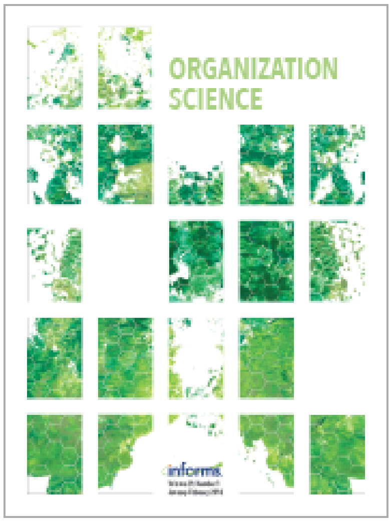

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Acquisition Integration and Productivity Losses in the Technical Core: Disruption of Inventors in Acquired Companies

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Acquisition integration is a pivotal factor in determining whether the objectives of an acquisition are achieved. In this paper, we hypothesize that the productivity of corporate scientists of acquired companies is generally impaired by integration, but that some scientists experience more disruption than others. In particular, acquisition integration will be most disruptive, leading to the most severe productivity drops, for those inventors who have lost the most social status and centrality in the combined entity. Drawing from prior literatures on the knowledge-based view of the firm, and on mergers and acquisitions, we develop hypotheses about a concise set of conditions that will lead to substantial performance drops for acquired technical personnel. We test our hypotheses, using patent application data, on a sample of 3,933 inventors in pharmaceutical firms whose companies were acquired. Results are strongly in line with our theorized expectations.

Key words: acquisition; integration; inventors; productivity; routines

Acquisitions continue to be a prominent vehicle for corporate growth and development, despite evidence that, on average, they reduce the shareholder value of acquiring firms (Aley and Siegel 1998; Berkovitch and Narayanan 1993, Jarrell et al. 1988). As part of the effort to comprehend the generally negative consequences of acquisitions, several studies have examined the effects of acquisitions on technological innovation, generally finding that innovation rates decline after acquisitions (Hitt et al. 1990, 1991). The explanations for these drops in innovative outputs have centered primarily on strategic factors, particularly the tendency for companies to use acquisitions as substitutes for organic development, thereby reducing their commitment to research and development (R&D) spending and internal innovation (Chatterjee 1986, Hitt et al. 1996).

What has not yet been considered is that acquisitions—or at least some acquisitions—are directly disruptive for technical personnel in acquired firms, causing their performance to suffer. Like many other types of knowledge workers, corporate scientists and engineers develop socially embedded routines for conducting their tasks (Drucker 1999, McFadyen and Cannella 2004, Nerkar and Paruchuri 2005). When the context that supports those routines is disrupted, as occurs with many acquisitions, these personnel can be expected to experience a sense of dislocation, loss, even trauma, and their productivity may suffer. Interestingly, organizational scholars have devoted considerable attention to empirically examining how being acquired affects top executives, particularly by examining their departure rates (Cannella and Hambrick 1993, Lubatkin et al. 1999, Walsh 1989), but far less attention has been directed toward comprehending the factors that affect the degree of disruption and productivity loss in the technical core of acquired firms, where knowledge work is actually done. In this paper, we adopt the perspective of the knowledge worker, in particular the corporate inventor, in theorizing about the effects of acquisitions on innovative productivity.

One of the central dilemmas in managing acquisitions—and perhaps the pivotal factor in affecting employee disruption—is the decision about whether to integrate the newly acquired firm and the acquiring firm (Ranft and Lord 2002, Risberg 2001). If the acquired firm is not integrated, but instead is allowed considerable autonomy, there is little chance that any knowledge sharing or other forms of synergy will occur (which is in most cases the original reasons for the acquisition). Moreover, if allowed autonomy, the acquired firm will not create much more value than it would have created on its own, and the premium paid by the acquirer will have been wasted (Puranam et al. 2003, Sirower 1997).

(Essentially all acquisition prices substantially exceed the prebid market values of the targets [Hayward and Hambrick 1997].) On the other hand, if the acquired firm is integrated, there is a heightened risk of organizational trauma, and an increased likelihood that the very resources that were so attractive in the acquired firm will be damaged or destroyed (Zollo and Singh 2004). Indeed, as we shall later discuss in depth, the literature on acquisition integration has provided considerable qualitative evidence that acquired entities experience a greater sense of disruption and loss when they are integrated with their acquirers than when they are not (Puranam et al. 2006). Clearly, decisions about acquisition integration are both important and difficult. After many years of exploring the issue of acquisition integration (dating at least to works by Salter and Weinhold 1978 and Pitts 1977), researchers still have not resolved the pros and cons of this important managerial decision (Ranft and Lord 2002).

There would seem to be two possible pathways for advancing insights about the benefits and costs of acquisition integration. One approach is to examine the various forms and nuances of acquisition integration that are available, in the hopes of learning how they differentially affect acquisition outcomes. In this vein, for instance, Shrivastava (1986) distinguished between three levels of integration: procedural, physical, and sociocultural. Similarly, Haspeslagh and Jemison (1991) discussed the implementation issues that can affect how disruptive integration will be.

A second alternative, and the one we pursue here, involves turning the question around by asking, which knowledge workers will be most negatively affected by acquisition integration? We consider the unexplored idea that acquisition integration is not uniformly disruptive or traumatic for all technical employees. Drawing from earlier acquisition integration research, we argue that integration causes substantive and social disruption that will—in general—negatively affect innovative outputs (Homburg and Bucerius 2005, Prabhu et al. 2005). Then, drawing from the knowledge-based view (KBV), we posit that some knowledge workers will experience greater substantive and social strain from integration than will others. Specifically, the KBV provides a foundation for portraying the routines of knowledge workers as socially embedded (Grant 1996, Nickerson and Zenger 2004, Tyre and von Hippel 1997). From this literature, we know that knowledge workers, even the most cosmopolitan of them, come to rely on an intricate, path-dependent context for doing their work; to the extent that that context is disrupted—substantively or socially—the knowledge worker's productivity is jeopardized (Ranft and Lord 2000, 2002). We posit that acquisition integration is most damaging to these knowledge workers who lose the most social status and centrality. In the absence of integration, an inventor's loss of status and centrality is a nonissue, because the acquired entity retains its distinct, separate identity and social structure. After integration, however, those who were previously socially lofty and central are the ones who stand to lose the most. These include inventors who have lost relative stature, those whose expertise is peripheral for the acquirer, and those who had extensive collaborative relationships in the preacquisition company. Namely, it is those inventors who suffer the greatest loss of status and centrality on being acquired who will experience, in turn, the greatest disruption—both substantively and socially—from integration with the acquirer. The irony, of course, is that these may be precisely the inventors on whom the acquirer is counting to make the acquisition worthwhile. However, by undertaking integration, the acquirer disproportionately disrupts these valuable technical resources.

We test our theory in the pharmaceutical industry, a setting in which innovation is strategically essential (Grabowski and Vernon 1992, Levin et al. 1987, Scott Morton 2000) and in which acquisitions are often made with the express aim of obtaining new technological wherewithal (Ahuja and Katila 2001, Grandstand et al. 1992, Link 1988, Wysocki 1997). Using data on patent applications, we track the productivity of 3,933 inventors in 62 acquired companies. We find considerable support for our hypotheses, based on multiple measures of postacquisition productivity of inventors. First, we find that the hypothesized factors are highly related to the likelihood that the acquired inventors cease patenting at all for the newly combined companies (reflecting an unobserved combination of involuntary departure, voluntary departure, and output reduced to zero). Second, in a more stringent test of our theory, we find that the hypothesized factors are strongly associated with reduced productivity of those acquired inventors who continue to patent at the combined firms, finding that our hypothesized factors are associated with reduced innovative outputs, as measured both by simple patent counts and citation-weighted patent counts in the postacquisition period.

By considering the idea that acquisition integration has differential effects on different subsets of employees, we open up a line of thought that can lead to new theoretical and practical insights. Theoretically, our paper adds a new perspective on advancing KBV research by examining the effectiveness of resources under changing conditions. Namely, some employees become ineffective at generating innovations on integration, while others experience only marginal effects from integration. Moreover, although Schweiger et al. (1987) introduced the idea that acquired employees may differ greatly in how they feel about being acquired (including whether they see it as an opportunity or a threat), researchers have not incorporated this premise into subsequent thinking about acquisitions. Our paper thus adds a new element to eventual understanding of why many acquisitions do not achieve their hoped-for results (Agrawal et al. 1992, Hayward and Hambrick 1997, Jemison and Sitkin 1986, Ravenscraft and Scherer 1988).

At a practical level, our line of thought might lead acquirers to assess the profiles of employee populations of target companies to decide whether or not integration would take a large toll on innovative productivity. At a more fine-grained level, acquirers who choose to integrate their acquisitions might be able to design targeted programs to minimize the trauma for those employee subgroups who are most vulnerable to disruption. In short, our approach may open up a new stream of research and practical ideas based on the premise that integration does not have a uniform, homogeneous effect on an acquired employee population. Instead, some employee subgroups may be severely negatively affected, some might be relatively unaffected, and some (although not addressed by our specific hypotheses) might even be positively affected by integration.

Background and Theory

Knowledge Creation as an Embedded, Path-Dependent Process

Over the past 20 years, scholars have had great interest in how a firm's resources allow it to achieve and sustain competitive advantage (Barney 1991, Teece et al. 1997, Wernerfelt 1984). Recently, theorists have shown particular interest in the role of a specific type of resource—knowledge—in enhancing firm advantage and performance, giving rise to the KBV of the firm (Berman et al. 2002, Grant 1996). One of the essential themes of the KBV is that the most valuable forms of knowledge are developed and exploited through highly embedded, path-dependent processes that are difficult to imitate (Dosi 1982, Nelson and Winter 1982). For example, researchers have concluded that firms that try to quickly match the complex knowledge that resides in other firms will encounter trouble in doing so due to "time-compression diseconomies" (Dierickx and Cool 1989, p. 1507).

If knowledge creation within a firm is a gradual, path-dependent process, then it follows that the knowledge workers in the firm similarly become accustomed to, and even dependent on, the elements of that process (Swart and Kinnie 2003). The firm develops routines (Nelson and Winter 1982), which in turn form the context in which the knowledge worker carries out her own routine. As Polanyi (1962) commented, "the aim of a skillful performance is achieved by the observance of a set of rules which are not known as such to the person following them" (p. 49). A similar view is advanced by the capabilities literature, which suggests that firm capabilities amount to recombination and integration of lower-level routines (Teece et al. 1997).

Tacit knowledge resides not only within individuals, but also in the complex pattern of relationships within a firm (Brown and Duguid 2001, Reed and Defillippi 1990). When individuals repetitively execute their activities, idiosyncratic networks of relationships are built over time. Moreover, the tacit knowledge generated in this process of repetitive execution is assimilated into the scientists' routines (Kogut and Zander 1992).

Thus, knowledge workers come to rely on a reliable, trusted context for doing their work. This context includes physical settings, formal and informal procedures, monitoring and control systems, colleagues, and so on (Pentland 1992, Szulanski 1999). We can envision some of the major elements that typically comprise the routines of individual innovators involved in such efforts: submitting research proposals and updates, supervising technicians, calibrating equipment, keeping data logs, accessing and reviewing scientific journals, discussing ideas and progress with colleagues and supervisors, and so on. Following Cohen et al. (1996), we anticipate that individual inventors arrange these various elements into comfortable, entrenched patterns through repetition and reinforcement.

Research Context: Scientists in Pharmaceutical Firms

The pharmaceutical industry is characterized by intense competition that has at its core continual drug discovery (Bogner et al. 1996). A pipeline of drugs is dependent to a large extent on the R&D capabilities of the firm (Cockburn et al. 2000). Pharmaceutical companies patent every idea possible, as their profit-making ability is dependent on their ability to retain competitive advantage derived from any innovation developed by them (Nerkar and Roberts 2004). While individual R&D skills are rarely available on the market and need to be cultivated over time within the firm (Dierickx and Cool 1989), companies sometimes resort to acquisitions to obtain the scientific capabilities of other organizations (Ruckman 2005).

Pharmaceutical research is a recombinant process that depends on the expertise of individuals who are highly trained, with doctorates or advanced degrees in biochemistry and pharmacology (Thomke and Nimgade 1998). The skills and capabilities employed by these scientists are generally nontransferable, tacit, and in most cases area specific (Thomke and Kuemmerle 2002). For instance, a scientist researching cures for cancer typically spends a lifetime in this area and is unlikely to shift to other areas of research.

An important distinction between research done by scientists employed by pharmaceutical companies and research done by scientists in other industries is the time delay involved in moving a drug project from idea to launch. A typical drug takes from eight to 13 years and more than $800 million to develop and launch (Thomke and Nimgade 1998). This, in conjunction with the area-specific skills of scientists, leads to substantial immobility of scientists working in the pharmaceutical sector. Therefore, scientists in acquired companies do not face a fluid job market that they can tap if they are acquired. Moreover, research teams in pharmaceutical labs tend to endure over relatively long periods, at least as evidenced by the persistence of coauthorship patterns over time (Cockburn and Henderson 1998).

Furthermore, pharmaceutical companies have widely differing corporate cultures and incentive structures. For instance, one company might reward its scientists for generating refereed articles, while another might reward its scientists for their patenting efforts (Galambos and Sturchio 1998). Such differences in organizational arrangements can prove to be very disorienting if a scientist who is accustomed to a certain company philosophy is acquired and placed under the aegis of a very different philosophy (Henderson and Cockburn 1994).

The motivational drivers of scientists are generally considered to be the puzzle (curiosity), the ribbon (recognition), and the gold (reward) (Dietz and Bozeman 2005, Stephan and Levin 1992). For pharmaceutical scientists, the puzzle is evident in their academic training and their joining organizations who recruit on the basis of sophisticated problem-solving skills. Recognition and rewards play a major role in the motivation of pharmaceutical scientists (Dietz and Bozeman 2005). While recognition for scientific efforts emerges from academic publications and professional acclaims, local stature and prestige within one's own company or laboratory is also important (Stern 2004). Because patents represent a widely recognized currency for determining scientific accomplishment, great care is taken to ensure that credit, in the form of patent coauthorships, is bestowed on the parties who are reasonably involved in developing a breakthrough (O'Brian 1996).

Acquisition Integration and the Disruption of the Knowledge-Creation Context

A substantial body of literature has described the challenges in creating value from acquisition integration (Haspeslagh and Jemison 1991, Sirower 1997). This prior work has identified two forms of disruption that occur with integration. First, acquisition integration causes disruption in the task environment because of substantive incompatibilities (Buono et al. 1985, Cartwright and Cooper 1992). Studies have noted the challenges of combining incompatible company cultures (Nahavandi and Malekzadeh 1988, Schein 1985), national cultures (Calori et al. 1994), human resources policies (Buono and Bowditch 1989, Marks and Mirvis 1985), and even elements as mundane as information systems (Gracomazzi et al. 1997, McKiernan and Merali 1995). Generally, the acquiring company's characteristics are seen as the prevailing standard, and members of the acquired firm are expected to adopt them to some degree (Jemison and Sitkin 1986, Sales and Mirvis 1984).

Second, acquisition integration also exacerbates disruption of the social context by creating an aura of conquest (Hirsch 1986), with resulting feelings of dominance and submission, and superiority and inferiority. Those in the acquired firm correspondingly experience humiliation, loss, and anger (Hambrick and Cannella 1993, Lubatkin et al. 1999), which can set off a downward spiral of erratic behavior, increased intrusions from the acquirer, and so on. The acquired employees may feel a culture shock, loss of identity, and feelings of hostility toward the acquiring firm whose policies and norms they are expected to adopt (Buono et al. 1985, Schweiger and Denisi 1991). Research on departures of acquired executives strongly indicates that integration aggravates conditions for those acquired (Hambrick and Cannella 1993, Lubatkin et al. 1999, Walsh 1988).

The disruptions that result from being integrated are expected to influence postacquisition productivity of technical personnel (Ernst and Vitt 2000, Ranft and Lord 2000). As discussed above, corporate inventors rely on an intricate organizational and social context for executing their routines (Nelson and Winter 1982). This context involves familiar physical settings, colleagues, communication flows, norms, and emotional support (Keller 1986). Even though scientists might be thought of as relatively cosmopolitan—given their identification with their scientific disciplines and their external networks of exemplars and colleagues—they still rely substantially on an elaborate local support system (Pelz and Andrews 1976).

When a company is integrated, there is considerable potential for the knowledge-creation context to be disrupted.[1] This disruption can occur through the concrete changes that confront the scientists—possibly new colleagues, new policies, new reporting relationships, new organizational values, and even, in some instances, new work locations—as well as through the social upheaval that causes emotional strain, sense of loss, and distraction that accompanies a takeover (Buono and Bowditch 1989, Levinson 1970). Acquired firms that are integrated with the acquirer's operations are required to adopt either the acquirer's procedures or a hybrid approach (Haspeslagh and Jemison 1991). This imposition of new procedures directly disrupts inventors; their familiar support systems are erased, replaced by new, alien systems (Haspeslagh and Jemison 1991, Zollo and Singh 1998).

Beyond these direct task disruptions that occur with integration, there is the potential for significant social disruption, as well. Removal of autonomy creates a sense of loss and failure in acquired entities (Bleeke and Daniels 1985, Siehl et al. 1990); moreover, the elimination of a familiar support system can be disorienting and traumatic (Elsass and Veiga 1994). Integration also can lead to power struggles within the newly combined units, which in turn can lead to substantial turmoil, stress, and a drop in productivity (Kenneth and Singh 1993). Thus,

Hypothesis 1. *Inventors in acquired companies that are integrated with acquiring companies will produce fewer innovations after being acquired than will inventors in acquired companies that are not integrated.*

Inventors Who Experience the Greatest Disruption from Integration

Being acquired, and then integrated, is expected to have a generally negative effect on the productivity of inventors, but the effects will be more substantial for some inventors than others. Specifically, we can anticipate that those acquired scientists who had the highest social standing and centrality in their preacquisition companies are the ones who stand to experience the greatest disruption of their routines if they are integrated with their acquirers. The inventors who experience disproportionate disruption include those who lose a great deal of relative standing, those whose expertise is peripheral to the acquirer, and those who were most socially connected in collaborative relationships in their preacquisition companies.

Inventor's Loss of Relative Standing. When a company is acquired, its members are subsumed by a larger entity. In addition, however, individual members may lose status within their peer group. Frank (1985) introduced the concept of *relative standing* to describe an individual's status relative to others in a proximate social setting. He used relative standing to explain the tendency for low-status individuals in a group to capture rewards out of proportion to their contributions—as compensation for being at the bottom of the social order. Similarly, high-status individuals give up some of the economic returns that are due to them for the satisfaction of having others below them in status. Thus, Frank used the concept of relative standing as a way to explain the trade-off between being a big frog in a small pond or a small frog in a big pond. As noted earlier, the concept of relative standing has been drawn on to explain departures of executives from acquired firms (Hambrick and Cannella 1993, Lubatkin et al. 1999), but its relevance for understanding social dislocation encountered by acquired inventors may be even more apt.

Consider a scientist who is the most productive inventor in his entire company and who, accordingly, has substantial local status and influence. Now assume that this company is acquired and integrated with another firm that has a number of inventors who are far more productive than anyone in the acquired company, including our scientist who was previously a star. Although one might anticipate that he will benefit from the intellectual association with his new superstar colleagues in the acquiring firm, and be enthusiastically received by his new colleagues because of his prior productivity, the logic of relative standing leads to a different prediction. Previously highly regarded by his superiors and peers, now he is in the middle of the pack and of only moderate status. He is now a smaller frog in a bigger pond.

The inventor who loses a great deal of relative standing will no longer have the same degree of influence over substantive matters that she previously enjoyed, and perhaps more importantly, she will not have the same degree of stature and social standing that she once had. Employees view being acquired as major life changes that trigger stress and insecurity (Buchholtz et al. 2003), but those who experience considerable social diminishment, or relatively great loss in the social pecking order, will be especially disoriented and negatively affected by acquisition.

We expect the disruption that is experienced by the inventor who has lost relative standing to be salient only if the acquired firm is integrated with the acquirer. With integration, the previous star is directly confronted with his loss of stature. He must now abide by policies and protocols that are alien and perhaps uncomfortable; in the preacquisition company, he would have had substantial influence over such matters (Buchholtz et al. 2003). Moreover, with integration, the previous star regularly encounters his new colleagues of higher stature, who most likely treat him with less esteem than he has been accustomed to Siehl et al. (1990). Thus,

Hypothesis 2. *The interaction between acquisition integration and an inventor's loss of relative standing will have a negative effect on subsequent productivity. Specifically, under conditions of acquisition integration, the more relative standing an inventor loses on being acquired, the fewer the innovations produced after acquisition.*

Inventor's Divergence from Acquirer's Expertise. Some acquired inventors specialize in the same scientific domains as the acquiring firm's inventors, and others have expertise that is divergent and unfamiliar to the acquirer. Although some acquisitions are undertaken precisely because the technological strengths of the two firms differ (Arora and Gambardella 1990), acquired inventors whose expertise differs from the acquirer will encounter disproportionate disruption, due to both substantive and social forces.

R&D processes are known to be stochastic, complex, and uncertain (Nelson and Winter 1982). Most scientists work in highly specialized domains, and a considerable familiarity with their respective fields is necessary in order to understand the scientists' protocols, progress, and performance (Winter 1987). Similarly, firms have procedures and norms in place that suit their areas of expertise (Sutton 1991). When there is a mismatch between the acquiring firm's expertise and an acquired inventor's expertise, we can anticipate that the procedures of the acquirer will be ill-suited to the inventor (Krishnan et al. 1997). This mismatch of expertise centrality will lead to errors in supervising, motivating, and evaluating the inventor.

The divergent inventor suffers social disruption, as well. The human tendency to place people into categories based on personal or professional characteristics is well established (summarized in Williams and O'Reilly 1998). Individuals trust, respect, and are attracted to others who they perceive to be like themselves (e.g., O'Reilly et al. 1989). They see those who are different as less attractive, less honest, and less competent (Hoffman and Hurst 1990, Kramer 1991, Tsui et al. 1992). Although research has focused primarily on demographic dimensions (Tajfel 1982), categorization also has been shown to occur on professional dimensions, including functional backgrounds and education (Brewer 1979, Pelled 1996). Similarly, categorization can be expected to occur on the basis of an inventor's expertise. An inventor whose expertise matches that of the acquiring firm's core expertise will feel, and will be made to feel, integral and included, which will affect her productivity. In contrast, an inventor whose expertise does not match the acquirer's core expertise will feel, and will be made to feel, peripheral and excluded (Wagner et al. 1984), even if the acquirer may have been intent on obtaining this inventor's complementary capabilities. Furthermore, inventors who lose their expertise centrality will also face ambiguity about funding and continuity of their research areas, which leads to stress and insecurity (Sinetar 1981).

Here again we can expect that the divergent inventor will only experience disruption if the acquired unit is integrated with the acquirer. Integration causes the imposition of policies, procedures, and supervision that will be ill-suited for the divergent inventor. Integration brings about the commingling of acquired and acquiring company personnel, which in turn creates the conditions by which the divergent inventor will experience a sense of social exclusion and marginalization among his new peers. Therefore, we posit the following interaction hypothesis:

Hypothesis 3. *The interaction between acquisition integration and an inventor's divergence from the acquirer's expertise will have a negative effect on subsequent productivity. Specifically, under conditions of acquisition integration, the greater the inventor's divergence from the expertise of the acquirer, the fewer the innovations she will produce after acquisition.*

Inventor's Preacquisition Social Embeddedness. The valuable knowledge within a firm resides in socially complex interactions and relationships among individuals and groups (Brown and Duguid 2001, Reed and Defillipi 1990). Thus, an inventor need not have know-how about everything to perform his routine; rather, it is enough to know "who knows what" within the firm to perform effectively (Nelson and Winter 1982). While this socially complex knowledge is critical for competitive advantage, it is not uniformly distributed among inventors. Some inventors more than others rely on collaborative relationships; they are relatively socially embedded in their preacquisition company (Nerkar and Paruchuri 2005). These individuals, who have put together extensive internal collaborative networks for executing their routines, will be disproportionately disrupted on acquisition integration.

Collaborative research is inherently complex to conduct and sustain. Collaboration requires intricate coordination and give and take, and above all it requires that multiple parties—not just one or two parties—remain focused on the joint task, and not become distracted or demoralized (Edmondson et al. 2001).

Acquisition integration jeopardizes these properties. Integration injects new policies and procedures, which can disproportionately complicate collaborative efforts (Puranam et al. 2006). Integration often involves the intermingling of acquired and acquiring company inventors, as well as new supervisors, which will tend to undo or disrupt existing collaborative webs (Homburg and Bucerius 2005), and integration, as we have discussed throughout, tends to heighten feelings of anxiety and insecurity (Bleeke and Daniels 1985, Lubatkin et al. 1999, Siehl et al. 1990), thus increasing the likelihood that a subset of previously reliable teammates will be emotionally unavailable for high-quality work (or perhaps even will depart).

The inventor who previously relied on very few others to get her work done will not be as susceptible to these joint disruptions; if she herself remains motivated and ready to proceed, she has a good chance of doing so. However, the inventor who previously relied on numerous others will be negatively affected, even if just a subset of her collaborators are rendered ineffective by acquisition integration. In this vein, Ranft and Lord (2002) concluded from their field research that when knowledge is interwoven in the social fabric of an organization, rather than residing in one or just a few individuals, acquired capabilities are especially fragile and easily disturbed.

Hypothesis 4. *The interaction between acquisition integration and an inventor's preacquisition social embeddedness will have a negative effect on subsequent productivity. Specifically, under conditions of acquisition integration, the greater the inventor's preacquisition social embeddedness, the fewer the innovations produced after acquisition.*

In sum, we have argued that acquisition integration tends to disrupt the routines of corporate inventors, thus reducing their innovative output. However, those scientists who have lost the most stature and centrality by being acquired will suffer the greatest substantive and social disruption on integration. These individuals, in many cases, were probably at the core of the knowledge-creating process in their acquired firms. With integration, though, their productivity will be the most negatively affected. Ironically, then, integration tends to disproportionately damage the most valuable knowledge-creation resources in the acquired firm.

Methodology

Sample

We drew our sample of acquired inventors from the pharmaceutical industry (SIC 2834), for three reasons. First, scientific innovation is strategically essential for pharmaceutical firms (Grabowski and Vernon 1992, Scott Morton 2000), and firms strive to patent every possible innovation (Levin et al. 1987). Second, a significant number of acquisitions have occurred in the pharmaceutical industry in recent decades (Graves and Langowitz 1993), allowing ample observations of the phenomena of interest. Third, acquisitions in this industry are rarely done in order to rationalize industry capacity, but instead to obtain new technical resources or complementary product categories (Arora and Gambardella 1990, Thompson 2001). R&D capabilities are often seen as an essential component of those purchases (Ranft and Lord 2000, Ravenscraft and Long 2000).

We identified all instances in which one pharmaceutical firm (active in SIC 2834) acquired 100% of another pharmaceutical firm or pharmaceutical subunit between the years 1979 and 1994, as indicated by the Securities Data Corporation (SDC). We further limited the selection only to cases in which both the acquiring and acquired companies had at least 10 U.S. patents granted to them in the five years prior to and including the acquisition year, to ensure that we were only studying combinations of scientifically active companies. This process yielded 62 acquisitions.

Because complete employment rosters for these companies were not available, we identified all *productive inventors*, defined as those who had patented with these 62 acquired firms at any time in the five years prior to the acquisition. Using records from the U.S. Patent and Trademark Examiner's office (USPTO), we identified every patent that each acquired company had applied for in the five years prior to being acquired, as well as the name(s) of the inventor(s) associated with each patent. This process yielded a total of 3,933 inventors, which is the sample we analyze.

Dependent Variables and Analytical Techniques

Our dependent construct, postacquisition productivity, was measured in two ways, both of them based on each inventor's patent applications. We examined successful patent applications (not issuances, which can lag considerably) to indicate inventor productivity, following the approach used by numerous other researchers of technical outputs (Achilladelis et al. 1987, Ahuja and Katila 2001, Griliches 1990, Griliches et al. 1986, Narin et al. 1987). As noted above, patents are particularly essential for pharmaceutical firms (Grabowski and Vernon 1992).

For our first measure of productivity, we identified those inventors who continued to patent at all with the newly combined company, as indicated by one or more patent applications in any of the first five years following the acquisition.[2] This variable, known survivors, was coded zero for those who ceased patenting at the firm and one for those who continued patenting. We examined the effects of our hypothesized variables on this binary outcome by using logistical regression, with robust standard errors to account for firm effects (White 1980).

Our other dependent variable, postacquisition productivity of known survivors, was operationalized in two ways, both of them based on the inventor's patent applications. For the first of these operationalizations, patent count, we identified all the known survivors (described above) and counted for each such person the total number of patent applications over the five years following acquisition. For our second operationalization of productivity of known survivors, citation-weighted patent counts, we calculated for each known survivor the sum of citation-weighted patent applications over the five years following acquisition; the weight for each patent was the number of citations it received in the five years following its application date. This measure has the advantage of incorporating an indication of each patent's technical significance (Albert et al. 1991). Because these latter two dependent variables have integer values with very restricted, nonnormal distributions, we tested for the effects of our hypothesized factors on these outcomes using negative binomial regression (Hausmann et al. 1984) (again with robust standard errors based on firms, because there were multiple observations for each firm).

There is a potential sample selection bias in our analysis of productivity of known survivors, because inventors who continued patenting with the firm may have been systematically different from those who stopped. Moreover, this analysis of the productivity of known survivors might be criticized as sampling on the dependent variable. To address these concerns, we used the Heckman's two-stage model (Heckman 1979), which deals with sample selection by including a correction factor, the inverse Mills ratio, calculated from the logistic regression predicting known survivors (first-stage analysis) as a control variable in the analysis of postacquisition productivity of known survivors (second-stage analysis).

Even though our sample consisted only of previously productive inventors, the statistical problem of regression to the mean was not an issue in these analyses, for two reasons. First, our hypotheses are not concerned with the overall degree of productivity loss among acquired inventors. Obviously, if we were attempting to explore whether inventors generally do less well after an acquisition, it would be a problem to examine only those inventors who had previously done well. Instead, we explore the factors that affect variation in innovative output among previously productive scientists. Second, as we shall discuss below, we statistically controlled for each scientist's preacquisition productivity, which is a conventional way to deal with regression to the mean.

Independent Variables

We coded R&D integration by examining press releases (through LexisNexis) at the time of the acquisition to determine if the acquirer intended to integrate the new unit's R&D activities with the parent's R&D activities. This intention was almost always clearly conveyed in the acquirer's press releases, because decisions about the handling of acquired R&D activities were of great salience to investors and other observers. Statements indicating intentions to keep the new R&D units independent were clear. These included statements such as "no plans to integrate R&D operations" and "will continue to operate as an autonomous company." Similarly, statements were clear about R&D integration, such as "will involve relocation of the 500 R&D employees," or "intend to completely integrate the research divisions" and "restructuring the [target]." Based on these clear indications, we coded R&D integration as a binary variable, coded to one if the acquirer's stated intentions were to integrate the R&D activities of the acquired company. We acknowledge that this measure does not allow for any gradations in the degree of integration, and hence it provides a conservative test of our hypotheses. As a further validity check, we examined press reports for at least three years after the acquisition to verify that the acquirer's initial intentions were carried out. We also contacted lab directors at four of the more recent acquisitions to determine if our coding accurately reflected the acquirer's actions in the first three years after acquisition; their assessments completely agreed with our coding.

Our three remaining independent variables describe characteristics of individual inventors, with patent records as our sources. The inventor's loss of relative standing was calculated to reflect the degree to which the inventor moved downward in the local status order once his company was acquired. First, we calculated each inventor's preacquisition status, measured as the percentage of all productive inventors in the acquired firm whose preacquisition productivity (number of patents in $t-4$ through t) was lower than that of the focal inventor. Then the inventor's percentage standing was similarly calculated relative to the preacquisition productivity of all inventors in the acquired and acquiring firms combined. The inventor's loss of relative standing is the preminus postdifference of these percentages, so that larger scores indicate larger loss of status. As an example, an inventor who had been the most productive among a preacquisition group of 10 inventors would have a preacquisition status of 90%; if his level of preacquisition productivity places him only at the middle of the combined groups, say at the 50th percentile, then his loss of relative standing is 40 (i.e., $90-50$).

Inventor's divergence from acquirer's expertise was constructed to indicate the degree to which the individual acquired inventor worked in scientific domains that were peripheral to the main expertise of the acquiring firm. To develop this measure, we relied on the USTPO's system of three-digit classes for assigning patents, which are based on specific technological areas. Patents can be assigned to more than one class. We first identified, for each acquiring firm, the top three classes in which its inventors had patented over the five years prior to the acquisition. Then we calculated an acquired inventor's divergence score to reflect how few of the same classes she had patented in during the same period, ranging from a divergence score of three if the inventor had patented in none of the acquiring firm's top three classes, to zero if she had patented in all three.

Inventor's preacquisition social embeddedness was constructed to indicate the degree to which the individual inventor depended on others in his preacquisition organization to carry out his knowledge-creation activities. We measured it as the average number of coauthors on the inventor's patent applications in the five years prior to being acquired (Wasserman and Faust 1994). The greater the inventor's dependence on others, the greater is the score on this measure of social embeddedness.

Control Variables

We controlled for several factors that could be expected to affect the results but that were not part of our theoretical scope. First, because our sampling time frame was broad, and patenting behavior may have changed over that period, we included a time trend indicating the year in which the acquisition took place. The size of the acquired firm relative to acquiring firm has been shown to affect acquisition outcomes (Ahuja and Katila 2001, Hambrick and Cannella 1993), so we included relative size, measured as the number of inventors in the acquired firm who had patented between $t-4$ through t, divided by the sum of such inventors at the acquiring and acquired firms. We used patent data to measure relative size because some of the acquired firms were young technology boutiques, and sales and asset figures often would not be meaningful; moreover, sales and asset figures were not available for acquired subunits.

Because the dissimilarity of acquirer and acquired firm capabilities could influence the productivity of inventors, we developed an indicator of technological dissimilarity, measured in terms of the Euclidean distance between acquirer and target firm's patents in the preacquisition five-year window. Specifically, we calculated

$$\left(\sqrt{\sum(X_i - Y_i)^2} \Big/ \left(\sqrt{\sum X_i^2}\right) * \left(\sqrt{\sum Y_i^2}\right)\right),$$

where X_i is the number of patents of the target firm in technological class i and Y_i is the number of patents of acquirer firm in the same technological class. We used technological classes as defined by USPTO. The greater the value of this measure, the greater the dissimilarity. To account for the potential nonlinear effect of this measure (Ahuja and Katila 2001), we also included its square term in the analyses.

Because a preexisting relationship between the acquiring and acquired firm could smooth the acquisition process (Kogut 1991), we coded the presence of a prior alliance between the two firms as a dummy variable, coded to one if there was a prior R&D relation and zero otherwise.[3] We gathered this information from the Recombinant database of pharmaceutical and biotechnology alliances.

Although most prior studies of postacquisition results have not included acquired subunits (instead only including public corporations), we can anticipate that the distinction between an acquired subunit versus an independent company may have covaried with some of our variables. Therefore, we included a dummy variable, subunit acquired, which was coded zero if the acquisition was an entire independent company, and one if it was a subsidiary unit (from SDC).

We also included a dummy variable, technological motivation, and coded it as one when one of the publicly espoused reasons for the acquisition was the research capability of the target firm. We gathered this information from the acquirer's press releases about the acquisition. For example, "Praxis brings to Cyanamid a complement of outstanding scientists, ... and a core technology" (*Newswire* 1989) was coded as one. Additionally, we included a dummy variable, biotech firm, and coded it one if the firm was involved in biotechnology operations and zero otherwise. We gathered this information from the names and business descriptions of the firms in the press accounts surrounding the acquisitions. For example, names such as SDS Biotechnology and IGI biotechnology, or a business description such as "products based on genetic probe technology" (*PR Newswire* 1989), indicated that these are biotechnology firms.

Because the premium paid for an acquisition might influence the pressures placed on the acquired firm and its inventors (Coff 1999), we included the premium paid as a control. When the acquired entity was a public company, we measured the premium as the percentage paid over the acquired firm's prebid market value (four weeks prior to first public rumor of a bid); when the acquired entity was a subunit, premium paid was calculated as purchase price divided by book value of equity (from SDC) (Hayward and Hambrick 1997, Sirower 1997). The inclusion of our control variable designating whether the acquired entity was a subsidiary allows our use of different measures of premiums paid for subunits and whole companies. Because the number of bidders can influence the outcomes of the acquisition process (Barney 1988), we included number of bidders, which was gathered from the SDC database. Finally, we included a variable, hostile acquisition, which was gathered from the SDC database and which was coded one if the acquisition was hostile (tender offer) and zero if it was friendly.

Because we did not have detailed employment or demographic data on the inventors, we used the available patenting data on each inventor to control for personal factors that could affect postacquisition productivity. The most important of these control variables was preacquisition patents, an indicator of each researcher's inherent ability. This was measured as the sum of all patents in the inventor's name between $t - 4$ and t. Because some inventors might already be at the end of their productive era (or possibly have departed) by the time the acquisition actually occurred, we included a variable, time since last patenting, measured as the number of years prior to the acquisition that the inventor made her last patent, ranging from zero to five. As a proxy for the inventor's age or seniority, we included patenting tenure, measured as the number of years (prior to the acquisition) since the inventor's first patent with the focal firm. Because our patent data started in 1972, this variable was left-censored. Inclusion of the acquisition year, as noted above, helps to mitigate biases from this censoring.

In our analysis of patent productivity of known survivors, we included a variable, postacquisition patenting duration, which is the number of years after the acquisition that the inventor was last observed to patent with the firm (ranging from one to five). This controls for the possibility that low postacquisition patent counts could be due to early departure.

Results

Table 1 presents descriptive statistics and correlations among all variables.

Table 2 presents multivariate results with robust standard errors based on firms. The first three models (1, 2, and 3) report results for the first-stage analysis, in which the dependent variable is known survival, our binary indicator of whether the inventor had any patent applications at all after the acquisition. Model 1

Table 1 Descriptive Statistics and Simple Correlations

Variable	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
1. Year	1992	3.56																				
2. Relative size	0.46	0.26	0.09																			
3. Acquirer-target technological dissimilarity	0.88	0.26	−0.09	−0.62																		
4. Prior alliance	0.09	0.29	0.08	0.16	−0.59																	
5. Subunit acquired	0.52	0.50	0.49	0.04	0.15	−0.34																
6. Technology motivation	0.45	0.50	−0.44	−0.28	0.14	0.06	−0.70															
7. Biotechnology target firm	0.23	0.42	−0.03	−0.01	0.02	0.18	−0.11	0.20														
8. Premium paid	1.12	0.31	0.11	0.20	−0.06	−0.24	0.19	−0.28	0.02													
9. Number of bidders	1.02	0.13	−0.21	−0.16	0.04	−0.04	0.07	0.14	−0.01	0.01												
10. Hostile acquisition	0.08	0.28	−0.25	−0.14	0.13	−0.10	−0.10	0.35	−0.17	−0.12	−0.04											
11. Preacquisition patents	2.20	2.79	0.03	0.01	0.06	−0.07	0.08	−0.01	−0.01	0.00	0.09	−0.03										
12. Time since last patenting	1.94	1.42	0.05	0.16	−0.12	0.03	−0.02	−0.04	−0.03	0.01	−0.01	−0.05	−0.25									
13. Patenting tenure	4.38	3.83	0.09	0.08	0.00	−0.06	0.05	−0.02	−0.11	−0.01	−0.01	−0.09	0.24	0.29								
14. Postacquisition patenting duration	1.90	1.52	−0.39	0.01	−0.05	0.24	−0.38	0.34	0.24	−0.10	−0.02	−0.20	0.04	−0.01	0.00							
15. R&D integration	0.48	0.50	−0.33	0.11	−0.12	0.04	−0.55	0.48	0.29	0.03	0.14	0.10	0.03	0.00	0.00	0.10						
16. Inventor's loss of relative standing	0.98	7.15	0.08	−0.25	−0.03	0.11	0.01	−0.18	−0.13	−0.04	−0.29	−0.01	−0.07	−0.05	−0.08	0.03	−0.28					
17. Inventor's divergence from acquirer expertise	2.81	0.48	0.00	0.01	−0.12	0.12	0.17	−0.14	−0.21	−0.10	0.03	0.12	−0.27	0.08	−0.12	−0.08	−0.30	0.08				
18. Inventor's preacquisition social embeddedness	2.09	1.54	0.12	0.02	0.00	−0.01	0.00	0.00	0.13	0.05	−0.04	−0.10	−0.27	0.05	−0.14	−0.03	0.05	0.05	0.05			
19. Known survivors	0.29	0.46	−0.01	−0.2	0.14	0.01	−0.01	0.08	0.07	−0.05	0.00	−0.06	0.19	−0.32	−0.02	.	−0.05	0.02	−0.12	−0.04		
20. Postacquisition patent counts	2.78	2.94	−0.14	−0.06	0.05	0.05	−0.2	0.16	−0.01	−0.09	−0.05	−0.11	0.29	−0.18	0.13	0.48	0.05	0.01	−0.15	−0.10	.	
21. Postacquisition citation-weighted patent counts	4.44	8.94	−0.29	−0.04	−0.07	0.22	−0.29	0.24	0.09	−0.18	0.00	−0.01	0.14	−0.14	0.03	0.39	0.05	−0.01	−0.04	−0.10	.	0.70

Notes. (a) All correlations with magnitude >|0.03| are significant at $p < 0.05$ level. (b) The size of the sample for all correlations is 3,933, except those involving "postacquisition patent counts," "postacquisition citation-weighted patent counts," and "postacquisition patenting duration," for which the sample is 1,090.

Table 2 Multivariate Analysis of Postacquisition Productivity of Acquired Inventors

Stage of analysis	First stage			Second stage					
Sample (*N*)	All acquired inventors (3,933)			Known survivors (1,090)			Known survivors (1,090)		
Dependent variable	Known survival			Postacquisition patent count			Postacquisition citation-weighted patent count		
Analysis	Logistic			Event count			Event count		
Model	1	2	3	4	5	6	7	8	9
Inverse Mills ratio				−0.531	1.76**	1.69**	−1.05*	3.47**	2.33
				(0.349)	(0.779)	(0.729)	(0.655)	(1.65)	(1.57)
Intercept	87.5	103	104	−68.2	21.8	12.6	161***	313***	211***
	(84.1)	(82.6)	(84.3)	(47.0)	(53.2)	(53.9)	(54.3)	(7.35)	(74.4)
Year/100	−0.044	−0.051	−0.053	0.035	−0.010	−0.006	−0.081***	−0.157***	−0.106**
	(0.042)	(0.041)	(0.042)	(0.024)	(0.027)	(0.027)	(0.027)	(0.035)	(0.037)
Relative size	−0.872	−1.16*	−1.16*	−0.166	−1.25***	−1.09***	1.09*	−1.54	−1.13
	(0.551)	(0.614)	(0.591)	(0.272)	(0.349)	(0.317)	(0.629)	(1.09)	(1.01)
Technological dissimilarity	−5.67**	−7.79***	−7.54***	0.748	−6.16***	−5.89**	4.48	−7.78	−3.16
	(2.15)	(2.57)	(2.52)	(1.27)	(2.36)	(2.30)	(2.88)	(6.46)	(6.12)
(Technological dissimilarity)^2	4.57*	7.71***	7.61***	−0.618	6.29***	5.72*V	−4.94*	7.53	3.34
	(2.33)	(2.672)	(2.53)	(1.17)	(2.29)	(2.26)	(2.74)	(6.48)	(6.15)
Prior alliances	0.937	0.222	0.106	−0.316*	−0.146	0.010	0.503	1.28***	1.04**
	(0.627)	(0.616)	(0.656)	(0.165)	(0.138)	(0.201)	(0.360)	(0.420)	(0.418)
Subunit acquired	0.833	0.440	0.350	−0.267	0.078	0.142	−0.208	0.494	0.162
	(0.566)	(0.564)	(0.574)	(0.190)	(0.210)	(0.210)	(0.373)	(0.391)	(0.387)
Technological motivation	1.06*	1.07**	1.05**	−0.223	0.682*	0.656*	0.115	1.62***	1.06*
	(0.583)	(0.523)	(0.505)	(0.219)	(0.397)	(0.394)	(0.374)	(0.619)	(0.645)
Biotechnology target firm	−0.069	0.208	0.193	−0.125**	0.058	0.042	−0.205	0.047	0.103
	(0.325)	(0.293)	(0.312)	(0.056)	(0.072)	(0.091)	(0.249)	(0.245)	(0.242)
Premium paid	0.326	0.378	0.366	−0.104	0.218*	0.201*	−0.231	0.337	0.106
	(0.234)	(0.236)	(0.240)	(0.076)	(0.112)	(0.105)	(0.314)	(0.395)	(0.383)
Number of bidders	−1.64	−1.36	−1.26	−0.380	−1.38***	−1.29***	0.454	−2.11**	−1.51*
	(1.06)	(1.13)	(1.07)	(0.312)	(0.429)	(0.428)	(0.633)	(0.907)	(0.857)
Hostile acquisition	−1.43***	−1.43***	−1.41***	0.073	−1.21**	−1.24*V	−1.04*	−1.44	−0.620
	(0.442)	(0.409)	(0.418)	(0.264)	(0.510)	(0.499)	(0.423)	(0.926)	(0.911)
Preacquisition patents	0.092**	0.082**	0.079**	0.031**	0.081***	0.074***	0.037	0.147***	0.109***
	(0.037)	(0.038)	(0.038)	(0.013)	(0.024)	(0.023)	(0.027)	(0.045)	(0.039)
Time since last patenting	−0.496***	−0.517***	−0.523***	−0.002	−0.497***	−0.485***	0.097	−0.894**	−0.657*
	(0.053)	(0.055)	(0.055)	(0.074)	(0.167)	(0.155)	(0.153)	(0.349)	(0.333)
Patenting tenure	0.015	0.019*	0.019*	0.007	0.028***	0.028***	−0.011	0.034*	0.023
	(0.010)	(0.011)	(0.011)	(0.008)	(0.010)	(0.009)	(0.018)	(0.019)	(0.017)
Postacquisition patenting duration				0.312***	0.307***	0.305***	0.312***	0.321***	0.312***
				(0.054)	(0.054)	(0.055)	(0.075)	(0.069)	(0.065)
R&D integration		−0.818***	2.33		−0.817***	0.010		−1.38***	1.22
		(0.300)	(1.59)		(0.241)	(0.341)		(0.528)	(0.994)
Inventor's loss of relative standing		−0.014	−0.009		−0.022***	−0.040*		−0.077***	−0.061*
		(0.015)	(0.028)		(0.009)	(0.022)		(0.022)	(0.034)
Inventor's divergence from acquirer's expertise		−0.295*	0.691		−0.306***	−0.095		−0.500**	0.043
		(0.188)	(0.461)		(0.109)	(0.090)		(0.238)	(0.351)
Preacquisition social embeddedness		−0.002	−0.023		0.020	0.047***		0.025	0.185***
		(0.033)	(0.020)		(0.024)	(0.012)		(0.102)	(0.037)
R&D integration ∗ Inventor's loss of relative status			−0.009			0.032			0.002
			(0.036)			(0.025)			(0.037)
R&D integration ∗ Inventor's divergence from acquirer's expertise			−1.13**			−0.190**			−0.375*
			(0.501)			(0.078)			(0.256)
R&D integration ∗ Preacquisition social embeddedness			0.045			−0.097**			−0.555***
			(0.085)			(0.042)			(0.048)
Log likelihood	−1,629.9	−1,480.7	−1,474.7	−1,633.7	−1,626.7	−1,620.6	−1,895.1	−1,885.2	−1,864.7
Pseudo *R*-square	0.273	0.339	0.342	0.393	0.399	0.405	0.368	0.376	0.391
Comparison of models		2 vs. 1	3 vs. 2		5 vs. 4	6 vs. 5		8 vs. 7	9 vs. 8
Improvement (by chi-square) (p-values)		<0.001	<0.005		<0.010	<0.010		<0.001	<0.001

Note. (a) $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$; two-tailed tests; (b) Robust standard errors in parentheses.

includes only the control variables, with several showing significant effects: acquirer-target technological dissimilarity (U-shape), technological motivation (positive), acquisition hostility (negative), the inventor's preacquisition patents (positive), and time since last patenting (negative).

Model 2 adds the main effects of the hypothesized variables—R&D integration, inventor's loss of relative status, inventor's divergence from acquirer's expertise, and inventor's preacquisition social embeddedness. R&D integration was significantly negatively related—as hypothesized—to the likelihood that an inventor remained on the newly combined company's patenting rolls. The inventor's divergence from the acquirer's expertise was also significantly negatively related to the likelihood of inventor survival.

Model 3 includes the interaction effects of R&D integration with each of the hypothesized inventor-level variables, yielding stronger results than Model 2 (by chi-square test, $p < 0.005$). Specifically, the interaction of R&D integration with the inventor's divergence from the acquirer's expertise was significantly negative, while the coefficient for the divergence measure itself ceased to be significant. This result indicates, then, that the inventor's divergence from the acquirer's expertise was only damaging to survival, or continued productivity, if coupled with integration, in support of Hypothesis 3.

In the second stage of analysis, our models examine the productivity of only the known survivors: those who still patented after the acquisition. As noted above, these models include the inverse Mills ratio as a control for sample selection bias (Heckman 1979). Models 4, 5, and 6 examine the productivity of surviving inventors, in terms of the number of patents they generated in the five years after acquisition. Model 4 shows that several of the control variables had significant effects: prior alliance (negative), biotechnology target (negative), the inventor's preacquisition patents (positive), and postacquisition patenting duration (positive). The addition of main effects of the hypothesized variables in Model 5 indicate that R&D integration (supporting Hypothesis 1), the inventor's loss of relative standing, and the inventor's divergence from the acquirer's expertise were all significantly negatively related to the postacquisition productivity of surviving inventors. The interaction effects in Model 6 indicate that the interaction of R&D integration both with the inventor's divergence from the acquirer's expertise and with the inventor's preacquisition embeddedness were significantly negatively related to the number of patents generated, thus supporting Hypotheses 3 and 4. Model 6, with the hypothesized interactions, is a statistical improvement over Model 5 ($p < 0.01$, by chi-square test).

Similar Heckman second-stage models for citation-weighted patent counts are presented in Models 7, 8, and 9. Several control variables in Model 7 were significantly associated with the citation-weighted patent count measure: year trend (negative), relative size (positive), acquirer-target technological dissimilarity (negative), acquisition hostility (negative), and the inventor's postacquisition patenting duration (positive). The addition of main effects of the hypothesized variables in Model 8 show that R&D integration (supporting Hypothesis 1), inventor's loss of relative standing, and inventor's divergence from acquirer's expertise were significantly negatively related to citation-weighted patenting. The interaction effects in Model 9 yield an improved model over Model 8 (by chi-square test, $p < 0.001$), indicating that the interactions of R&D integration with the inventor's divergence from the acquirer's expertise and with the inventor's preacquisition social embeddedness, were significantly negatively related to the productivity of inventors—again supporting Hypotheses 3 and 4. Integration, by itself, did not have a negative effect on inventor productivity, once the interactions were included.

Overall, our results are generally consistent across three measures of postacquisition inventor productivity. We find that acquisition integration had a negative effect on all three measures of productivity, in support of Hypothesis 1. However, when we add a consideration of the inventors' characteristics, we find that acquisition integration harms the productivity of some inventors more than others. Specifically, in support of Hypothesis 3, integration was highly damaging to inventors whose expertise diverged from the acquirer's main areas of expertise (across all three performance measures); and, in support of Hypothesis 4, integration was highly damaging to inventors who were most socially embedded in collaborative relationships with their preacquisition colleagues (for the two patent count measures).

Interestingly, the main negative effect of acquisition integration consistently disappeared when interactions with inventor characteristics were included. This finding suggests an insight beyond what we envisioned in our theoretical argument: Acquisition integration hurts the productivity of some knowledge workers more than others (as we argued), but once these most negative effects are accounted for, acquisition integration has a neutral effect on the productivity of inventors in general.

Finally, we should note that an inventor's loss of relative standing, or downward movement in the local status order, was negatively related to both of the patent count measures ($p < 0.10$). This inventor variable had no significant interactive effect with acquisition integration, suggesting that loss of status has a generally adverse effect on inventor productivity.

Discussion

Effects of Acquisition Integration

Studies have found that innovation rates generally decline after acquisitions (Hitt et al. 1990, 1991). One critical factor in this decline is acquisition integration (Puranam et al. 2006). Specifically, the only way to recoup the premium paid for an acquisition is to do something with the company that it could not or would not do on its own. This will most likely entail integrating some or all of the acquired firm's activities with those of the acquirer in a quest for synergies. Unfortunately, however, integration is highly disruptive for the acquired entity and creates organizational trauma, resulting in capability damage or even destruction. The prescriptive literature on acquisitions also carries warnings about poor morale, disorientation, and disaffection of employees following acquisition integration (Chaudhuri and Tabrizi 1999, Levinson 1970, Schweiger et al. 1987); scholars who have observed aggregate negative shareholder returns following acquisitions often speculate that disrupted human behavior is among the causes. However, there has been only sparse evidence about changes in employee performance following acquisition integration.

We explored this issue by examining the effects of acquisition integration on the productivity of acquired employees. We focused on the productivity of those responsible for creating value through their day-to-day tasks, which specifically implies scientific inventors, in an industry in which technological innovation is strategically important (Levin et al. 1987, Scott Morton 2000). Indeed, acquisitions in the pharmaceutical industry are often undertaken with the goal of obtaining the technological wherewithal residing in the target firm (Ravenscraft and Lord 2000). If that technological capacity becomes damaged because of integration, then the acquirer's aims will not be achieved and the purchase price will not be recouped.

We generally found, consistent with Hypothesis 1, that acquisition integration negatively affects inventor productivity. This finding is in line with prior research that documented the disruption that occurs when an acquired entity is integrated with the acquirer's activities (Haspeslagh and Jemison 1991). The acquired unit is required to adopt new processes and procedures, its work units and social architecture are reconfigured, and its members may even be physically relocated (Zollo and Singh 1998). Compared to acquisitions that are allowed a great deal of autonomy, integrated acquisitions are required to make substantive and social changes (Baumann et al. 1997) that lead to emotional turmoil (Buono and Bowditch 1989), in turn disrupting knowledge-creation capabilities. Our results suggest that this disruption takes a toll on the productivity of acquired knowledge workers, both in terms of their survival (or continued patenting) with the combined firm and the productivity of survivors with the combined firm.

One of the new insights from our study, however, is that the main negative effect of acquisition integration inventor productivity goes away, disappears entirely, when the interaction of inventors' characteristics and integration are jointly taken into consideration. This important finding suggests that the effects of integration need to be considered in light of their differential effects on different groups of inventors.

Inventors Who Experience the Greatest Disruption from Integration

While integration had a generally negative effect on productivity of acquired inventors in our sample, the negative effects of integration were more severe for some scientists than for others. Specifically, those inventors who will lose the most stature and centrality by being integrated suffered the greatest disruption, or at least their technical productivity dropped the most.

Our results show that, when integrated, an acquired inventor's outputs were lower to the extent that his or her research expertise differed from the core areas of expertise of the acquiring firm, consistent with Hypothesis 3. This is a noteworthy result for two reasons. First, it suggests that inventors who provide skills that differ from those in the acquiring firm are most vulnerable to disruption of their routines, even though they might be highly attractive to the acquirer precisely because of their nonoverlapping capabilities (Larsson and Finkelstein 1999). When integrated, we can anticipate that these inventors feel socially isolated and defensive about their research orientations, as accompanies interpersonal differences generally (Wagner et al. 1984), and we can anticipate that these inventors might be required to operate under policies, procedures, or norms that suit the core technical fields of the acquiring firm, but that are ill-suited for other scientific domains. Second, while it might be expected that acquired inventors whose expertise diverges from the acquiring firm's expertise will generate path-breaking innovations by bringing fresh streams of knowledge (Henderson and Cockburn 1994), we find that these inventors seem to be most negatively affected, with greatly reduced productivity following integration. This finding sheds light on the process of assimilation of acquired inventors into an acquiring firm's activities: Some acquired inventors can be integrated more readily than others.

In a similar vein, our results show that upon integration a target inventor's output was lower to the extent that her preacquisition social embeddedness was high, consistent with Hypothesis 4. The inventor who had extensive preacquisition collaborations depended on a large number of colleagues to successfully carry out her routines. However, this inventor's network dissolves, or is frayed, if integration demotivates or distracts just a subset of the collaborative team. This makes the execution of the focal inventor's routines difficult, resulting in her own departure or reduced productivity. This finding is also interesting because it sheds light on the fact that it takes time to develop an understanding of who knows what in an organization. Conceivably, an inventor who flourishes in collaborative research has ample opportunity to team up with the acquirer's inventors immediately after integration, but she lacks deep insight about their expertise, their styles, their reliability as teammates, and so on. Thus, inventors who have a tendency to collaborate may not produce much following acquisition integration, at least in the short run, because their collegial webs have been damaged.

Interestingly, the third hypothesized individual factor, loss in relative standing, had a general main negative effect on the acquiring inventor's productivity: It did not interact with integration. Frank (1985) used the concept of relative standing to explain why individuals who have high status within a working group tend to receive wages lower than their marginal products. According to Frank, individuals attach value to being high status—and having others around them of lower status—and hence give up some of their economic income in exchange for this psychic benefit. As noted earlier, Hambrick and Cannella (1993) and Lubatkin et al. (1999) used the concept of relative standing to explain executive departures following acquisitions. In our study, we found that an inventor's loss of relative standing—going from being a big frog in a small pond to being a small frog in a big pond—was followed by a drop in the inventor's technical outputs. This result particularly highlights the importance of the social disruption that accompanies acquisitions, because relative status loss by itself (after controlling for the other factors that might accompany it) primarily induces disaffection and demotivation, not substantive dislocation. Thus, disaffection and demotivation appear to generally follow loss of relative standing, irrespective of acquisition integration.

Implications for Theory and Research

Our study sheds light on the KBV of the firm. Our results support earlier findings of KBV that knowledge-creation capabilities are not utterly fungible, and that acquiring productive employees is not a guarantee that their productivity will continue. Our paper, however, goes beyond this established finding by showing that inventors are differentially embedded in their substantive and social contexts, and integration can have varying effects depending on such prior embeddedness. We showed that those scientists who had the most stature and centrality before acquisition suffered the greatest disruption by being integrated. This finding implies that inventors play differential roles in the effective execution of their firm's capabilities, with some being linchpins of the capabilities that hold most of the organizational social fabric together.

Our study also has implications for research on acquisitions. Researchers have studied acquisitions primarily as vehicles for corporate growth and development (Berkovitch and Narayanan 1993), only recently starting to focus on acquisitions as means for obtaining technology resources (Hitt et al. 1990, 1991). We contribute to this stream of research by bringing in a somewhat different perspective: Scientists are the key for successful transfer of technological capabilities. While technological acquisition are undertaken primarily to retain and integrate innovative capability of the target, this process of acquisition and integration demotivates inventors and disrupts their routines, thereby destroying the innovative capability of the target. The success of the acquisition, then, depends on the success in retaining acquired inventors and maintaining their productivity. Thus, research on acquisitions can gain new insights by including consideration of the impact of integration on key groups of employees. For example, there is room to examine the possible benefits of acquisitions on inventor learning, knowledge transfer, and renewed stimulation (Ahuja and Katila 2001, Argote 1999).

Practical Implications

This study also provides practical implications for management of acquisitions. Managers have so far considered acquisitions from a strategic perspective, such as how they open up new product-market opportunities. However, our study suggests that managers should not only consider acquisitions from a financial or strategic angle, but also from a human angle, particularly if knowledge workers are involved. Because synergistic benefits from acquisition can only be realized with integration, managers need to think about the effects of integration on different subgroups of employees. Our finding that different groups of scientists experienced differential negative effects from integration indicates that managers may need to design targeted initiatives to mitigate the effects felt by specific groups. For example, our study shows that scientists who were highly socially embedded before acquisition and those scientists whose expertise diverged from the acquirer's expertise experienced the most negative effects. If acquiring managers are interested in keeping these scientists equally productive after acquisition, they should perhaps design special forums, communication programs, and incentive systems in efforts to overcome the distinctive apprehensions and fears of these valued subgroups of knowledge workers.

Limitations and Future Research

Our project, like any, is bounded in its scope and thus provides room, and we hope impetus, for future studies. The obvious need is to complement our large-sample study with more detailed field research that would directly examine the effects of acquisitions on inventors' routines. Observing and documenting, and if possible measuring, changes in routines and context dependence of inventors upon integration will corroborate and complement our study. One way of achieving this is through qualitative study, by observing changes in the physical, social, and procedural contexts of acquired scientists and then linking these with their productivity. Without really observing these routines and their dependency on contexts, we are limited in our understanding of the KBV.

A second research opportunity is to extend our ideas about the disruptive effects of acquisition integration to other employee groups in different settings. For instance, in recent years there have been numerous acquisitions in the advertising and banking industries—two additional settings in which professional employees who are responsible for core activities probably have elaborate routines that would be susceptible to disruption by acquisition integration. Third, although we do not examine the performance of inventors who were with the acquiring firms, they might exhibit patterns that are very different from those in the acquired companies. Future research could explore the effects on acquiring firms' inventors. A fourth need is to complement our focus on the negative impacts of acquisitions by focusing on the positive side. There is room to examine the possible benefits of acquisitions on inventor learning, knowledge transfer, and renewed stimulation (Ahuja and Katila 2001, Argote 1999). Finally, there is a need to study the managerial interventions that might be taken to minimize the negative consequences we have reported. We would hope that our research would eventually lead to new prescriptive insights for managing acquisitions.

Summary

Our study has added a new perspective for comprehending the generally negative outcomes from acquisition integration. We provide evidence on the factors that influence the performance of key employees inside the technical core of the firm following acquisitions. Specifically, we identified those inventors who will be most negatively affected by integration. If scholars wish to improve their understanding of acquisitions aftermaths, they will not focus strictly on top executives (Lubatkin et al. 1999), strategic synergies (Sirower 1997), and financial factors (Haunschild 1994, Hayward and Hambrick 1997), but will also look inside the organization at those employee groups whose day-to-day tasks comprise the firm's value-creation activities, and who, in many cases, are the very resources that the acquirer finds so valuable.

Endnotes

[1]When we refer to *integration*, we mean integration of at least that part of the acquired company that houses a focal inventor, typically an R&D unit. We recognize that integration is not always company wide (Ranft and Lord 2002).

[2]These patent applications could be either in the name of the acquired firm, the acquiring firm, or a new name of the combined unit. Only in very few cases did we observe inventors who were patenting with wholly new employers, which we coded as nonsurvivors for the focal firms.

[3]We assume that patents will be issued with both firms as assignees when innovations are generated in an alliance. However, in our data set we did not find patents that were issued to two assignees. Hence, we assume that all collaborators on a patent belong to the same firm.

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