies with three additional distinct integration decisions that capture physical, technological, and managerial integration after acquisition.

Our results help illuminating the internal dynamics by which integration after horizontal acquisitions affects innovation by extending the understanding of how integration decisions hinge on inventors' choices and actions. We discussed how integration through R&D team reorganization directly creates the conditions for higher coordination, common language and knowledge sharing between inventors of the acquiring and the acquired firms. However, to the extent that team reorganization implies a change in team routines it can also harm knowledge recombination. In line with the idea that the characteristics of tacitness, inimitability and firm-specificity of organizational knowledge and routines create inertia and rigidity which inhibit firm organizational change (Leonard-Barton, 1992), we find that team reorganization imposing changes and adaptation of team-specific routines inhibits team learning and negatively affect team members' productivity. However, the effect of team reorganization on inventor productivity is not independent from other integration decisions firms might implement concurrently. Our findings support this expectation. We find that the closure of acquired R&D laboratories and the launch of R&D programs in technological field new to the acquired firms aggravate the negative effect of R&D team reorganization on inventor productivity. On the contrary, the negative effect of team reorganization is alleviated when the acquired R&D top manager is replaced.

To fully understanding *how* value is created from acquisition, post-acquisition research needs to take into account the multifaceted nature of integration (Haspeslagh and Jemison, 1991). Our findings strongly support this view by theoretically arguing and empirically showing how the effects of different integration decisions acting upon the interdependence between resources of the acquired and acquiring firms are intertwined. Specifically, the divestiture of redundant assets which is often a necessary decision to implement physical integration

(Shrivastava, 1986; Capron, 1999; Capron *et al.*, 2001; Anand, 2004), adds additional stress and sense of disruption to inventors already engaged in higher efforts to learn and align their routines with the dominant (or new) routines of the team in which they have been reorganized. Also, in line with team literature showing that successful team members will have to well-perform task-related as well as team-related functions (Mcintyre and Salas, 1995; Mathieu *et al.*, 2000), we highlight that post-acquisition integration decisions which have an impact on task- and team-related routines moderate the negative effect of team reorganization of inventors' productivity. First, we looked at technological integration which creating the conditions to specialize or broaden the firm's technological competencies affects task-related routines. Acquired inventors had developed skills and routines as a result of their work experience within the technological fields in which the acquired firm is specialized. Team reorganization—placing together acquired and acquiring inventors with different information, knowledge, and expertise—can potentially promote search behaviors that lead to innovative solutions. Firms can enhance this process by formally launching new R&D programs. However, this decision exacerbates the effect of integration through team reorganization on innovative performance by imposing inventors to learn new task-related routines. Second, we examined managerial integration and found that the replacement of the acquired R&D top manager facilitates the homogenization of team-related routines by forcing unlearning of old and different team-related routines. Highly similar team-related routines result in more effective team processes that alleviate the main negative effect of integration on team members' performance.

This final result has also broader implications for the literature on acquisition and top management turnover. Management scholars have suggested that retaining acquired R&D managers results in better coordination and knowledge integration after acquisition (Graebner, 2004). However, parallel research also shows that the replacement of the acquired R&D top manager will be beneficial for R&D performance when the similarity between acquiring and acquired firms increases (Colombo and Rabbiosi, 2014). We add to this work on the role of acquired R&D top managers showing the importance of qualifying the effect of one integration decision in relation to other concurrent integration decisions. On one hand, we find that replacing acquired R&D top manager is beneficial; on the other hand, we also confirm that the replacement per se as a negative effect on the inventor innovative performance after acquisition.[6] In line with our theoretical arguments, by replacing acquired R&D top managers firms can enhance unlearning processes which favor the adoption of new team-related routines and, therefore, reduce the negative effects on inventor productivity of team reorganization that directly induces changes on inventors' team routines. However, the replacement of the acquired R&D top manager can be detrimental if the team work environment of acquired inventors is not reorganized.

[6] In table 3, Models 5and 6 show a negative and significant coefficient of the variable *acquired R&D top management replaced × post-acquisition*.

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TABLES

Table 1. Descriptive Statistics and Correlations Coefficients (N = 7,386; Units= 3,693)

	Variable	Mean	S.D.	Min	Max	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
[1]	Patenting performance	1.75	3.1	0.00	43.00	1.00								
[2]	Post-acquisition x R&D team reorganization	0.25	0.43	0.00	1.00	-0.16	1.00							
[3]	Post-acquisition	0.50	0.5	0.00	1.00	-0.27	0.58	1.00						
[4]	R&D team reorganization	0.50	0.5	0.00	1.00	0.07	0.58	0.00	1.00					
[5]	Divestiture	0.45	0.5	0.00	1.00	0.09	0.36	0.00	0.62	1.00				
[6]	R&D program diversification	0.46	0.5	0.00	1.00	-0.03	0.28	0.00	0.49	0.73	1.00			
[7]	Acquired R&D top manager replaced	0.15	0.36	0.00	1.00	0.10	0.09	0.00	0.16	-0.05	-0.20	1.00		
[8]	High tech	0.08	0.27	0.00	1.00	0.11	-0.05	0.00	-0.08	-0.26	-0.06	0.15	1.00	
[9]	Cross-border	0.89	0.31	0.00	1.00	-0.06	0.13	0.00	0.22	0.31	0.03	-0.03	-0.62	1.00
[10]	Hostile	0.69	0.46	0.00	1.00	-0.07	-0.05	0.00	-0.09	0.02	0.16	-0.58	0.05	-0.08
[11]	Innovation related motives	0.02	1.03	-0.37	3.29	0.11	-0.22	0.00	-0.38	0.02	0.04	-0.16	0.57	-0.50
[12]	Technological links	0.07	0.25	0.00	1.00	-0.05	-0.07	0.00	-0.12	-0.25	-0.10	0.62	0.20	0.09
[13]	Technology similarity	0.62	0.17	0.00	0.91	0.08	-0.28	0.00	-0.49	-0.15	-0.43	-0.31	0.14	0.09
[14]	Relative size	148.75	93.08	0.00	280.55	0.00	0.41	0.00	0.72	0.74	0.71	-0.33	-0.12	0.31
[15]	Inventor tenure	5.22	5.67	0.00	24.00	0.15	0.10	0.00	0.18	0.23	0.16	0.17	0.00	0.03
[16]	Search depth	0.14	0.28	0.00	1.00	0.33	0.05	0.00	0.08	0.02	0.03	0.01	0.20	-0.08
[17]	Familiarity with acquirer's expertise	0.09	0.27	0.00	1.00	0.06	-0.13	0.00	-0.22	-0.18	-0.16	0.12	0.24	-0.18

	Variable	Mean	S.D.	Min	Max	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
[10]	Hostile	0.69	0.46	0.00	1.00	1.00							
[11]	Innovation related motives	0.02	1.03	-0.37	3.29	-0.18	1.00						
[12]	Technological links	0.07	0.25	0.00	1.00	-0.41	-0.09	1.00					
[13]	Technology similarity	0.62	0.17	0.00	0.91	0.47	0.26	-0.30	1.00				
[14]	Relative size	148.75	93.08	0.00	280.55	0.40	-0.21	-0.20	-0.12	1.00			
[15]	Inventor tenure	5.22	5.67	0.00	24.00	-0.05	-0.03	0.15	-0.09	0.17	1.00		
[16]	Search depth	0.14	0.28	0.00	1.00	-0.02	0.13	0.03	0.04	0.08	0.12	1.00	
[17]	Familiarity with acquirer's expertise	0.09	0.27	0.00	1.00	-0.05	0.25	0.26	0.10	-0.16	0.03	0.05	1.00

Table 2. Differences in Inventors Patenting Productivity for the pre- and post-acquisition periods

	Average Patent Count at the Inventor level					
	Pre-acquisition		Post-acquisition			
Treatment Group *(Acquisition with R&D team Reorganization)*	Subsample mean:		Subsample mean:		First difference (row):	
	Patent Count=	3.039	Patent Count=	0.913	Patent Count=	-2.126
	(N= 1,857)	(0.086)	(N= 1,857)	(0.086)	(N= 3,714)	
Control Group *(Acquisition with no R&D team Reorganization)*	Subsample mean:		Subsample mean:		First difference (row):	
	Patent Count=	2.954	Patent Count=	1.586	Patent Count=	-1.368
	(N=1,836)	(0.087)	(N=1,836)	(0.087)	(N= 4,136)	
Differences	***First difference*** *(Column)*		***First difference*** *(Column)*		***Difference-in-differences:***	
	Patent Count=	0.085	Patent Count=	-0.673***	Patent Count=	-0.758***
	(N= 3,693)	(0.123)	(N= 3,693)	(0.123)		(0.173)

*** p<0.01; ** p<0.05; * p<0.10

Table 3. Panel Negative Binomial Regression Models with Random Effects

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Post-acquisition × R&D team reorganization		-0.635***	-0.331**	-0.143†	-0.975***	-0.528***
		(0.061)	(0.103)	(0.079)	(0.072)	(0.123)
Divestiture × Post-acquisition × R&D team reorganization			-0.628***			-1.028***
			(0.145)			(0.202)
Divestiture × R&D team reorganization			-0.490			0.784
			(0.564)			(1.041)
Divestiture × Post-acquisition			0.302**			0.937***
			(0.098)			(0.167)
R&D program diversification × Post-acquisition × R&D team reorganization				-0.779***		0.261
				(0.128)		(0.192)
R&D program diversification × R&D team reorganization				-1.075		-1.548
				(0.679)		(1.306)
R&D program diversification × Post-acquisition				-0.096		-0.794***
				(0.089)		(0.153)
Acquired R&D top management replaced × Post-acquisition × R&D team reorganization					1.613***	1.342***
					(0.200)	(0.212)
Acquired R&D top management replaced × R&D team reorganization					2.275	0.299
					(1.606)	(0.529)
Acquired R&D top management replaced × Post-acquisition					-0.699***	-0.740***
					(0.176)	(0.178)
Post-acquisition	-1.389***	-1.089***	-1.142***	-1.058***	-1.038***	-0.997***
	(0.031)	(0.039)	(0.043)	(0.044)	(0.039)	(0.045)
R&D team reorganization	-0.173	-0.033	0.134	0.425	0.442	0.507
	(0.311)	(0.312)	(0.371)	(0.418)	(0.381)	(0.420)
Divestiture	0.384*	0.375*	0.939	0.219	-0.151	-0.779
	(0.165)	(0.165)	(0.623)	(0.198)	(0.370)	(1.233)
R&D program diversification	-0.249	-0.238	-0.682	0.247	0.178	1.028
	(0.201)	(0.202)	(0.462)	(0.337)	(0.340)	(1.218)
Acquired R&D top manager replaced	0.349	0.294	0.721	0.908*	-2.758	0.119
	(0.327)	(0.328)	(0.496)	(0.462)	(2.058)	(0.517)
High tech	0.910†	0.836	1.339†	1.096†	-3.502	-0.277
	(0.543)	(0.545)	(0.714)	(0.562)	(2.776)	(0.499)
Cross-border	0.168	0.109	0.327	0.700	-2.094	0.166
	(0.377)	(0.380)	(0.424)	(0.500)	(1.459)	(0.631)

Hostile	-0.868***	-0.834***	-0.847***	-0.196	0.739	0.299
	(0.234)	(0.234)	(0.231)	(0.437)	(1.011)	(0.654)
Innovation related motives	-0.028	-0.032	0.112	0.187	-0.157	0.077
	(0.130)	(0.131)	(0.181)	(0.168)	(0.159)	(0.143)
Technological links	-1.235*	-1.137*	-1.755*	-1.324*	3.932	0.301
	(0.570)	(0.573)	(0.789)	(0.579)	(3.263)	(0.624)
Technology similarity	0.585	0.657	-0.280	-0.219	2.911†	0.948
	(0.667)	(0.671)	(1.088)	(0.841)	(1.596)	(0.765)
Relative size	0.004*	0.004†	0.007*	0.006**	-0.007	0.001
	(0.002)	(0.002)	(0.004)	(0.002)	(0.007)	(0.003)
Inventor tenure	0.019***	0.019***	0.020***	0.020***	0.020***	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Search depth	1.200***	1.222***	1.223***	1.239***	1.237***	1.248***
	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)
Familiarity with acquirer's expertise	0.248***	0.261***	0.263***	0.272***	0.273***	0.275***
	(0.057)	(0.056)	(0.057)	(0.057)	(0.057)	(0.057)
Year Dummies	YES	YES	YES	YES	YES	YES
Constant	-0.808	-0.735	-2.061	-3.002†	5.175	-0.920
	(1.075)	(1.080)	(1.632)	(1.626)	(3.949)	(1.212)
Ln (r) Constant	2.138***	2.160***	2.156***	2.168***	2.170***	2.176***
	(0.058)	(0.057)	(0.057)	(0.056)	(0.056)	(0.056)
Ln (s) Constant	2.134***	2.102***	2.098***	2.064***	2.061***	2.036***
	(0.074)	(0.073)	(0.073)	(0.071)	(0.071)	(0.070)
Number of Observations	7.386	7.386	7.386	7.386	7.386	7.386
Chi2	4055.543***	4097.047***	4100.084***	4051.216***	4002.890***	4019.368***
Log Likelihood	-12015.078	-11959.832	-11950.258	-11914.703	-11905.702	-11874.298
Likelihood Ratio Comparison		110.492***	129.640***	200.750***	218.752***	281.560***

† p<0.10, * p<0.05, ** p<0.01, *** p<0.001