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WHAT THEY KNOW VS. WHAT THEY DO: HOW ACQUIRERS LEVERAGE TECHNOLOGY ACQUISITIONS

PHANISH PURANAM* and KANNAN SRIKANTH

Existing research suggests that in acquisitions of small technology-based firms by large established firms post-merger integration both enables and hinders acquirers’ efforts to leverage the technology of acquired firms. This apparent paradox can be resolved once we account for the qualitatively distinct ways in which acquirers leverage technology acquisitions. Integration helps acquirers use the acquired firm’s existing knowledge as an input to their own innovation processes (leveraging what they know), but hinders their reliance on the acquired firm as an independent source of ongoing innovation (leveraging what they do). We also show that experienced acquirers are better able to mitigate the disruptive consequences of the loss of autonomy entailed by integration, though we find no evidence that they achieve greater coordination benefits from integration.

INTRODUCTION

Acquisitions of small technology-based firms are an important source of technological inputs for established firms in high-velocity industries (Leonard-Barton, 1995; McEvily, Eisenhardt, and Prescott, 2004; Kale and Puranam, 2004). A growing body of research on such ‘technology acquisitions’ points to an underlying paradox: post-merger integration both enables and hinders acquirers’ efforts to leverage the technology of acquired firms (Birkinshaw, 1999; Chaudhuri and Tabrizi, 1999; Graebner, 2004; Puranam, Singh, and Zollo, 2006; Ranft and Lord, 2002). This is because organizational integration mechanisms can enhance knowledge transfer and coordination between acquirer and acquired organizations, but can also significantly disrupt organizational processes in the acquired firm due to the reduction in its organizational autonomy (Hespeslagh and Jemison, 1991). In an attempt to understand this paradoxical impact of integration on coordination and autonomy, some scholars have relied on detailed qualitative data to uncover the multiple consequences of post-merger integration. They have also identified integration mechanisms (such as the retention of key employees and the creation of channels for rich communication) and integration strategies (such as integrating different parts of the acquired company to different degrees) that promote knowledge flows and coordination without generating significant disruptive effects through the loss of autonomy (Graebner, 2004; Ranft and Lord, 2002; Schweizer, 2005).

In this study, we propose an alternative approach to understanding the integration paradox based on distinguishing two distinct ways in which acquirers leverage technology acquisitions. We argue that when acquirers use the acquired firm’s existing...
knowledge as an input to their own innovation processes, they are primarily leveraging what the acquired firm ‘knows.’ In contrast, when acquirers rely on the acquired firm as an independent source of ongoing innovation, they are primarily leveraging what the acquired firm ‘does.’ We argue that post-merger integration helps acquirers leverage what the acquired firm ‘knows’ by promoting coordination between acquirer and target firm, but hinders their ability to leverage what the acquired firm ‘does’ because of the disruptive effects on the target organization caused by a reduction in autonomy. Thus, we propose that the effect of post-merger integration in technology acquisitions becomes more transparent and less paradoxical once we account for the qualitatively distinct ways in which acquirers can leverage technology acquisitions. In doing so, we shift the emphasis from integration mechanisms to the impact of integration strategies (broadly defined) on different kinds of post-acquisition outcomes.

We focus on two archetypes of post-acquisition integration: structural integration, and its converse, structural separation. These correspond to situations in which the acquired firm is completely integrated into the acquirer and loses its distinctive identity as an organizational unit, or it is preserved as a distinct organizational entity within the merged firm (Haspeslagh and Jemison, 1991). We use patenting data to decompose the acquirer’s innovation efforts after acquisition into leveraging what the acquired firm knows and what the acquired firm does (Ahuja and Katila, 2001; Almeida, 1996; Almeida, Song, and Grant, 2002; Ernst and Vitt, 2000).

We develop theoretical arguments for the impact of structural integration on the mix autonomy and coordination that characterizes the post-acquisition organization, and the consequences for the resulting mix on different kinds of technology leverage. Consistent with our predictions, we find that structural integration enhances the acquirer’s ability to leverage the existing knowledge base of acquired firms. However, structural integration detracts from the acquirer’s ability to leverage the capability of the acquired firm for further invention. We also analyze the extent to which acquisition experience (Zollo and Singh, 2004) helps acquirers avoid this stark trade-off between leveraging knowledge and leveraging capability. We find that experienced acquirers are better able to mitigate the disruptive consequences of the loss of autonomy entailed by integration, though we find no evidence that they achieve greater coordination benefits from integration.

The results of this study contribute to our understanding of technology acquisitions in particular and to post-merger integration in general. However, we also believe that this study has broader implications for understanding how firms acquire and integrate knowledge-based inputs from external sources. The distinction between knowledge (‘what they know’) and capability (‘what they do’) is well established in the strategy literature (Winter, 1987). Yet, this theoretically meaningful distinction plays a limited role in the literature on technology sourcing relationships such as partnerships, joint ventures, and acquisitions. Our analysis shows that new insights can be gained by being precise about exactly what is being leveraged in such relationships. In particular, our results suggest that organizational arrangements necessary to leverage knowledge may be fundamentally incompatible with those necessary to leverage capabilities, though greater experience may help mitigate this trade-off to some extent.

TECHNOLOGY ACQUISITIONS: PRIOR LITERATURE

Small technology-based firms are attractive to acquirers as sources of technological inputs in regimes of rapid technological change (Arora, Fosfuri, and Gambardella, 2001; Granstrand and Sjolander, 1990). Acquiring such firms allows acquirers to avoid the time-consuming, path-dependent, and uncertain processes of internally accumulating technological resources—the knowledge and intellectual property that underlie technologies (Dierickx and Cool, 1989; Leonard-Barton, 1995; Steensma and Fairbank, 1999). In addition, acquisitions of small technology-based firms may also provide acquirers with an opportunity to acquire an organizational unit that is capable of producing further innovations. The acquired unit then functions effectively as a bundle of individual and organizational capabilities that generates further innovations. Acquirers can ‘graft’ the resulting innovation streams onto their own organization (Huber, 1991; Puranam, 2001), and exploit the fruits of the acquired firms’ inventive efforts by linking them to their own complementary assets in manufacturing, marketing, and distribution (Doz,
The management of technology acquisitions is, however, far from simple; although they provide quick access to technologies and innovation streams, problems of implementation frequently beset them, and they are prone to high failure rates (Chaudhuri and Tabrizi, 1999; Hagedoorn and Duysters, 2002; Steensma and Corley, 2000).

The conflicting demands of autonomy and coordination are often suggested to underlie implementation difficulties in technology acquisitions (Birkinshaw, 1999; Chaudhuri and Tabrizi, 1999; Graebner, 2004; Haspeslagh and Jemison, 1991; Puranam et al., 2006; Ranft and Lord, 2002). For instance, integration mechanisms identified in the literature on organization design such as the homogenization of organizational processes across acquirer and acquired firm, the rotation of R&D personnel, and joint product development activities can in principle help acquirers leverage the acquired firm’s technology and innovation capability through enhanced coordination between them (Galbraith, 1974; Lawrence and Lorsch, 1967; Nadler and Tushman, 1998). However, such mechanisms may also harm efforts to leverage technology, because they impinge on the organizational autonomy of the acquired firm, thereby disrupting existing organizational routines and lowering extrinsic and intrinsic motivation (Benner and Tushman, 2003; Haspeslagh and Jemison, 1991). Indeed, the few existing large sample studies on the performance effects of such integration mechanisms in technology acquisitions report mixed results (Chakrabarti, Hauschildt, and Suverkrup, 1994; Gerpott, 1995; Ranft, 1997), consistent with the observation that integration enhances coordination at the expense of autonomy.

One approach to understanding the paradoxical nature of post-merger integration in technology acquisitions has been to rely on fine-grained qualitative data. Ranft and Lord (2002) build on seven detailed case studies of technology acquisitions to induce propositions about integration and performance. Consistent with the notion of the integration paradox, they argue that autonomy for acquired firms (in terms of formal administrative structure and culture) simultaneously preserves tacit and socially embedded technologies and capabilities, but impedes acquirer’s efforts to leverage them, because autonomy limits effective coordination. However, rich unstructured communication, in the form of frequent face-to-face interactions, avoids the disruptive consequences of administrative and cultural integration while also enabling high levels of coordination. Graebner (2004) uses case data on eight technology acquisitions to focus on the role played by leaders of the acquired firm in post-merger integration. She finds that acquired leaders can moderate the effects of integration on performance; they may simultaneously enable greater integration and coordination and mitigate its disruptive consequences stemming from the resulting loss of autonomy due to their superior knowledge of and influence over the acquired organization. Schweizer (2005) draws on five case studies of acquisitions of biotechnology companies by large pharmaceutical companies to argue for the value of hybrid integration strategies that integrate different parts of the acquired firms value chain to different degrees. He suggests that by providing autonomy to upstream R&D units while integrating downstream non-R&D activities like sales and regulatory approval, acquirers can meet both short-term goals of adding to their pipeline while also preserving the target’s capabilities at generating innovation for the future.

While qualitative analysis enriches our understanding of the working of integration mechanisms at a fine-grained level, we believe that an equally valid and complementary approach lies in analyzing technology leveraging outcomes at a more fine-grained level. To better understand exactly what acquirers leverage in technology acquisitions, we draw on the distinction between the knowledge that underlies a technology and the capability to produce new technologies. The stock of technological knowledge in an acquired firm at the time of acquisition includes knowledge embodied in artifacts as well as embedded in the minds of individuals that pertains to existing technologies (Winter, 1987). In contrast, the capability to generate further innovations is primarily resident in individual and group processes that allow for the recombination of existing knowledge into new knowledge (Kogut and Zander, 1992, 1996). The distinction between knowledge and capability has been extensively discussed in both theoretical and empirical contributions to the strategy literature (Eisenhardt

1 A Price Waterhouse Coopers report released in 1999 estimated that about 80 percent of technologically motivated acquisitions in the time period 1994–97 have failed to achieve their objectives. A study by the Hay group of Philadelphia in the same period found that as many as 60 percent of such acquisitions suffer from severe problems in the post-merger integration stage.

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Prior research on technology acquisitions has been largely agnostic to the distinction between knowledge and capability leverage by the acquirer. For instance, Ahuja and Katila (2001) show that, on average, the impact of technologically motivated acquisitions on the innovative performance of the combined firms (measured through patenting) is positive, but they do not distinguish between patenting that arises from leveraging the existing knowledge of the acquired firm and from leveraging its capabilities for ongoing innovation. Ernst and Vitt (2000) explore the effects of acquisition on innovativeness, but focus only on the number and quality of the patents filed post-acquisition by highly productive (pre-acquisition) inventors. In their sample, acquirers appear to have failed to fully leverage the capabilities for innovation embodied in the key inventors of the acquired firm, but their analysis does not take into account the leveraging of existing knowledge by acquirers as an alternate source of value creation.

Why does the distinction between leveraging existing knowledge (‘what they know’) vs. capabilities for ongoing innovation (‘what they do’) matter in technology acquisitions? In the following section, we introduce a theoretical framework that suggests that the distinction between existing knowledge and innovative capabilities is important because their leverage requires distinct organizational arrangements.

THEORY AND HYPOTHESES

The organizational antecedents of knowledge and capability leverage

It is generally accepted that in technology acquisitions organizational autonomy minimizes disruption in the target firm, thereby preserving motivation and capacity for ongoing innovative activity by the target firm employees (Birkinshaw 1999; Ranft and Lord, 2002; Graebner, 2004; Schweizer, 2005). The additional point we wish to highlight, however, is that the extent of coordination required between acquiring and acquired units depends on what the acquirer wants to leverage from the acquisition. When the goal is primarily to leverage the existing knowledge of the target firm by transferring it to the acquirer’s personnel, than the need for coordination dominates the need for autonomy. In contrast, when the primary goal is to keep the acquired employees capable of producing ongoing innovation, then the need to preserve autonomy dominates the need for coordination between acquirer and target firm.

We represent these arguments graphically in Figure 1. Points below the diagonal represent an emphasis on autonomy over coordination, whereas points above the diagonal represent an emphasis on coordination over autonomy. The area below the diagonal can therefore be thought of as the ‘zone of capability leverage,’ whereas that above the diagonal is the ‘zone of knowledge leverage.’ We note that the distinction between the zones is a matter of emphasis—the zone of capability leverage also entails some degree of coordination between acquirer and target organization, just as the zone of knowledge leverage also entails some degree of organizational autonomy. Put differently, the marginal rate of technical substitution between coordination and autonomy is different for capability and knowledge leverage, though both coordination and autonomy may be complements in either kind of leverage.

Our arguments about the distinct organizational antecedents of knowledge and capability leverage are an elaboration of a more general point first made by Haspeslagh and Jemison (1991). These authors argued that acquisition integration strategies are conditional on the extent of strategic interdependence between acquirer and target, and the need for organizational autonomy of the target firm, and suggested four generic integration strategies that arise from crossing these two dimensions.
Their argument implicitly ascribes a single objective to the acquisition, which determines the level of interdependence and autonomy. We suggest that within the context of technology acquisitions there may exist different objectives for the same acquisition (i.e., knowledge and capability leverage), which require distinct organizational antecedents.

**Structural form, knowledge and capability leverage**

In acquisitions, the choice between structural integration and its converse, structural separation, is a fundamental choice about the form of the combined organization (Haspeslagh and Jemison, 1991). As a formal design choice concerning the ‘grouping’ of organizational units, structural integration precedes decisions about the use of ‘linking’ mechanisms between organizational units (such as the alignment and standardization of processes and systems, common hierarchical control, cross-unit teams, and integrating managers) both temporally and in importance (Galbraith, 1977; Nadler and Tushman, 1998; Thompson, 1967). Scholars who study acquisition implementation describe the choice between complete absorption and preservation of autonomous organizational status as an important initial decision that shapes further fine-grained integration actions (Haspeslagh and Jemison, 1991; Pablo, 1994; Ranft and Lord, 2002; Zollo and Singh, 2004).

Structural integration enhances the acquirer’s efforts to leverage the technical knowledge embedded in the human capital of acquired firm employees. By grouping organizational units together within administrative boundaries through structural integration, the coordination mechanisms of programming, hierarchy, and feedback can be effectively used to enable knowledge transfer and coordination (Galbraith, 1977; March and Simon, 1958; Thompson, 1967; Gulati, Lawrence, and Puranam, 2005). For instance, structural integration will typically result in common procedures, common goals, and common authority between acquired and acquiring firms’ technical employees, which enhances coordination and knowledge sharing between them (Haspeslagh and Jemison, 1991). In addition to the impact on the formal systems and procedures of the organization, structural form also shapes the emergence of informal organizational processes that aid knowledge transfer, such as the creation of common knowledge, informal communication channels, and group identity (Camerer and Knez, 1996; Kogut and Zander, 1996; Krackhardt, 1990; Moran and Ghoshal, 1996; Grant, 1996). These effects may be strengthened if structural integration also results in collocation. Structural integration may also be conducive to the leverage of knowledge that is embodied in physical artifacts. Administrative integration can enable superior access to the knowledge embodied in documents, equipment, and procedures because of enhanced awareness of the existence and location of these knowledge resources, as well as control over their use (Haspeslagh and Jemison, 1991; Zollo, 1998). We refer collectively to these consequences of structural integration as the ‘coordination effect’—as cumulatively they serve to enhance coordination between the acquirer and target firm.

Thus, structural integration, through the coordination effect, is expected to create organizational conditions that enable acquirers to successfully leverage what the acquired firm knows: the existing knowledge base of the acquired firm. This is because knowledge leverage relies primarily on enhanced coordination between acquirer and target firms, which structural integration promotes. We therefore predict:

*Hypothesis 1: Structural integration is positively associated with acquirer’s success at leveraging the existing knowledge of acquired firms in technology acquisitions.*

In addition to the coordination effect, however, structural integration can impede the acquirer’s efforts to leverage the acquired firm’s capabilities for innovation because it ends the autonomous existence of the target firm. This ‘loss of autonomy’ effect reduces the capacity of the inventors within the target firm to continue doing innovative work in two different ways. First, since integration implies a standardization of work practices and procedures between the target and acquirer firm, the work practices in the target firm must undergo change. Change can cause disruption, independent of any improvements brought about by a new configuration of organizational attributes (Amburgey, Kelley, and Barnett, 1993; Hannan and Freeman, 1984). Such changes can alter organizational routines within the acquired firm, and in doing so can undermine its innovative capabilities (though,
as we have noted, integration may promote coordination between the acquirer and target organizations) (Benner and Tushman, 2003; Leonard-Barton, 1992; Ranft and Lord, 2002). These effects go beyond the short-term disruption of productivity, to describe a long-term reduction in the innovative capability of the target firm.

Second, there is the possibility of lowered motivation and productivity of inventors in the target firm after being structurally integrated. Arguments from agency theory suggest that structural integration weakens the link between reward and effort. Free riding increases as formerly distinct organizational units are grouped together, and precludes the use of sharper incentives (Baker, 2002). Talented employees with hard-to-measure skills and efforts are often attracted to smaller organizations because of their ability to offer high-powered incentives (Zenger, 1994). Such employees are likely to become demotivated, and could possibly even leave after their firm has been fully integrated into the acquirer, which would critically undermine the target firm’s innovation capacity (Ernst and Vitt, 2000). Lowered intrinsic motivation due to lowered task autonomy following structural integration can lead to similar results (Osterloh and Frey, 2000; Wageman, 1995). These adverse consequences for motivation can significantly and permanently damage innovation capabilities in acquired firms.

Thus structural integration may enhance the linkages between the acquired and acquiring units through the coordination effect, but may prevent acquirers from being able to successfully leverage the capabilities of the acquired firm employees for ongoing innovation, because of the ‘loss of autonomy’ effect (and consequent long-term disruptions). Put differently, structural integration may enhance the acquirer’s ability to leverage what the target firm employees ‘know,’ but may impede their efforts to leverage what they ‘do.’

**Hypothesis 2:** Structural integration is negatively associated with the acquirer’s success at leveraging the innovative capabilities of acquired firms in technology acquisitions.

Figure 2 also provides a graphic representation of how structural integration forces a transition from the zone of capability leverage to the zone of knowledge leverage, by changing the mix of coordination and autonomy.

**The moderating effects of acquisition experience**

Experiential learning is a fundamental mechanism through which limitedly rational individuals come to grips with complexity (Cyert and March, 1963). The extensive literature on the learning curve in manufacturing processes (e.g., Yelle, 1979; Epple, Argote, and Devedas, 1991) has documented this mechanism on shop floors. Recent research suggests its existence in corporate boardrooms as well; experience effects have been studied for infrequent, high-impact events such as contracting, alliances, and acquisitions (Mayer and Argyres, 2004; Kale, Dyer, and Singh, 2001; Zollo and Singh, 2004). It would, however, be fair to say that prior empirical work on the effect of acquisition experience on acquisition performance has been inconclusive. Some empirical tests have shown a positive effect of experience on performance (Fowler and Schmidt, 1989; Bruton, Oviatt, and White, 1994), while others have shown non-significant effects (Lubatkin, 1987; J.A.C. Baum and A. Ginsberg, unpublished MS, 1997; Zollo and Singh, 2004). A few studies have found a ‘U-shaped’ effect for acquisition experience on performance (Haleblian and Finkelstein, 1999), which other studies have, however, failed to replicate (Hayward, 2002).

One important explanation of these inconclusive findings is that the value of experience is contingent on the integration strategy—not accounting for the latter (which is typically the case in most prior studies) may partly explain the absence
of reliable results for experience effects. Popular accounts of highly successful acquirers such as Banc One (Winter and Szulanski, 2001) and Cisco Systems (Reinhardt, 1999; Goldblatt, 1999) do suggest that acquisition experience impacts focal acquisition performance at least partly through building expertise at post-acquisition management. Consistent with this view, Zollo and Reuer (2005) find that firms with greater acquisition experience are able to derive superior performance when they manage the focal acquisition with greater levels of integration. We extend this line of thinking by examining how acquisition experience may influence the coordination and loss of autonomy effects generated by structural integration.

In analyzing the influence of experience on the effects of structural integration, it is useful to distinguish between the process by which structural integration is achieved—the set of short-term changes that must be accomplished to create an integrated organization—from the longer-term effects of the final integrated organizational form. Acquisition experience may undoubtedly be useful in managing the logistics of the transition to an integrated organizational form, as this transition involves a complex set of interrelated and time-bound decisions spanning multiple organizational sub-units (Zollo and Singh, 2004). However, these short-term benefits that accrue during the integration period are not our focus. Both the coordination and loss of autonomy effects we described are the long-term consequences of a realized structurally integrated organizational form. To understand how experience influences the coordination and loss of autonomy effects of structural integration amounts to asking if (and why) these effects differ across firms with different experience levels, even when all chose structural integration. Put differently, our focus is on how experiential learning can help acquirers strengthen the coordination effect or weaken the loss of autonomy effect, rather than how they can transition to a structurally integrated form more efficiently.

We expect that, through experience, acquirers learn how to better manage the consequences of structural integration. Structural integration is a change to the formal organization design resulting in changes to reporting relationship, incentives, and operating procedures across acquiring and acquired organizations. However, the effectiveness of these changes across acquirers may differ as a function of their prior experience with managing acquisitions. Through experiential learning, acquirers may be able to develop competence at leveraging the new formal organizational arrangements more effectively to enhance coordination—the same standards and procedures may yield superior coordination benefits to experienced users (Kale et al., 2001). Experienced acquirers may also be able to influence the emergent aspects of coordination following structural integration—such as the creation of group norms, identity, and common knowledge—through more sophisticated interventions than those used by relatively inexperienced acquirers (Stahl and Voigt, 2004). Experience may also help to mitigate the disruptive consequences of structural integration. Repeat acquirers may develop capabilities at minimizing the adverse motivational consequences of structural integration through better communication programs, which explain the rationale for the changes and minimize ambiguity about the future fate of acquired firm employees. They may also develop capabilities at targeted retention efforts—at identifying the key individuals whose departure or demotivation would be most disruptive, as well as at designing retention packages that are likely to be most effective for such individuals.

In sum, we expect acquisition experience to enhance the effective implementation of structural integration by strengthening the coordination effect as well as weakening the disruptive consequences of the loss of autonomy effect. Hence, we test the following hypotheses:

**Hypothesis 3:** The relationship between structural integration and knowledge leverage is positively moderated by acquirer acquisition experience.

**Hypothesis 4:** The relationship between structural integration and capability leverage is positively moderated by acquirer acquisition experience.

**METHODS**

**Sample and data**

In keeping with prior literature, we define technology acquisitions as the acquisition of small technology-based firms by large established firms to gain access to their technology and capabilities (Doz, 1988; Graebner, 2004; Granstrand...
and Sjolander, 1990; Ranft and Lord, 2002). We chose acquisitions from the information technology (computing and communications) and pharmaceutical industries for two reasons: First, these sectors are frequently profiled in popular publications as being extremely active in acquisitions aimed at accessing the technology expertise of smaller companies (Reinhardt, 1999; Goldblatt, 1999); second, both these industries are characterized by appropriability regimes that encourage significant patenting activity (Cohen, Nelson, and Walsh, 2000; Klevorick et al., 1995; Levin et al., 1987).

Acquiring firms were selected from SIC codes of manufacturing industries connected to computing, communications, and pharmaceuticals. We used the U.S. Small Business Administration definition of small businesses (<500 employees) to distinguish large acquirers from small target firms. Our criteria for selecting established acquirers required them to have been listed continuously in COMPUSTAT between 1988 and 1998 and to have had more than 500 employees at every point in time in the study. The choice of the time window was driven by the availability of good public information on acquisitions and ex post performance measures (the data were collected in 2001). Continued existence during the study window operationalized our definition of established firms. We identified the technology acquisitions made by these firms through SDC Platinum’s M&A database. These were acquisitions of independent firms (as opposed to divestments) that had fewer than 500 employees at the time of the acquisition, and had filed at least one patent prior to acquisition. Similar criteria and techniques have been used to identify technology-based entrepreneurial firms and acquisitions in the literature (Ahuja and Katila, 2001; Ernst and Vitt, 2000; Granstrand and Sjolander, 1990). These screening criteria resulted in 99 acquisitions by 43 acquirers. Data limitations reduced this to 97 acquisitions by 43 acquirers.

**Variable definitions and measures**

**Acquirer’s success at knowledge and capability leverage**

One of the novel features of this study is our ability to differentiate between an acquirer’s success at leveraging the existing knowledge base of the acquired firm and its capability for further innovation based on patent data. Hence, we describe and theoretically justify our measures for knowledge and capability leverage at some length in this section.

A patent is the grant of a property right to an inventor for an invention. The patents assigned to a firm represent the knowledge that a firm is acknowledged as having created (Jaffe, Trajtenberg, and Henderson, 1993). In this sense, the patents filed by the acquired firm prior to acquisition are a measure of the knowledge stock of the acquired firm. The patents filed by acquirers after the acquisition represent additional stocks of knowledge created through successful inventive activity after the acquisition (Ahuja and Lampert, 2001; Henderson and Cockburn, 1994). In keeping with prior studies, we use a count of patents filed after the acquisition by the acquirer–acquired firm combination as a measure of the successful leveraging of technology acquisitions (Ahuja and Katila, 2001; Ernst and Vitt, 2000). However, we introduce two critical refinements by focusing exactly on those patents after acquisition that involve either the leveraging of the acquired firm’s pre-existing knowledge, its innovation capabilities, or both, and distinguishing between these categories.

In order to track the successful leverage of the acquired firm’s knowledge base by acquirers, we rely on patent citations. A newly patented invention typically builds on the knowledge created by the firm in the past or by other firms that have preceded it in that line of inquiry. Several studies using patent and citation data argue that citations are evidence of inter-firm and intra-firm knowledge transfer (Almeida et al., 2002; Rosenkopf and Almeida, 2003; Song, Almeida, and Wu, 2003). This is because a citation implies ‘material influence’ on the current patent and assumes successful transfer of tacit knowledge, apart from the knowledge codified in the patent itself (Almeida and Kogut, 1999; Almeida et al., 2002; Jaffe and Trajtenberg, 1996; Jaffe, Trajtenberg, and Fogarty, 2002; Jaffe et al., 1993; Song et al., 2003). Hence, we propose that post acquisition an acquirer’s patent citing an acquired firm patent is evidence of inventive effort that leverages the acquired firm’s existing knowledge codified in the patent and other secondary sources as well as the tacit component resident in the acquired firm’s employees.

To track the leverage of innovation capabilities, we rely on patent authorship data. The authors of
a patent are referred to as the ‘inventors.’ Studies of innovation frequently use patent authorship as a measure of productivity of engineers and scientists (Almeida et al., 2002; Song et al., 2003; Ernst and Vitt, 2000; Nerkar, 2003). We argue that when an inventor previously employed by the acquired firm is the author of a patent filed by the acquirer subsequent to the acquisition, the acquirer firm has leveraged the innovative capabilities of the acquired firm, both as an individual and in conjunction with his or her colleagues. Through a process of exhaustive search and matching on surnames, initials, technology classes and location, we could construct measures of capability leverage by tracking patents filed by target firm inventors after the acquisition.

Figure 3 illustrates how we measure the success of knowledge and capability leverage. We started by identifying the acquired firm’s active knowledge base prior to the acquisition—all patents (and inventors therein) that were filed in the 3 years preceding acquisition. Three years appeared to be a reasonable window, given the typically young age of entrepreneurial firms, as well as the possibility of inventor mobility between firms through job changes. We then tracked down new patents filed by the acquirer/acquired firm combination after the acquisition, and linked them back to the active knowledge base of the acquired firm prior to acquisition. All such new post-acquisition patents were placed in one of the four cells in Figure 3.

The patents in cell A are a measure of both successful knowledge leverage and capability leverage, since these patents both cite a previous acquired firm patent and at least one acquired firm inventor is among the authors of these patents. The number of patents in cell B is used as a measure of the success of ‘pure’ knowledge leverage. These patents cite patents that were previously filed by the acquired firm, thus acknowledging that the innovation embodied in the focal patent utilizes the knowledge previously created by the acquired firm. However, no acquired firm employee is an author of the focal patent, implying that no significant utilization of acquired firm employee’s innovative capabilities occurred in the focal innovation. The patents in cell C are a measure of the success of ‘pure’ capability leverage. These patents include at least one acquired firm employee as an author, thus acknowledging those employees’ contributions to the innovation in the focal patent. However, no acquired firm patent is cited, signifying that the focal patent does not build on the codified knowledge base of the acquired firm represented by its stock of patents. While cells B and C represent ‘pure’ forms of knowledge and capability leverage, it also appears reasonable to count patents in cell A in both categories—i.e., patents in cells A and B represent the leverage of existing knowledge, while those in cells A and C represent the leverage of innovation capabilities. Our analysis results in qualitatively identical results with either measure. We deem post-acquisition patents that are not linked by citation or authorship to the acquired firm’s patents prior to acquisition as irrelevant to the study (cell D). Even if a potential recombination of ideas between acquirers and acquired firms took place that resulted in such a patent, it was minor enough not to warrant either authorship or citation of acquired firm knowledge.

**Structural integration**

To record the structural integration decision for each acquisition, we examined the CORPTECH database in the year after the acquisition. CORPTECH conducts an annual survey of technology firms and units within firms that maintain independent P&L accounts, or distinct status as operating entities. The continued appearance of the acquired firm in the CORPTECH database published in the second year after the acquisition was interpreted to mean that structural integration had not been carried out. If the firm disappeared from CORPTECH, we interpreted this to mean that structural integration had occurred so that it was no longer

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Figure 3. Measuring leverage of innovation capability and existing knowledge through post-acquisition patenting
traceable as a distinct organizational entity or it maintained separate P&L accounts. We verified the validity of this measurement of structural integration through an examination of press releases and articles.

**Acquirer acquisition experience**

While our study window began in 1988, we measured acquisition experience as a count of prior acquisitions conducted by the acquirer from the earliest date for which SDC data are available (1984).

**Acquired firm size and age**

We obtained the number of employees in the acquired firm, and its age at the time of acquisition from CORPTECH and SDC Platinum. Age and size of acquired firms may influence their innovation outcomes and also how they are managed (in terms of organizational autonomy) by acquirers (Ranft and Lord, 2002).

**Acquired firm current knowledge base**

We measured the size of the current knowledge base of the acquired firm by the number of patents granted to the acquired firm in the past 3 years before the acquisition. Since these patents form the basis on which we identify future post-acquisition inventive activity, their number can be expected to critically influence observed patenting outcomes.

**Acquired firm pre-citations and prior-stock of patents**

We measured the quality of the acquired firm at the time of the acquisition in two ways. First, we measured the number of citations (‘pre-citations’) the acquired firm’s patents received prior to acquisition by all firms (including the acquirer firm). Citations received by a patent are regarded as a measure of the quality of the patent (Trajtenberg, 1990). As a second measure of acquired firm quality, we measured the prior stock of knowledge (‘prior stock’) in the acquired firm by the number of patents that were granted to the acquired firm from its inception until 3 years before acquisition. In conjunction with the variable measuring ‘Current knowledge base,’ these variables include a comprehensive count of all pre-acquisition patents.

**Acquirer R&D intensity**

Investment in R&D as a percentage of sales for acquirers was calculated from data available from COMPSTAT. R&D investments by acquirers could lead to superior innovation outcomes on their own, and could also build absorptive capacity, enabling successful utilization of external sources of knowledge (Ahuja and Katila, 2001; Cohen and Levinthal, 1990).

**Acquirer size**

We obtained the number of employees in the acquirer at the time of acquisition from CORPTECH and SDC Platinum. Acquirer size may affect retention of key inventors, since employees with hard-to-measure skills tend to self-select toward small companies (Zenger, 1994).

**Technological relatedness**

We included a measure of technological relatedness between acquired firm and acquirer (Seth, 1990; Singh and Montgomery, 1987). Relatedness was assessed through the extent of overlap between the technology codes assigned to acquired firms and acquirers by SDC Platinum. The extent of overlap was calculated as the number of codes common to acquirer and acquired firm divided by the total number of technology codes of the acquired firm.

**Time**

Our sample consists of acquisitions that occurred in a 10-year time window between 1989 and 1998, in which an acquisition could have happened at any time. We measure patenting after acquisition from the time of acquisition until 2002. Since patents accumulate over the years after acquisition, we control for time elapsed after acquisition until the end of our observation period.

**Model specification and econometric issues**

Since our dependent variables are counts that take on non-negative integer values, use of the Poisson model is indicated (Hausman, Hall, and Griliches, 1984; Henderson and Cockburn, 1994). This model assumes that the number of patents filed by a firm in any given year, or the number of acquired firm
inventors who appear on patents, is a random variable that is approximated via a Poisson process, in which the mean is equal to the dispersion of the data. This implies that the probability of obtaining \( q \) counts of patents or inventors in a particular year is given by

\[
\Pr(y = q) = \frac{\lambda^q e^{-\lambda}}{q!}
\]  

(1)

where \( \lambda \) is the expected value (and the variance) of the random variable \( q \). Poisson regressions estimate this parameter in log-linear models of the form

\[
\log(\lambda) = \beta' x
\]

(2)

using the method of maximum likelihood. Since the Poisson process models counts per unit time (year), and our data contain inventions accumulated over several years after acquisition, in our estimation we control for exposure time: the time period over which patenting is observed.

Our data display overdispersion (the variance is greater than the mean), thus violating the Poisson distribution assumption. However, Poisson regressions have the appealing property that whether or not the distributional assumptions are met, the estimates of \( \beta \) will be consistent and asymptotically normal (Wooldridge, 2000: Ch. 17). Therefore we report heteroskedastic-consistent robust standard errors for coefficients estimated through Poisson models, as these provide consistent estimates for the standard errors even under misspecification of the distribution (Cameron and Trivedi, 1998; Hall and Ziedonis, 2001).

In our setting, we believe that unobserved stable features of acquirers are an important aspect to be taken into account. Differences in terms of post-acquisition inventive activity could potentially be attributed to stable acquirer features such as superior routines and incentive mechanisms, management methods, and better acquired firm selection capabilities. With multiple acquisitions observed for each acquirer, it is possible to control for such stable acquirer features. With multiple acquisitions per acquirer, Equation 2 becomes modified to

\[
\log(\lambda_{it}) = \beta' x_{it} + \alpha_i
\]

(3)

where the \( \alpha \) term captures acquirer level heterogeneity. Our data reject the hypothesis that the \( \alpha \) are all zero. We can therefore estimate Equation 3 either via random or conditional fixed effects (Hausman et al., 1984). In our data, the Hausman test rejects the null hypothesis of random effects for some of the models; we report the more conservative conditional fixed-effects results, and compare these results to the random-effects model in the robustness analyses (Wooldridge, 2001).

RESULTS

Descriptive statistics

The descriptive statistics for our data are displayed in Table 1. There is considerable variance on the key acquirer characteristics of size, acquisition experience and R&D intensity, and target characteristics such as age, size, quality, and previous patenting behavior. Post acquisition, about 40 percent of the target firms were structurally integrated. In about 44 percent of the acquisitions no patenting activity from either knowledge or capability leverage was observed at the end of the observation period.

Examining the correlations displayed in Table 2, we note that there is only a small (\( \rho = 0.27 \)) correlation between the measures of the success of knowledge leverage and capability leverage. This suggests that these measures are indeed capturing different conceptual entities. We also note that correlations between independent variables do not suggest any obvious concerns about collinearity.

Hypothesis testing

The fixed-effects Poisson regression estimates for the effect of structural integration on different innovation activities are presented in Table 3. In this table, the controls were entered first (Model 1a, b), followed by structural integration (Model 2a, b) and the interaction term with experience (Model 3a, b). In this table, the measure of knowledge leverage includes all patents in which a target firm inventor appears as an author (cells A and B in Figure 3), while capability leverage includes all patents that cite the target firm’s pre-acquisition patents (cells A and C in Figure 3).

In Hypothesis 1 we predicted a positive relationship between structural integration and the acquirer’s success at leveraging existing knowledge from the acquired firm. From Model 2a in...
Table 1. Descriptive statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measurement</th>
<th>Obs.</th>
<th>Mean</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural integration</td>
<td>Dummy coded 1 if structurally integrated</td>
<td>97</td>
<td>0.37</td>
<td>0.48</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Acquirer size</td>
<td>Log of acquirer sales</td>
<td>97</td>
<td>6.41</td>
<td>2.51</td>
<td>2.01</td>
<td>10.67</td>
</tr>
<tr>
<td>Acquirer R&amp;D intensity (%)</td>
<td>Acquirer R&amp;D budget as a fraction of acquirer sales</td>
<td>97</td>
<td>11.03</td>
<td>5.19</td>
<td>0</td>
<td>33.3</td>
</tr>
<tr>
<td>Acquirer acquisition experience</td>
<td>Number of firms the acquirer had bought prior to focal acquisition</td>
<td>97</td>
<td>6.88</td>
<td>6.17</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>Acquirer employees</td>
<td>Number of employees in acquirer at time of acquisition</td>
<td>97</td>
<td>37,252</td>
<td>40,573</td>
<td>748</td>
<td>156,373</td>
</tr>
<tr>
<td>Technology relatedness</td>
<td>Normalized measure of the number of shared technology codes</td>
<td>97</td>
<td>0.31</td>
<td>0.41</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Acquired firm age</td>
<td>Number of years from founding until acquisition</td>
<td>97</td>
<td>11.67</td>
<td>11.12</td>
<td>0</td>
<td>88</td>
</tr>
<tr>
<td>Acquired firm size</td>
<td>Number of target employees at time of acquisition</td>
<td>97</td>
<td>132.2</td>
<td>110.7</td>
<td>3</td>
<td>500</td>
</tr>
<tr>
<td>Acquired firm pre-citations</td>
<td>Number of citations received by target patents prior to acquisition</td>
<td>97</td>
<td>9.5</td>
<td>19.4</td>
<td>0</td>
<td>103</td>
</tr>
<tr>
<td>Acquired firm prior stock of patents</td>
<td>Number of patents filed by target until 3 years prior to acquisition</td>
<td>97</td>
<td>9.8</td>
<td>21.9</td>
<td>0</td>
<td>182</td>
</tr>
<tr>
<td>Acquired firm current innovativeness</td>
<td>Number of patents filed by target in the 3 years prior to acquisition</td>
<td>97</td>
<td>4.9</td>
<td>6.5</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td>Capability leverage</td>
<td>Patents filed by acquirer or target after acquisition in which at least one target inventor is an author</td>
<td>97</td>
<td>2.9</td>
<td>5.3</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>Knowledge leverage</td>
<td>Patents filed by acquirer or target after acquisition in which at least one target patent is cited</td>
<td>97</td>
<td>3.1</td>
<td>6.4</td>
<td>0</td>
<td>38</td>
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</tbody>
</table>

Table 3 we note that the coefficient for structural integration is positive and significant ($p < 0.10$). Hence, we find support for Hypothesis 1. In Hypothesis 2 we predicted a negative relationship between structural integration and the acquirer’s success at leveraging the innovation capabilities of the acquired firm. From Model 2b in Table 3 we find a negative and significant ($p < 0.05$) coefficient for structural integration, supporting Hypothesis 2.

In Hypothesis 3 we predicted that acquisition experience would positively moderate the effect of structural integration on knowledge leverage. From Model 3a in Table 3 we see that the coefficient for the interaction term is negative but not significant. We also conducted a joint test of significance for structural integration and the interaction term to assess whether collinearity between these terms was suppressing a significant effect. However, we found no evidence for this as the coefficients are not jointly significant ($\chi^2(2) = 3.48$, $p = 0.17$). Hence, Hypothesis 3 is not supported. In Hypothesis 4 we predicted that acquisition experience will positively moderate the effect of structural integration on capability leverage. From Model 3b in Table 3 we see that the interaction term has the expected positive sign and is significant ($p < 0.10$). Hence, we find support for Hypothesis 4.

The results on the control variables emphasize the conclusion that knowledge and capability leverage have distinct antecedents. Knowledge leverage is enhanced by the quality of the acquired firm at the time of acquisition, as measured by the stock of accumulated patents granted prior to 3 years before acquisition. Capability leverage, on the other hand, is enhanced not by the stock of accumulated knowledge but by the extent to which the target firm is active in patenting prior to the acquisition. Capability leverage is also diminished by increasing target size, which is consistent with prior work on scale diseconomies in R&D (Zenger, 1994).

Robustness checks

A number of robustness checks lend confidence about the basic validity of our results. A basic premise in our argument is that the coordination and autonomy effects are temporally stable. Thus,
Table 2. Correlation table

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tr>
<td>1</td>
<td>1.00</td>
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</tr>
<tr>
<td>2</td>
<td>0.05</td>
<td>1.00</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>3</td>
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</tr>
<tr>
<td>4</td>
<td>−0.07</td>
<td>0.20∗∗</td>
<td>−0.16</td>
<td>1.00</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.15</td>
<td>0.22∗∗</td>
<td>0.28∗∗</td>
<td>0.10</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>−0.01</td>
<td>−0.05</td>
<td>0.08</td>
<td>0.12</td>
<td>0.15</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>0.03</td>
<td>−0.18∗</td>
<td>−0.13</td>
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<td>−0.13</td>
<td>−0.11</td>
<td>1.00</td>
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<td></td>
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<td></td>
<td></td>
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<td>8</td>
<td>0.02</td>
<td>0.00</td>
<td>−0.12</td>
<td>−0.01</td>
<td>−0.13</td>
<td>0.12</td>
<td>0.26∗∗</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>9</td>
<td>0.14</td>
<td>0.02</td>
<td>0.35∗∗∗</td>
<td>−0.10</td>
<td>0.20∗∗</td>
<td>0.27</td>
<td>−0.08</td>
<td>0.13</td>
<td>1.00</td>
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<td></td>
</tr>
<tr>
<td>10</td>
<td>−0.11</td>
<td>−0.14</td>
<td>0.27∗∗∗</td>
<td>0.06</td>
<td>0.00</td>
<td>0.15</td>
<td>0.02</td>
<td>0.16</td>
<td>0.45∗∗∗</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.08</td>
<td>0.06</td>
<td>0.03</td>
<td>−0.04</td>
<td>−0.07</td>
<td>0.00</td>
<td>−0.02</td>
<td>0.15</td>
<td>0.03</td>
<td>0.40∗∗∗</td>
<td>1.00</td>
<td></td>
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</tr>
<tr>
<td>12</td>
<td>−0.19∗</td>
<td>−0.23∗∗</td>
<td>0.31∗∗∗</td>
<td>0.02</td>
<td>0.00</td>
<td>0.06</td>
<td>−0.08</td>
<td>−0.13</td>
<td>0.02</td>
<td>0.34∗∗∗</td>
<td>0.22∗∗</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>−0.07</td>
<td>0.09</td>
<td>0.15</td>
<td>−0.17</td>
<td>0.24∗∗</td>
<td>0.10</td>
<td>−0.15</td>
<td>−0.11</td>
<td>0.30∗∗∗</td>
<td>0.06</td>
<td>0.04</td>
<td>0.27∗∗∗</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

*** p < 0.01; ** p < 0.05; * p < 0.1
Table 3. Impact of structural integration on knowledge leverage: Poisson fixed-effects models with robust standard errors

<table>
<thead>
<tr>
<th></th>
<th>Knowledge leverage</th>
<th>Capability leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1a</td>
<td>Model 2a</td>
</tr>
<tr>
<td>Acquirer acquisition experience</td>
<td>-0.05</td>
<td>-0.08</td>
</tr>
<tr>
<td>(0.11)</td>
<td>(0.11)</td>
<td>(0.14)</td>
</tr>
<tr>
<td>Structural integration</td>
<td>0.57∗</td>
<td>1.37∗</td>
</tr>
<tr>
<td>(0.35)</td>
<td>(0.81)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>Acquisition experience × Structural integration</td>
<td>-0.07</td>
<td></td>
</tr>
<tr>
<td>(0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquirer size</td>
<td>-0.11</td>
<td>-0.14</td>
</tr>
<tr>
<td>(0.46)</td>
<td>(0.42)</td>
<td>(0.44)</td>
</tr>
<tr>
<td>Acquirer R&amp;D intensity</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>(0.1)</td>
<td>(0.11)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>Acquirer number of employees</td>
<td>-8.4 e-6</td>
<td>1.6 e-5</td>
</tr>
<tr>
<td>(3.8 e-5)</td>
<td>(3.5 e-5)</td>
<td>(3.8 e-5)</td>
</tr>
<tr>
<td>Technological overlap</td>
<td>0.24</td>
<td>0.27</td>
</tr>
<tr>
<td>(0.48)</td>
<td>(0.53)</td>
<td>(0.55)</td>
</tr>
<tr>
<td>Acquired firm age</td>
<td>-0.08∗</td>
<td>-0.07∗∗</td>
</tr>
<tr>
<td>(0.04)</td>
<td>(0.03)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Acquired firm number of employees</td>
<td>-0.001</td>
<td>-0.002</td>
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<tr>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
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<tr>
<td>Acquired firm pre-citations</td>
<td>0.02***</td>
<td>0.02***</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.005)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Acquired firm current innovativeness</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Acquired firm prior stock of patents</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>(0.03)</td>
<td>(0.02)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Time</td>
<td>Exposure</td>
<td>Exposure</td>
</tr>
<tr>
<td>N</td>
<td>97</td>
<td>97</td>
</tr>
<tr>
<td>LL</td>
<td>-109.9</td>
<td>-106.3</td>
</tr>
<tr>
<td>Wald χ²</td>
<td>115.0***</td>
<td>111.1***</td>
</tr>
</tbody>
</table>

*** p < 0.01; ** p < 0.05; * p < 0.1

we assume that structural integration moves the configuration of organizational attributes towards an emphasis on coordination over autonomy (Figure 2), but assume away the possibility that over time the disruption effects may get weaker or the coordination effects could get stronger. If this assumption is invalid, we could well find that over time the effects we found may weaken or disappear. To assess how stable the effects of structural integration are over time, we re-estimated the main-effects models for the impact of structural integration in Table 3 with an interaction term between structural integration and the time period over which we observed patenting activity for each firm. If over time the loss of autonomy or coordination effects weakened/strengthened significantly, then we would expect significant interaction terms. We find that the interaction term between time and structural integration is not significant for capability leverage, but positive and significant for knowledge leverage.

Thus we conclude that there is no evidence that the disruption effects arising from the loss of autonomy following structural integration weaken significantly over time. This is quite consistent with our view of the loss of autonomy effect as a long-term effect due to the demotivation of key inventors and the disruption of productive routines that tie them to each other, rather than a short period of lowered productivity after the acquisition. In contrast, we find that the effect of structural integration on knowledge leverage strengthens over time, suggesting that the coordination effect becomes even stronger over time, leading to even greater knowledge leverage in later periods than would be apparent from examining the average effect of structural integration over the entire time period (as we did in testing Hypothesis.
Thus accounting for time-varying effects of structural integration does not alter our basic results and conclusions.\(^2\)

We reported the results for the fixed-effects models as the Hausman test suggested that they were preferable to a random-effects model in some cases; however, despite the Hausman test indicating differences in the vector of covariates across the fixed- and random-effects models, we found that the coefficients of interest to us (i.e., those tested in Hypotheses 1–4) are in fact qualitatively identical in the fixed- and random-effects models, and are estimated more precisely in the latter. This lends additional confidence to our conclusions.

We also re-estimated our models with a number of alternative measures. First, we included alternative measures for target quality including number of citations obtained by the target firm’s patents from firms other than the acquirer prior to acquisition, the number of citations received from the acquirer prior to acquisition, and the dollar value per employee paid by the acquirer for the target. We also used measures of capability and knowledge leverage that restricted patent counts to only ‘pure’ capability and knowledge leverage. In Figure 3 this corresponds to excluding patents that indicated both knowledge and capability leverage (cell A) in measures of knowledge leverage, for instance. We obtain qualitatively similar results from these specifications. Second, we also conducted a number of checks to identify outliers and influence points, including constructing ‘bootstrapped’ standard errors and coefficients and examining residuals in linear versions of our specifications. We could not identify any individual observations that significantly altered the results. Third, by estimating fixed effects for acquirers, we are implicitly controlling for industry differences between IT and pharmaceuticals. However, we also assessed the extent to which our results vary across these two industries. We therefore constructed interaction terms with all variables in the model and a dummy variable for industry. We find that there is no impact of industry on the effect of structural integration on knowledge or capability leverage.

\(^2\) We thank an anonymous referee for suggesting this analysis.

DISCUSSION

The results of this study indicate that acquirers can leverage technology acquisitions in two qualitatively distinct ways; they may leverage the existing knowledge of the acquired firm (‘what they know’) and/or its capabilities for ongoing innovation (‘what they do’). Structural integration has a negative impact on the acquirer’s attempts to leverage innovative capabilities, but has a positive impact on the leveraging of existing knowledge. Our results are consistent with the theory we propose that these two leverage processes have distinct organizational antecedents—the optimal mix of coordination and autonomy is distinct in the two cases, and structural integration shifts the balance in favor of coordination over autonomy. We also find that the acquirer’s acquisition experience alleviates the adverse consequences of structural integration on the acquirer’s efforts to leverage innovation capabilities, but do not find any evidence that prior experience enhances efforts to leverage knowledge. This suggests that in terms of long-term performance consequences (rather than efficiency of the integration process itself) acquisition experience may primarily be useful in mitigating the loss of autonomy effect rather than strengthening the coordination effect. We discuss the implications of our results for research and practice, as well as limitations and scope for further research.

Implications for research and practice

This study helps to shed new light on the integration paradox in technology acquisitions. Rather than focusing on the conflicting effects on all leveraging activities, we show that structural integration has different effects on qualitatively different forms of leveraging activities. These findings suggest several implications for research on technology acquisitions in particular, and technology sourcing relationships in general.

First, this study suggests that organizational arrangements necessary to leverage existing knowledge may be incompatible with those necessary to leverage capabilities for ongoing innovation. Acquisition management practices that encourage innovation outcomes from capability leverage are likely to do so at the cost of reduced innovation from knowledge leverage, and vice versa. This argument is particularly clear in the case of structural integration, which is essentially a discrete
choice about post-acquisition organizational form. While other formal coordination mechanisms such as process overlays, compensation systems, and the standardization of procedures are not as discrete as structural integration choices, the existence of complementarities between elements of an organizational form creates natural limits to the extent to which discreteness in organizational alternatives can be overcome (Gersick, 1991; Ghemawat and Costa, 1993; Milgrom and Roberts, 1990; Nickerson and Zenger, 2002; Williamson, 1991). A related implication is that post-acquisition innovative activity is likely to be dominated by whichever mode of technology leverage that the post-acquisition organizational form supports: observed inventive activity will correspond primarily to capability leverage or knowledge leverage, but is unlikely to be characterized by balanced levels of both activities. In our sample, we find some evidence in favor of this argument. We performed t-tests with the null hypothesis that the number of patents from capability leverage and knowledge leverage are the same in each acquisition. The t-test shows that the number of patents corresponding to knowledge and capability leverage are different from each other on average ($p < 0.05$).

Our theory and analysis reflect to some extent the well-known trade-off between exploration and exploitation in organizational learning (March, 1991). From the acquired firm’s perspective, knowledge leverage may be seen primarily as an exploitation of its current knowledge base, whereas capability leverage involves exploration of new opportunities through ongoing innovation. The different organizational antecedents of exploration and exploitation, and the difficulties of reconciling them, have been recognized in other contexts (Benner and Tushman, 2003; Ghemawat and Costa, 1993; Siggelkow and Levinthal, 2003). Our analysis can be seen as linking post-merger integration strategies to specific forms of exploration (capability leverage) and exploitation (knowledge leverage). This interpretation treats the difference between exploration and exploitation primarily in terms of the degree to which the use of existing knowledge vs. the pursuit of ongoing innovation is emphasized. However, an alternative perspective is also feasible, if exploration and exploitation are viewed primarily in terms of local vs. more distant search in the opportunity space. Both knowledge and capability leverage can be seen as exploratory search from the perspective of the acquirer, as either form of leverage may generate innovations that are distinct from the acquirer’s existing technological trajectory (Dosi, 1982, 1988; Nelson and Winter, 1982). Conversely, either may be exploitative if the technology trajectories of the two firms are related. Thus, from the acquirer perspective, knowledge and capability leverage do not necessarily correspond to exploitation and exploration, as either form of leverage is consistent with both local and distant technological search (Rosenkopf and Almeida, 2003).

Second, our findings also indicate the important and different roles played by acquisition experience in influencing the coordination and loss of autonomy effect. Our results suggest that experience had a positive moderation effect on the link between integration and capability leverage, implying that acquirers with experience can mitigate the disruptive consequences of the loss of autonomy resulting from structural integration. However, we found no moderation effects for knowledge leverage. This suggests that the value of experience in acquisitions arises primarily from managing the loss of autonomy effect, rather than enhancing the coordination effect. This also suggests a broader insight—experience effects may be most significant in acquisitions where autonomy preservation is critical but some degree of integration is unavoidable (Zollo and Singh, 2004).

Third, this study points to the importance of being precise about exactly what is being leveraged in inter-firm technology sourcing relationships. Leveraging existing knowledge may involve knowledgeable individuals teaching others ‘what they know’—through a process of knowledge transfer or capability replication (Szulanski, 1996). However, leveraging the innovative capabilities of individuals and teams may involve the utilization of their creative outputs as they continue to do ‘what they do’ rather than having them teach their creative skills to others. Huber (1991) and Puranam (2001) make similar observations about the benefits of transferring knowledge vs. ‘grafting’ on knowledgeable employees. Our analysis extends these theoretical observations by showing how the success of these different leverage mechanisms can be measured (through citations and authorship patterns in patenting), and also developing and testing a theoretical framework about their distinct and incompatible organizational antecedents. A related implication of our
results for researchers is that they must specify innovation performance more accurately in empirical work on technology acquisitions, as lumping together inventive activity from capability leverage and knowledge leverage may not yield any effects for organizational variables like structural integration. The absence of effects may in fact disguise two offsetting effects.

Fourth, the findings of this study also draw managerial attention to an important choice: managers should form clear ideas regarding whether the potential for future innovation from an acquisition is likely to be derived from leveraging capability or knowledge. Based on this decision, managers should plan their acquisition integration strategies accordingly to maximize the innovation returns from acquisitions.

**Limitations and scope for further research**

Several limitations of this study are worth noting. Patents have both significant strengths and weaknesses as measures of innovative outputs, which have been extensively discussed in prior literature (Caballero and Jaffe, 2002; Jaffe et al., 2002). Clearly, our study suffers from the same weaknesses and benefits from the same strengths as other studies that rely on patenting data. Of concern is the specific critique that citations are a noisy measure of knowledge flow, since they could also be used to delineate the rights of the present patent from that of other closely related patents. Citations could also be introduced by patent examiners, rather than by the inventors (Trajtenberg, 1990). In our setting, we expect the ‘noisiness’ of citations is of less concern because both the citing patent and the cited patent belong to the same legal entity. Hence, it is more likely that the firm would be aware of the existence of relevant prior art.

Using patent data limits our ability to draw any conclusions about the eventual commercial success of innovations arising from acquisitions. We have therefore been careful to draw inferences only about the success of acquirers at leveraging the existing knowledge and capabilities of acquired firms, and have not discussed their success at innovation per se. Although patenting is an imperfect indicator of innovation in general, it does represent a fairly reliable indicator of efforts at innovation (Hausman et al., 1984) in industries with strong appropriability regimes (Klevorick et al., 1995; Teece, 1986). As regards the two industries that comprise our sampling frame, there is strong consensus in the literature that patenting is an indicator of innovations in the IT hardware and pharmaceutical industries (Cohen et al., 2000). Future studies could utilize alternate measures of innovation especially when generalizing to industries without strong intellectual property regimes, where patents may not be a meaningful indicator of innovation.

Our analysis has also been confined to studying the effect of structural integration on innovation outcomes conditional on acquisition, rather than the effect of acquisition on innovation outcomes (e.g., Ahuja and Katila, 2001). In future studies, it may be useful to analyze the effect of acquisition on the continued productivity of inventors or in the utilization of their knowledge in innovation activity (e.g., Ernst and Vitt, 2000). Further, we have focused on only one aspect of post-acquisition structural form—structural integration—whose discrete nature throws the tradeoff between knowledge and capability leverage into sharp relief. We have argued that additional coordination mechanisms like process overlays and linking mechanisms primarily elaborate and reinforce the fundamental decision about post-acquisition organizational structure (Hassenplag and Jemison, 1991). Nonetheless, we believe that further research that explores the limits of using process overlays and other formal coordination mechanisms to compensate for the discrete nature of organizational grouping choices in acquisitions will prove valuable in understanding the issues in this study.

Finally, our analysis stops short of leading to conclusions about causation. While we are able to control for unobserved features of acquirers (through fixed effects) that may induce spurious correlations between structural integration and innovation outcomes, we cannot econometrically rule out the possibility that other unobserved features of the transaction, such as the culture, structure, or technological properties of the acquired firm may have influenced both structural integration and innovation outcomes in a manner that spuriously induces a correlation between the two.\(^3\) However, we feel confident about the basic

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\(^3\) Accounting for such unobservable transaction features through Heckman-style endogeneity corrections requires the availability of a good instrumental variable; we could not find a satisfactory one in our data. In addition, this approach is computationally
validity of our results for two reasons. First, we believe we have controlled for plausible alternate explanations through control variables for the acquired firm’s age, size, pre-acquisition technological quality, technological activity, and similarity to acquirer. We believe these variables should be correlated with important features of acquired firms that we cannot directly observe, such as culture, leadership, structure, and technological properties. Second, we are comforted that our hypotheses are supported across different model specifications with different dependent variables (knowledge and capability leverage) and with moderation effects. It seems difficult to suggest a plausible alternative explanation that accounts coherently for all of these effects.

CONCLUSION

Scholars interested in the specific mechanisms through which firms use acquired knowledge and capabilities have often relied on fieldwork and qualitative data (Haspeslagh and Jemison, 1991; Leonard-Barton, 1992, 1995; Ranft and Lord, 2002; Schweizer, 2005). While the richness of case data is undisputed, they typically play a limited role in testing rather than inducing theoretical arguments. Patenting activity provides a reliable if not rich record of the knowledge flows characterizing inventive activity, a feature that has been extensively used in studies on inter-firm technology transfer (Almeida and Kogut, 1999; Almeida et al., 2002). However, studies based on patent data have typically been agnostic to the organizational antecedents of observed patenting behavior. Our study combines the analysis of inventive activity and its organizational antecedents. We thus contribute to the literature on how firms acquire, use, and generate new knowledge by refining and complementing existing theory derived from case-based inductive research as well as patent-based analysis of inter-firm technology transfer (Almeida and Kogut, 1999; Leonard-Barton, 1985; Ranft and Lord, 2002; Song et al., 2003). By clarifying the conceptual and empirical distinctions between leveraging knowledge (‘what they know’) and leveraging capabilities (‘what they do’), we hope to have helped refine future theorizing and empirical analysis of these important phenomena.

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