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Knowledge distance and innovation in the context of mergers: A bridge too far?

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Abstract

Past literature has been limited in exploring the motivations of firms in acquiring targets with varying levels of knowledge relatedness and the relative roles played by knowledge distance vs. relatedness in shaping invention outcomes. In this paper we examine the antecedents and consequences of mergers between firms with unrelated knowledge bases. We suggest that narrowly specialized firms seek distant firms to broaden their knowledge base while firms with more general, broader knowledge base seek firms that will deepen their existing knowledge. We also suggest that while a distant search space is one of the factors that influence novelty, this alone does not ensure novel recombination of ideas; the search space must be characterized by both relatedness and distance in order to facilitate the generation of novel and useful inventions. Lastly, we propose that intra-organizational factors such as team diversity influences the process of recombination; diverse and similar teams will differentially assimilate new knowledge and have different effects on most-merger inventions. We find that post-merger period, target firms with homogenous teams are likely to generate more novel and useful inventions relative to those that have heterogeneous teams. This indicates that when firms are already distant to each other in their past technological expertise, adding within-team heterogeneity compounds the distance, and drives the firms too far apart to be able to leverage the diversity of ideas. This paper sheds light on firms' strategies in seeking differing search spaces to either deepen or broaden their knowledge bases and their implications.

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1.0 Introduction

Mergers and acquisitions have been a popular tool firms use to acquire new knowledge and capabilities (Uhlenbruck, Hitt, and Semadeni, 2006; Vermeulen and Barkema, 2001; Rosenkopf and Almeida, 2003) as organizations learn from technologically rich and diverse acquisition targets (Ghoshal, 1987; Hitt et al.,1996). Past literature has established the importance of relatedness of knowledge bases of target and acquirer firms in driving post-merger invention outcomes (Ahuja and Katilla, 2001; Makri, Hitt and Lane, 2011). However, the literature has been limited in exploring the motivations of firms in acquiring targets with related vs. unrelated knowledge bases and the relative roles played by knowledge distance vs. similarity in shaping invention outcomes. Acquisitions constitute a tool in firms' broader corporate strategy and therefore, firms' motivations in acquiring targets with unrelated knowledge bases would presumably be different from those in acquiring firms with relatedness; this would in turn shape invention outcomes. For these reasons it is important to explore firms' antecedents for different kinds of acquisitions, and their implications for inventions, thereafter.

In this paper we explore the 'double-edged sword' (Kaplan and Vakili, 2015) of distant and local search in the context of ex-ante acquisition motivations and ex-post innovation outcomes of mergers between technologically unrelated (or knowledge-distant) firms vis-à-vis technologically overlapping (knowledge-proximal) firms. We theorize and find that firms that hold more generally applicable knowledge are more likely to acquire target firms that have more overlapping or similar knowledge bases while firms with less general knowledge are likely to acquire firms with distant technologies. These ex-ante motivations are associated with consistent ex-poste outcomes: firms merging with knowledge proximal firms subsequently consolidate or deepen their expertise in a few select areas while firms engaging in knowledge-distant mergers broaden their knowledge into new areas.

Past literature predicts that relative to firms undertaking deepening mergers, those undertaking broadening mergers would generate more economically valuable (measured by patent citations) inventions (Rosenkopf and Nerkar, 2001) and that breakthroughs are likely to be the result of firms experimenting in and exploring unfamiliar, pioneering (technologies not built on other technology) or newly developed technologies (Ahuja and Lampert; 2001). This results from the recombination of distant and diverse knowledge components (Fleming; 2001). These mergers should also generate the lowest quantity of inventions (Ahuja and Katilla, 2001; Makri, Hitt and Lane, 2011). Contrary to our expectations, however, we find that these distant or broadening mergers result in both lower quantity and less economically valuable innovations after the merger. These effects are, however, moderated by low intra-firm distance: invention outcomes of broadening mergers are better when target firms are composed of more homogeneous teams or teams with higher shared knowledge. Target firms comprised of heterogeneous teams perform poorest when undergoing broadening mergers: this constitutes a bridge too far – firms are not able to leverage the diversity of experience to recombine ideas without shared knowledge.

We suggest that although past literature has shown knowledge distance to be an important component in generating breakthrough technologies, when knowledge elements are too distant firms are unable to recombine effectively. In order to search a space comprising of distant knowledge elements and recombine them to produce valuable technologies inventor teams must have shared experience and common knowledge bases to draw from. After the merger of knowledge-distant firms inventor teams encounter a larger and unfamiliar scope of knowledge and have to absorb, process and choose between many new ideas. They must do so at a time when the organizations are in a state of flux resulting from the merger event. When the teams of inventors are comprised of individuals with very diverse experience and lower shared knowledge, teams can suffer from an overload of ideas leading to over searching the new combined knowledge space. Thus broadening a knowledge space does not necessarily result in positive invention outcomes; firms must have organizational characteristics that can search such a broad space.

This paper makes three contributions to the literature on firm innovation. Firstly, there is little literature on understanding strategic antecedents for mergers and we seek to fill this gap. We explore the antecedents of knowledge distant vs. proximal mergers and document that firms' knowledge generality can shape their decision on whether to seek a deepening or broadening merger. Our findings provide some insights into strategic choices made by firms in shaping their invention strategy. We next add to the literature on firm innovation by studying the relative roles played by relatedness vs. distance in firms' innovation outcomes after mergers. Predictions made by past theory on innovation and search have been tested on populations of firms that share some overlap in technological expertise, where inter-firm knowledge distance has been studied on a continuum. We conceive of distance vs. proximity as discrete: either firms share technological overlap or they do not. We test theoretical predictions using this lens. We seek to contribute to the emergent literature that examines the double edge of knowledge distance vs. proximity (Kaplan and Vakili, 2014; Vasudeva and Anand, 2011). While Rosenkopf and Nerkar (2003) found that when firms explore technology and boundary spanning knowledge they are more likely to generate more economically valuable inventions, we do not find support for this. We suggest that such distant search spaces can constitute a bridge too far:

when knowledge elements are too diverse firms are unable to recombine them to produce breakthrough inventions. Lastly, we provide evidence that distance between knowledge elements can be bridged by shared experiences of team members: intra-firm knowledge homogeneity moderates inter-firm knowledge-distance. In order to leverage the benefits of a distant search space firms must have team inventors that are not so distant from each other. This paper adds to a growing body of work (Agarwal, Hsu and Wu; 2015) that explores the implications of team structure and experience in shaping firm strategy and outputs. We hope that investigation into innovation outcomes from the perspective of firm strategies will help the literature become more generative on the motivations and antecedents of such mergers.

2.0 Theoretical Motivation

2.1 Broadening and Deepening mergers

In this paper we delineate the antecedents for different kind mergers and follow the innovation outcomes of these mergers. Knowledge-distant firms will have expertise in different areas of technology. The innovation outcome of mergers between two such firms is likely to be different from that of two firms that share expertise in overlapping areas. There are some well-developed theories related to the characteristics of firms' search space that can help us understand the origins and the dimensions of these differences in innovation patterns.

Past work that has studied antecedents of mergers has examined factors such as strengths and weaknesses of partner (Angwin, 2001) and value creation (Weber and Fried, 2011; etc.) among other organizational characteristics. Firms engage in acquisitions as a strategy to source external inventions as an alternative for in-house development (Cassiman and Veugelers, 2006; Hitt, Hoskissen and Ireland, 1990), a tool to reconfigure their businesses (Capron, Dussauge and

Mitchell, 1998), diversify businesses (Singh and Montgomery, 1987) or a means by which to overcome path-dependency (Singh and Zollo, 1997; Capron and Mitchell, 1998). Therefore the choice of the target is shaped by firms' broader corporate strategy to ensure a sustainable competitive advantage.

Past literature has confirmed that mergers take place between firms that seek complimentary resources (Cassiman and Veugelers, 2006; Wang and Zajac, 2007) and mergers between dissimilar firms take place because acquirers leverage hidden synergies from targets that rivals cannot recognize or understand (Harrison, Hitt and Hoskissen, 1991). This insight can be extended to innovation as well: firms with complimentary innovative qualities merge and the ex-ante choice of partner is reflective of the kind of innovation the acquirer and target ex-poste wish to engage in. Specific ex-ante innovation characteristics will be associated with the likelihood of choosing broadening or deepening mergers.

Acquirers will choose targets based on the knowledge that the target will bring to the acquiring firm and vice versa. After a merger firms can choose to develop expertise in areas of expertise of either the target or acquirer or both, or it can choose to develop expertise in a completely new area by recombining elements of knowledge held by both firms. Karim and Mitchell (2000) found that when merging firms have overlapping resources, acquirers engage in resource-deepening measures by retaining the overlapping resources and building on existing core competencies. Makri, Hitt and Lane (2011) found that acquiring firms experience superior performance outcomes when targets have technical knowledge that is complimentary to their own. Moreover, they retain non-overlapping resources and engage in path-breaking exploration when the resources provide complementary capabilities that enhance the acquirer's potential to retain competitive advantage.

We propose the argument that firms will engage in knowledge-proximal acquisitions when they seek to build or consolidate expertise in a few key areas, but will engage in knowledge-distant acquisitions when they seek to broaden their expertise in many different areas. The dimensions of ex-ante knowledge held will determine the choice of acquisition partner. Knowledge of a firm is held in its patents and so, studying the characteristics of its patents held sheds light on the dimensions of the knowledge held. In this paper we focus on classifying the depth and/or breadth of knowledge based on the number of classes the firm patents in, and the generality of its patents.

Generality of knowledge is a measure of the outreach of the patent. The generality measure (Trajtenberg, Jaffe and Henderson; 1997) of a patent is high when it is cited by other patents belonging to many different fields, while it is low when it is cited by patents belonging to a few fields. The generality of knowledge is an indication of how widely the knowledge is applicable. The more pervasive across fields the knowledge held in the patent, higher the generality score.

Rosenkopf and Nerkar (2001) found that patents that cite wider ranges of technologies are also in turn cited by a broader range of fields. This implies that more general patents (which are cited by broader range of fields) draw upon many different fields of knowledge (Argyres and Silverman, 2004) relative to less general patents. Controlling for the number of classes, firms that have more general patents are therefore, more likely to hold wide knowledge that spans many areas, while firms with less general patents have narrower focused knowledge. Firms with wide spanning knowledge will have more to gain in developing expertise in a few chosen areas than further broadening into new areas as breadth of knowledge is associated with diminishing marginal returns. Moreover, since they span broad areas of expertise they are likely to have overlap with many more firms than firms with narrower focus who will overlap with fewer firms.

There is a second reason why we may hypothesize that firms that hold more general patents will seek knowledge-proximal firms to merge with. General-purpose technologies have been associated with higher innovation across all industries the technology is associated with (Jovanovic and Rousseau, 2005). More general patents likewise have been identified with higher social returns to innovation (Henderson, Jaffe and Trajtenberg, 1997). However, these returns are not equally shared among all firms; more general patents are associated with more innovation by other firms across industries and not necessarily the patenting firm. In fields characterized by low competition social returns to more general patents may be localized to a few firms including the patenting firm, but in highly competitive fields these returns are dispersed among many and the patenting firm does not necessarily experience any of these returns. The patenting firm will be able to exploit the diverse set of connections with many fields only when it has sufficient depth in its knowledge to be able to do so. Therefore, these firms will seek to enhance their depth in chosen areas and will seek more knowledge-proximal firms for greater innovation (Ahuja and Kattila, 2001).

The flip side of our argument is that less general patent holding firms are likely to seek knowledge-distant firms. When firms hold less general patents it suggests that their knowledge base is relevant to a less variety of fields. By Argyres and Silverman (2004) this implies that these firms also draw upon a lesser number of fields. Extending the idea of firms seeking complementary knowledge through mergers, we may expect that these firms will seek to broaden into newer areas where they do not hold expertise in and will therefore engage in knowledge-distant mergers. Based on the above reasoning we formulate our first hypothesis:

H1: Firms with more general patents will be associated with the likelihood of merging with knowledge proximal firms while firms with less general patents are associated with merging with knowledge distant firms.

2.2 Knowledge distance and innovation: Post-merger outcomes

According to our past hypothesis firms with general but less useful knowledge are more likely to engage in mergers with knowledge-proximal firms. We believe this to be the case if these firms pursue such targets with the intention of building on an existing area of expertise and gaining deeper knowledge in this domain. Firms merging with knowledge-distant firms seek to broaden their existing knowledge base and will be more likely to invent in newer areas. Past literature supports this idea: Karim and Mitchell (2001) found that when firms with overlapping resources merge they tend to pursue resource-deepening in an existing area and when firms that do not share overlapping resources merge they tend to engage in resource-broadening after the merger. Makri, Hitt and Lane (2011) showed that mergers between firms with overlapping technologies are followed by higher quality of inventions in the overlapping area. Ahuja and Katila (2001) similarly showed that relatedness of knowledge bases are related to post-merger inventions in an inverted U-shape and there is an increase in invention output of the acquirer when there is a moderate level of similarity of technology between acquirers and targets. Since the firms overlap in technological areas, the absorptive capacity of the acquirer will facilitate absorption of the target's knowledge (Cohen and Levinthal, 1991). Similarity also enhances the ability to integrate the two knowledge bases (Kogut and Zander, 1992). We thus believe that

H2) Part I: Firms in broadening mergers are more likely to invent in newer areas relative to those engaging in deepening mergers.

2.3 Knowledge distance and innovation

Distant knowledge and ideas can be useful to firm invention due to potential recombination. Alliances or mergers have traditionally been a way for firms to seek distant knowledge or knowledge that is outside the firms' existing scope. Rosenkopf and Almeida (2003) showed that in the semi-conductor industry alliances increased the flow of knowledge and scientists between firms and the usefulness of the alliance increased with technological distance. While there is a rich literature on mergers between firms with related technologies, we are agnostic about the innovation outcomes of mergers between firms that do not share any overlap at all.

Theories on knowledge recombination (Fleming, 2001; Sorenson and Fleming; 2001) emphasize that diversity and breadth of the search space shapes innovation outcomes. In this literature innovation outcomes have been quantified in terms of novelty (or economically valuable), which is measured by patent citation counts or new production introductions. More diverse the knowledge base or the search area, more valuable is the innovation output. Deeper and narrower the search area, less general but more predictable is the innovation outcome. Rosenkopf and Nerkar (2001) draw upon these theories to predict that when a firm searches knowledge that spans organizational and technological boundaries the firm is likely to be able to engage in widely explorative activities, leading to radical inventions. This is a result of firms conducting non-local searches to recombine knowledge across boundaries. When knowledge spans organizational but not technological boundaries, however, the impact of exploration is positive for innovation within the same technological domain but has a negative overall impact on firm innovation. Drawing upon related knowledge across firm boundaries, firms engage in more local search related to the areas of expertise, thereby limiting the impact of innovation to this area. When they draw upon unrelated knowledge, however, they are more likely to conduct more distant searches, which ultimately yield more radical inventions. Ahuja and Lampert (2001) echo this observation in the context of large corporations when they argue that firms are able to generate radical (or breakthrough inventions that are empirically characterized by higher economic value) inventions through three paths: a) experimentation with technologies the firm is unfamiliar with, b) pioneering technologies that do not directly build on other existing technologies, c) investing in emerging technologies that have recently been developed within the industry. Their theorizing is rooted in the idea that more effective recombination takes place in the absence of familiarity, as firms engage in distant searches that lead to economically valuable outcomes. Other related work have found consistent results: scope or breadth of knowledge comprising the search space available to a firm has been found to be positively associated with the number of new innovations carried out by the firm (Katila and Ahuja; 2002) and that the variety of distinct external sources comprising the width of search scope is also similarly related (Laursen and Salter; 2006). Phene et al. (2006) in studying the interaction of geographical and technological distance found that national but technologically distant knowledge has a curvilinear effect on breakthrough innovation. Vasudeva and Anand (2015) show that medium level of technological diversity in firms' alliance portfolios results in optimal innovation.

A broader search scope comprises of a higher variety of knowledge and provides more choices with which to solve problems and also increases the variety of recombination possible. From these theories we can anticipate that when firms share overlapping knowledge, they are more likely to engage in local search and will also be searching over a narrower search space relative to knowledge distant firm. Knowledge distant firms, post merger must engage in wider exploration and non-local searches that should lead to more economically valuable outcomes. This leads us to our next hypothesis.

H2) Part II: Innovation outcomes of knowledge distant mergers will be more valuable relative to knowledge proximal merger.

Knowledge-distant mergers result in sharing of non-overlapping technology and firms will therefore cite a wider range of fields, leading to more general patents (Rosenkopf and Nerkar, 2001; Argyres and Silverman, 2004). We may therefore expect knowledge distant mergers to be associated with more general patents as well, leading us to the second part of Hypothesis 3:

H2: Part III): Innovation outcomes of knowledge distant mergers will be more general relative to knowledge proximal merger.

Past research has established that relatedness of technologies between the acquiring and target firms plays an important role in shaping subsequent innovation strategies adapted by the merged firm. The absorptive capacity resulting from overlapping knowledge bases affects the expedience with which new knowledge can be assimilated and commercially exploited (Cohen and Levinthal, 1991) and accounts for the positive association of innovation with knowledge relatedness. Target and acquirers' familiarity with knowledge of the target and the acquirer allows inventors to be better positioned to select appropriate knowledge components. This would reduce inventive uncertainty and the variability of outcomes (Taylor and Greve, 2006). The literature has consistently shown that knowledge proximity is associated with higher quantity of innovations. Ahuja and Katila (2001) showed that the relationship between relatedness of the knowledge base of varies with quantity of innovation output in an inverted U shape. When firms do not share overlap in technology these mergers are associated with lower quantity in subsequent innovations. Katila and Ahuja (2002) showed that search depth or the extent to which a firm uses familiar knowledge is associated with the quantity of new innovations. Cloodt et al. (2006) also found an inverted U shape between knowledge relatedness and post merger innovation performance. Makri, Hitt and Lane (2011) constructed their own measures and used a sample of 95 firms from the chemical, drugs and electronics industry to show that post-merger innovation quantity was highest when there was a moderate degree of overlap between merging firms. This helps us to shape the last part of H2 Part IV:

H2): Part IV: Innovation outcomes of knowledge distant mergers will lower in quantity relative to that of knowledge proximal mergers.

2.3 Knowledge distance and team composition

We next propose that invention outcomes of mergers spanning technological and organizational boundaries will be moderated by intra-organizational factors such as the composition of teams. Past literature has studied invention outcomes while remaining agnostic on the roles played by individuals or teams of inventors in achieving recombination effectively in the context of mergers or acquisitions, but it reasonable to expect invention outcomes to be influenced by team composition, especially in the context of mergers between knowledge-distant firms that do not share common experiences and hence can be weighed down by costs.

There is vast literature on whether team diversity in experience is beneficial for innovation or not. Diversity in organizational experience and work history has generally been found to be positively associated with organizational outcomes: Beckman (2006) showed that teams who worked for different organizations prior to founding a new firm were more likely to engage in explorative behavior while those who worked for the same organization were more likely to be exploitative in their search behavior. Rosenkopf and Almeida (2003) showed that higher diversity in inventor experience is associated with higher knowledge flow. These findings are consistent with those on the effects of diversity in educational background (Brown and Duguid, 1991, 2001); educational diversity in team members provides different approaches to problem solving, norms and habits.

Even though past findings should predict that higher intra-firm knowledge distance should be associated with better innovation there is also reason to argue that it may have different effects when interacted with inter-firm knowledge distance. Indeed Grant (1991) has asserted that there needs to be a balance between overlapping and non-overlapping knowledge held by team members. Other scholars have shown that a highly diverse team with little shared knowledge will face high coordination and communication costs leading to inefficient performance (Buckley and Carter, 2004; Hambrick et al., 1996; Casson, 1998. Ancona and Caldwell (1992) find that diversity in team experience is negatively associated with task processes as it impedes collaborative productivity even though it encourages higher creativity. Teams composed of people from diverse functional backgrounds are sometimes unable to develop a shared purpose and find it challenging to agree on courses of action. They found that functional and tenure diversity led to higher exchange and recombination of ideas and is positively related to team and managerial performance.

Within the organizational creativity literature, diversity in specialization has been found to facilitate certain aspects of team collaborations but impede others. Majchrzak et al. (2011) found that knowledge differences between team members make knowledge integration more challenging especially when they encounter novelty. The literature on cross-functional teams has found that high degrees of specialization overlap between team members is positively associated with barriers that impede integrative collaborative problem solving (Carlile, 2004; Dougherty, 1992; Leonard-Barton, 1995; Lovelace et al. 2001). Dougherty (1992) proposed that higher specialization is associated with different world-views that arise from differing perspectives, interpretations (Boland and Tenkasi, 1995) and practices (Bechky, 2003). These differences can create barriers to understanding between team members, especially in the absence of deeply shared ties (Hansen, 1999) or history where they learned from one another and knowledge of shared processes that allow them to integrate and recombine ideas and knowledge (Eisenhardt and Santos, 2002). The more diverse the teams are, higher are the differences in interpretation of problems and therefore more varied the solutions. This fosters a lack of common ground and greater challenge in being able to collaboratively generate solutions.

After the merger of knowledge-distant firms, inventor teams suddenly encounter a larger (in scope), unfamiliar and more diverse search space resulting from the merger. This can lead to wasted effort during the search process (Koput, 1997). First there may be too many new ideas and knowledge to manage, process and choose between. Second, a merger event brings about many organizational changes and hence these ideas may come forth at the wrong time to be fully exploited. Thirdly, because of the copious number of the ideas very few of them may be given attention to or taken seriously. Past work on managerial attention has found that effective managers must 'concentrate their energy, effort and mindfulness on a limited number of issues' in order to achieve sustained strategic performance (Ocasio, 1997: 203). Highly heterogeneous teams will have experience a magnified attention problem when undergoing knowledge-distant mergers – not only do team members have to navigate exchange of many ideas within the team, they must encounter and process a completely unfamiliar knowledge base. Their attention will simply be stretched too thin, leading to worse invention outcomes.

Theories on knowledge integration within teams (Tsoukas, 2009; Boland and Tenkasi 1995, Carlile 2004) have argued that specialists in diverse teams have to externalize their deep knowledge in a manner that facilitates the understanding of differences and dependencies between each specialists' knowledge and allows the team to collectively traverse boundaries to arrive at a solution. This entails questioning their own assumptions and search for dependencies between their assumptions and core perspectives. Majchrzak et al. (2011) found, however, that instead of identifying and traversing boundaries of knowledge, practices that fostered knowledge exchange through the minimization of differences between team members were as effective in knowledge integration within the team. The authors (p. 2) say:

> "These practices helped to avoid interpersonal conflict, fostered the rapid cocreation of intermediate scaffolds, encouraged continued creative engagement and flexibility to repeatedly modify solution ideas, and fostered personal responsibility for translating personal knowledge to a collective knowledge."

They find that these practices are particularly effective when teams are tasked with something novel or unfamiliar. These findings suggest that when teams are more uniform in their knowledge background, there can be faster exchange of ideas through a reduction in conflict, higher creative engagement and more flexibility in finding solutions and these effects are magnified when dealing with new problems.

High inter-firm distance coupled with high functional diversity within teams compounds the challenges related to sharing knowledge and engaging in recombination collaboratively. These challenges are likely to be less in knowledge-proximal merging firm pairs as teams are at least partially familiar with the search space of the firm it is merging with. After the merger each inventor must first traverse the boundaries of her knowledge and the new knowledge acquired from the merging firm, and then approach collaborative recombination with other team members. While this larger scope of knowledge available in a knowledge distant merger can potentially result in higher availability of ideas, these new ideas are not salient within a diverse team and may not lead to meaningful recombination. This leads to exponentially higher effort in generating new innovations and therefore, diverse teams within knowledge-distant mergers will experience worse innovation outcomes than homogenous teams. The heterogeneity in the knowledge arising from the diversity of experience of team members within the firm combined with unfamiliar knowledge external to the firm will be counterproductive to the search and recombination efforts of firms and will be associated with worse invention outcomes. Team homogeneity or similarity of experiences of team members, on the other hand will moderate invention outcomes. This leads to our third hypothesis.

H3: Low intra-firm knowledge distance (high homogeneity within team members' experiences) will moderate the outcomes of knowledge-distant mergers.

3.0 Data and Methods

In the innovation literature there are three established measures of innovation that are relevant for this paper: the number of patents measures the overall quantity of innovation, the number of citations is held to be a measure of the usefulness or economic value of the patent (Jaffe, Hall and Trachjtenberg, 1999), and generality is a measure of how relevant the patent is to various different. We use the US Patent and Trademark Office data to construct these measures. We match the invention characteristics at the firm-year level with data on M&A. We begin with the universe of all M&A in the Life Sciences industry in the USA between the years 1980 to 2014 that were available from the database SDC Platinum. Since our focus within this paper is to explore the impact of knowledge distance, we focus on technological acquisitions within industries and eliminate mergers that were not technologically motivated. We eliminate firms in the categories of Health or Business services, Electrical and Electronic equipment and "Investor Group" as these mergers were not technologically motivated and are irrelevant for our study. We limit our sample to M&A within the Drugs, Chemicals and Allied Products, and Measuring, Medical Devices industries as these are related areas and mergers between these firms within these areas will be technologically motivated. We eliminate those mergers where acquirer took less than 70 percent of the firm. We further windsorized our data at a valuation of 5 million USD on the left end and 3 billion USD on the right end in order to limit the influence of outlying observations. This eliminates around 5 percent of the total observations. We obtain firm-year level control measures by matching firm names of public firms from Compustat and private firms from Thompson One database.

3.1 Variables

Dependent variables

The dependent variables are the number of forward citations (*TarNumFCit)*, the number of patents (*TarNumPatent*), the generality (*TarMeanGen*) and the originality of patents received *(TarMeanOrig)*. Forward citations constitute an accepted measure of usefulness or impact of inventions (Trajtenberg, 1990), while the number of patents is a measure of the quantity of inventions.

Independent variables

Our first independent variable of interest is whether the merging firms share knowledge overlap or not *(CB*). For that we first construct a measure based on the cosine similarity or angular distance (Jaffe, 1986) between the two firms. For each firm year observation we create a class experience vector based on the proportion of total patents the firm patented in that class in that year. Thus each entry of the class vector represents a proportion of the firm's patents that belonged to that class in that year. Cosine similarity is the angular separation between the two merging firms in that year. This measure ranges between 0 and 1 where 0 indicates that there is no similarity between the two firms and 1 indicates that they are completely similar. When firms do not share any overlap in knowledge that is, for knowledge-distant firms we define *CB=1* and when they have any overlap that is, when the firms are knowledge-proximal, then *CB=0*.

We conduct our analysis in a [-4,4] time window around the merging event year. For years that follow the merging event we designate the treatment as *Post=1* and for those years that precede the merging event we designate the treatment as *Post=0.*

We construct a similar measure to measure the homogeneity of experience within a team. This variable *TarAvgTeamSimilarity* is a measure that ranges between 0 and 1 where 0 indicates that the team members have no similarity in past experience while 1 indicates that the team has identical experience. We measure the angular distance between the functional experience between each pair of inventors on a team and then average over all pairs of inventors and then aggregate over all teams to obtain the team homogeneity measure at a firm-year level. For this measure we create a class experience vector for each inventor based on the stock of the number of patents the inventor has patented in that class to that year. We calculate the angular distance between each pair of inventors and then aggregate to the firm-year level to find a measure of team homogeneity.

Control Variables

We use firm and year fixed effects to control for time-invariant firm-specific factors. To account for time-varying firm-specific heterogeneity we use observables at the firm level such as assets held, number of employees etc. We employ patenting controls that measure the characteristics of the firm's overall patenting experience, such as the total number of patents in the previous year, the number of inventors and the number of classes the firm patents in. We do this at the level of the target firm. In addition we control for several inventor-related characteristics to account for the team's overall experience.

3.2 Model

Our methodology is rooted in comparisons of dyad pairs (target-acquirer pairs) before and after the merger event for knowledge-distant vs. knowledge proximal firms. We use a treatment-control setting with the flavor of a differences-in-differences approach. To test Hypothesis 1 we first estimate the association of various firm antecedents with the likelihood of undertaking a knowledge distant merger. We take the cross-section of firms within the sample and use a logit estimation according to the equation below.

$$CB_i = \alpha_i + \beta_1 * AcquirerPriorCitations + \beta_2 * AcquirerPriorPatents +$$
$$\beta_3 * TargetPriorCitations + \beta_4 * TargetPriorPatents + \gamma X_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The vector X represents the control variables.

To test Hypothesis 2 we estimate the number of new classes that the dyad pairs invent in, before and after the merger event for knowledge-distant and knowledge-proximal dyads. We estimate the following equation on a panel of dyad-year observations with conditional firm and year fixed effects and bootstrapped standard errors in order to account for serial autocorrelation in the error terms. The firm and year fixed effects account for the time-invariant heterogeneity within each firm and over each year. For time-varying variables we use control variables that we identified in the above section.

$$Number\ of\ New\ Classes_{it} = \alpha_i + \beta_1{*}Post + \beta_2{*}CB + + \beta_3{*}Post{*}CB + \gamma X_{it} + \varepsilon_{it}$$

…………………. (2)

As our patent count variables are overdispersed in distribution, we use a negative binomial distribution to estimate the effects of the treatment using the following equations to test Hypothesis 3

$$Log\ FCit_{it} = \alpha_i + \beta_1{*}Post + \beta_2{*}CB + + \beta_3{*}Post{*}CB + \gamma X_{it} + \varepsilon_{it} \text{ …………………. (3)}$$

Here *i* represents the firm and *t* represents the year. The coefficient on *Post*CB* gives us the relative effect of the treatment (merger) on knowledge-distant (*CB=1)* vs. knowledge-proximal firms (*CB=0)* firms.

To estimate the association between the treatment and non-count values such as originality and generality of patents we use an OLS with firm and year fixed effects and bootstrapped standard errors to account for serial autocorrelation among the error terms in the form of equation 2 below. This gives us the average effect. To examine whether there is an effect on the tails of the distribution we repeat the same estimation for the extreme values of *Generality*, that is, when the values are higher than the mean value + one standard deviation or lower than the mean value- one standard deviation.

$$Generality_{it} = \alpha_i + \beta_1{*}Post + \beta_2{*}CB + + \beta_3{*}Post{*}CB + \gamma X_{it} + \varepsilon_{it} \text{ …………………. (4)}$$

To test Hypothesis 4 we estimate the effect of team homogeneity on inventions we add the variable *TarAvgSimilarity* which captures the similarity in experience within each team of the target firm for both models above. The three-way interaction term *Post*CB*TarAvgSimilarity* gives the marginal effect of team homogeneity (*TarAvgSimilarity)* on knowledge-distant firms (*CB=1)* on post-merger years (*Post=1)*.

$$Log\ FCit_{it} = \alpha_i + \beta_1 {*}Post + \beta_2 {*}CB + + \beta_3 {*}Post{*}CB + \beta_4 {*}TarAvgSimilarity\ + \beta_5 {*}Post{*}TarAvgSimilarity + \beta_6 {*}Post{*}CB{*}TarAvgSimilarity + \gamma X_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots \text{(5a)}$$

$$Generality_{it} = \alpha_i + \beta_1 {*}Post + \beta_2 {*}CB + \beta_3 {*}Post{*}CB + \beta_4 {*}TarAvgSimilarity\ + \beta_5 {*}Post{*}TarAvgSimilarity + \beta_6 {*}Post{*}CB{*}TarAvgSimilarity + \gamma X_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots \text{(5b)}$$

4.0 Empirical Results

4.1 Summary Statistics

Our data consists of mergers of firms between the years of 1976 to 2006. There are 376 unique firms in our sample and 3747 firm-year observations. On a firm-year basis 66 percent of the observations are *CB=1*. That is, on a yearly basis 66 percent of the firms did not share any overlap in the classes in which they patented. On a purely firm basis, however, the percentage is 50%. This means that in the Drugs and Medical Devices industries half of the mergers take place between knowledge-distant firms. After the merger the mean equity holding in the target firm is 99.74 percent. The size of the deals ranges between 5 million to 2.9 billion USD with an average of 356 million USD. The assets held by an average target firm comprised of around 202 million USD with a standard deviation of 3009 million, ranging to 1770 million. An average target firm patented in 4 classes on an average each year, with 14 new patents each year and 70 new forward citations. The mean originality value of the patents held by the target firm was .33 and a generality value was around .34. An average acquiring firm patented in 4.7 classes and filed for 22 new patents, invoking 104 forward citations each year. The mean originality value of the as well as the generality value of patents held on a firm-year basis was .16. The average within-team similarity measure of the target firm was .36 with a standard deviation of .29.

[Table 1 goes here]

4.2 Results

Columns 1 and 2 of Table 2 show the factors associated with a higher likelihood of engaging in a knowledge-distant or CB merger. Acquirers with higher citations patents but lower generality of patents are more likely to engage in such mergers. This suggests that firms which have narrower specialization of patents will be more likely to seek broadening mergers.

[Table 2 goes here]

Table 3 shows that dyads are likely to have a larger number of new classes after the merger when the merger is a broadening one vs. a deepening one. This provides support for Hypothesis 2 Part I.

[Table 3 goes here]

Column 1 in Table 4 shows that while the number of patents is higher for the dyad post-merger, the coefficient on *Post* being positive, the interaction of *Post* and *CB* is negative, indicating that post-merger, the number of patents for knowledge-distant firms is lower relative to those for knowledge-proximal firms (evidence for Hypothesis 2 Part IV). The same is true for Column 2, which measures the forward citation count (Hypothesis 2 Part III). The forward citation count on knowledge-distant firms is lower than those on knowledge-proximal firms following a merger event. The generality values follow the same pattern as shown in Column 3 while the originality values do not seem to be significantly different between knowledge distant and knowledge proximal firms.

[Table 4 goes here]

In Table 5 Column 1 when we add the within-team homogeneity values measured by *TarAvgSimilarity* we find that the coefficient on the three-way interaction term on *PostCBTarAvgSimilarity* is positive, indicating that, while the total count of patents for knowledge-distant firms is lower relative to knowledge-proximal firms when the firms have more homogeneity within the teams the effect is moderated. Thus, similar teams moderate the negative effect of knowledge-distance on innovation outcomes such as patent counts. The same holds for forward citations and generality measures.

[Table 5 goes here]

4.3 Robustness and Placebo tests

The most significant concern in interpreting our results is rooted in selection driving our results rather than treatment. That is, we may worry that firms select to merge with knowledge distant or knowledge proximal firms based on certain other unobservable qualities, which drive the invention outcomes post-merger. For instance if two knowledge distant firms decide to merge with the intention of obtaining access to each other's diverse product market rather than knowledge base then these firms would defacto experience worse innovation outcomes post-merger as they abandon their own and the joined research program. We approach finding solutions to this concern in two ways.

Firstly, we redo all our tests based on a matched sample of firms using Coarsened Exact Matching (CEM) techniques. We coarsen our pre-event data based on number of classes, patents, assets, value of the merger deal and the number of inventors – the matched sample is shown in Table 1 of the Appendix Table 8. We then match firms based on this data and then run our regressions based on the matched firms. This method yields a smaller sample of mergers, but this sample consists of firms that are similar on observable qualities. We thus obtain a more balanced pre-event sample. This procedure eliminates the requirement for some of the stronger assumptions on the treatment effects that we require in non-matched sample estimation. The Table 6 shows the results of estimation on this matched sample – we find the results to be consistent.

[Table 6 goes here]

Table 2 of Appendix shows the moderation effects of the target team similarity: the results remain consistent with the original sample. While the CEM method yields a better matched sample of observations we are still limited by the fact that we are matching on observables and therefore cannot account for endogeneity stemming from self-selecting based on unobservable qualities. We employ a second estimation method that alleviates this concern to a greater extent.

The second check we perform is to conduct the original estimation on a sample of firms that announced a merger but did not implement the merger eventually. The core assumption is that if firms decide to merge based on unobservable characteristics and motivations then this is captured in the sample of firms that announce the merger. If these omitted variables drive the innovation outcomes then we should see the same innovation pattern persists in these sample of firms – that is, mergers between knowledge-distant firms should have lower innovation quantity and quality relative to knowledge proximal firms. We do not, however, find this trend – shown in Table 3 of the Appendix. We find that among firms that announce a merger but do not implement it there is no significant difference between knowledge-distant merger outcomes vs. knowledge-proximal outcomes. This gives us greater confidence to support our hypothesis that the costs of sharing knowledge between two very distant firms impedes innovation after mergers.

5.0 Discussion

In this paper we categorize mergers between firms as one of two types: knowledge-distant vs. knowledge-proximal. Disney acquiring Pixar is an example of a deepening merger: prior to Pixar Disney had a broad knowledge base comprising of competencies in animation drawing technology, non-animated feature films targeted towards the family, television-based entertainment and theme parks. The acquisition of Pixar in 2006, a firm narrowly specializing in computer-graphics based animation technology represented a step towards deepening one of its core competencies and becoming more competitive in this area, namely animation. This is a deepening acquisition as Pixar and Disney shared competencies in the same area, namely animation. This was followed by several more acquisitions of film studios such as Marvel in 2009. The Marvel acquisition, however, is broadening as Marvel's knowledge base did not include competency in animation; Marvel specialized in special effects and story-telling based on superhero characters.

We examine the antecedents of mergers of firms vis-à-vis their knowledge relatedness. We find that firms with less general knowledge bases tend to seek mergers with distant firms, presumably to use this new knowledge and broaden their existing knowledge. Firms that hold more general knowledge tend to seek mergers with firms with related knowledge bases, presumably to deepen their existing knowledge capabilities. We find that following the merger event knowledge-distant firms pursue a deepening strategy while knowledge-proximal firms follow a broadening strategy. Our paper sheds light on the strategic choices behind how firms use mergers as a tool to acquire new knowledge. We next study the relative importance of knowledge distance and proximity in influencing innovation outcomes and find that knowledge distant mergers experience worse innovation outcomes relative to knowledge proximal mergers. We document that over half of the mergers that take place in the Drugs and Medical Devices sector take place between firms that are knowledge distant and do not share any overlap in their patent classes. These mergers both patent less and have lower generality in their patents relative to firms that share knowledge overlap. Lastly, we find that intra-knowledge distance moderates inter-knowledge distance: innovation outcomes are moderated when the target firms are composed of teams with shared experience. Firms with homogenous teams undergoing distant or broadening mergers will experience better invention outcomes relative to those with heterogeneous teams. We posit that the latter mergers are unable to leverage the diverse elements in the knowledge space and that distance without relatedness is not enough to generate economically valuable inventions.

The binary categorization of mergers by knowledge distance helps us understand the motivations and outcomes of mergers when firms have no shared experience. While there is an established literature on the curvilinear relationship between technology relatedness and innovation, there has not been an in-depth look at why firms choose to merge when there is no relatedness, and the outcomes thereafter. The first argument in this paper is that firms choose targets according to ex-ante beliefs about possible innovation outcomes following the merger. Our sample shows more than half of mergers take place between knowledge-distant firms. Even though the ex-post innovation strategy seems to be consistent with ex-ante motivation knowledge-distant mergers are not associated with higher economic value, generality or innovation quantity. The puzzle is then why do firms choose to engage in such acquisitions if on average they are better off merging with similar firms; this is potentially a topic of future research. There is also a self-reinforcing cycle we observe in our sample: firms with less general technologies engage in knowledge-distant mergers and ex-post produce innovations with less generality. Firms who choose knowledge-distant partners also tend to keep making the same choices.

In this paper we do not draw inferences on treatment effects of mergers: we recognize that firms select each other. We examine antecedents of mergers to identify firms' propensity to select others and subsequent innovation trajectories. Therefore, our ex-poste results are conditional on ex-ante selection; we do not capture pure treatment effects of merging and our results should be interpreted accordingly. Secondly, we look at subsectors within the life sciences industry. Since there are many inherent industry-specific characteristics that can be influence our core assumptions and estimates, therefore we must be cautious in extrapolating and generalizing our results to other industries. This comprises an area of future work as well; it will be interesting to explore to what extent the patterns we observe regarding knowledge distance acquisitions are upheld in industries where knowledge distant mergers constitute less than half of the total number of acquisitions.

Past literature on innovation following mergers has not linked ex-ante motivations of acquisitions to outcomes.

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Tables

Table 1: Descriptive Statistics and Pairwise Correlations

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
ofSharesAcq	3,514	98.19	9.463	5.750	100
OwnedAfterTransaction	3,514	99.74	2.082	77.70	100
ValueofTransactionmil	3,747	356.9	579.4	5	2,925
countfcit	3,747	6.388	10.61	0	187
gen	3,257	0.390	0.272	0	0.909
orig	3,309	0.376	0.286	0	0.933
TarMeanOrig	3,747	0.335	0.231	0	0.886
TarMeanGen	3,747	0.343	0.226	0	0.859
TarNumFCit	3,747	69.84	242.3	0	4,257
TarNumPatent	3,747	13.56	43.75	1	579
TarNumPatentClass	3,747	1.749	2.135	1	66
TarNumClass	3,747	3.966	8.612	1	106
AcqMeanOrig	3,747	0.163	0.210	0	0.895
AcqMeanGen	3,747	0.160	0.203	0	0.872
AcqNumFCit	3,747	104.6	426.3	0	9,304
AcqNumPatent	3,747	21.94	70.92	0	1,043
AcqNumPatentClass	3,747	0.984	2.278	0	35
AcqNumClass	3,747	4.704	10.72	0	119
Eventyear	3,747	1,999	7.466	1,980	2,014
DyadNumPatentClass	3,747	2.733	3.207	1	66
DyadNumPatent	3,747	35.50	85.76	1	1,071
DyadNumFCit	3,747	174.5	494.9	0	9,324
DyadMeanOrig	3,747	0.498	0.318	0	1.586
DyadMeanGen	3,747	0.503	0.318	0	1.538

DyadNumClass	3,747	8.670	14.16	1	127
TarAvgSimilarity	7,120	0.362	0.286	0	1
TarMeanTeamProductivity	7,120	158.7	584.8	0	15,118
CB	7,502	0.662	0.473	0	1

Table 2: Logit estimation showing association of variables with the likelihood of engaging in a knowledge-distant merger*

VARIABLES	(1) CB	(2) CB
lPreTarNumFCit	0.104	-0.0246
	(0.175)	(0.198)
lPreAcqNumFCit	-0.849***	-0.864***
	(0.212)	(0.241)
lPreAcqNumPatent	0.448**	0.469*
	(0.228)	(0.259)
lPreTarNumPatent	-0.162	0.0227
	(0.198)	(0.227)
lPreTarGen	0.216	0.215
	(0.311)	(0.361)
lPreAcqGen	-0.524**	-0.569***
	(0.235)	(0.265)
num_prods_pre1		-0.253***
		(0.0719)
Observations	353	323

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*The prefix of l indicates the log. We take the log to dampen the effect of outliers. Logit estimation was performed on the cross-section of merger events in the life sciences industry. The sample of years taken consists of all years prior to the merger event for which data is available. The table estimates the likelihood of engaging in a knowledge distant merger on log of number of patents, citations, originality and generality of target and acquirer and other control variables. The table shows that firms with less general patents are more likely to engage in knowledge-distant mergers.

Table 3: Table showing the association of merger type and the number of classes following a merger.

VARIABLES	(1) NumNewClass
CB	-0.00182
	(0.0145)
Post	0.238***
	(0.0188)
PostCB	0.103***
	(0.0223)
o.ValueofTransactionmil	-
DyadNumPatent	-0.000634***
	(0.000140)
Constant	0.0161
	(0.0116)
Observations	3,749
Number of UniqueID	353

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table presents the results of a poisson estimation showing the association between the number of new classes firms patent in, and the type of merger. The significant coefficient on *Post* indicates that the number of classes increases on average following a merger. The significant and positive coefficient on *PostCB* indicates that knowledge distant mergers are associated with a higher number of patent classes after the merger relative to knowledge proximal mergers.

Table 4: Average Effects of knowledge distance after merger event*

VARIABLES	(1) DyadNumPatent	(2) DyadNumFCit	(3) DyadMeanGen
CB	-0.622***	-0.531***	-0.115***
	(0.0449)	(0.0500)	(0.0186)
Post	0.201***	-0.111	-0.199***
	(0.0720)	(0.0907)	(0.0327)
PostCB	-0.302***	-0.441***	-0.0692*
	(0.0899)	(0.113)	(0.0367)
Observations	2,559	2,554	2,649
Number of UniqueID	376	374	376
Event Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes

Standard errors in

parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Columns 1 and 2 were estimated using a conditional negative binomial with firm-year fixed effects and bootstrapped standard errors to correct for serial autocorrelation. Columns 2 and 3 were estimated using OLS with firm-year fixed effects and bootstrapped standard errors. We observe a [-4,4] window around the merger year. We control for lagged number of patents and the lagged number of patent classes and the size of the assets of the target firm.

Table 5: Average Effects of knowledge distance when moderated by team similarity levels*

	(1)	(2)	(3)
VARIABLES	DyadNumPatent	DyadNumFCit	DyadMeanGen
CB	-0.630***	-0.523***	-0.116***
	-0.047	-0.0522	-0.0192
Post	0.301***	0.266*	-0.082
	-0.106	-0.146	-0.0505
PostCB	-0.450***	-0.956***	-0.221***
	-0.136	-0.18	-0.0579
PostTarAvgSimilarity	-0.336	-1.107***	-0.392***
	-0.25	-0.386	-0.121
PostCBTarAvgSimilarity	0.836***	1.924***	0.542***
	-0.316	-0.448	-0.139
AcqAvgSimilarity	0.206**	-0.0931	-0.0204
	(0.0954)	(0.128)	(0.0492)
Observations	2,283	2,279	2,359
Number of UniqueID	337	335	337

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Columns 1 and 2 were estimated using a conditional negative binomial with firm-year fixed effects and bootstrapped standard errors to correct for serial autocorrelation. Columns 2 and 3 were estimated using OLS with firm-year fixed effects and bootstrapped standard errors. We observe a [-4,4] window around the merger year. We control for lagged number of patents, number of inventors and the lagged number of patent classes and the size of the assets of the target firm.

Table 6: Estimating average effects on a sample of CEM matched firms

	(1)	(2)	(3)

VARIABLES	DyadNumPatent	DyadNumFCit	DyadMeanGen
CB	-0.251***	-0.196***	-0.136***
	(0.0560)	(0.0688)	(0.0240)
Post	-0.0473	-0.226***	-0.104***
	(0.0619)	(0.0828)	(0.0277)
PostCB	-0.100	-0.397***	-0.112***
	(0.0893)	(0.123)	(0.0378)
Observations	1,092	1,092	1,184
Number of UniqueID	202	202	294
Event Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*The sample above is that of CEM matched firms. A balanced sample was created by matching on target firms' number of classes and patents, acquirer firms' number of classes and patents, size of assets and price per share (if available) of the target firm. Columns 1 and 2 were estimated using a conditional negative binomial with firm-year fixed effects and bootstrapped standard errors to correct for serial autocorrelation. Columns 2 and 3 were estimated using OLS with firm-year fixed effects and bootstrapped standard errors. We observe a [-4,4] window around the merger year. We control for lagged number of patents, number of inventors and the lagged number of patent classes and the size of the assets of the target firm.

Appendix

Table 1: CEM Balancing*

	Pre-CEM Balancing	**Post CEM**
	2.099	-.7773
TarNumPatent	(1.546)	(1.286)
	-.8015	-7.907
TarNumFcit	(9.777)	(6.373)
	.9084***	-.1061
TarNumClass	(.2988)	(.2094)

*The table shows the difference in means (standard errors in parenthesis) of the difference in means between treatment (CB) vs. non-CB sample prior to the merger event for CEM and non-CEM samples. A balanced sample was created by matching on target firms' number of classes and patents, acquirer firms' number of classes and patents, size of assets and price per share (if available) of the target firm.

Table 2: Estimating average effects with target team characteristics on CEM matched firms

VARIABLES	(1) DyadNumPatent	(2) DyadNumFCit	(3) DyadMeanGen
CB	-0.421***	-0.317***	-0.0935***
	(0.0554)	(0.0645)	(0.0231)
Post	0.0610	-0.169	-0.142***
	(0.0869)	(0.113)	(0.0404)
PostCB	-0.579***	-1.066***	-0.193***
	(0.151)	(0.200)	(0.0618)
PostTarAvgSimilarity	0.179	0.0883	0.0494
	(0.168)	(0.226)	(0.0795)
PostCBTarAvgSimilarity	1.452***	2.369***	0.557***
	(0.344)	(0.466)	(0.155)
Observations	1,176	1,176	1,286
Number of UniqueID	237	237	347
Event Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Estimating average effects on sample of mergers where the event was announced but was not completed

VARIABLES	(1) DyadNumPatent	(2) DyadNumFCit	(3) DyadMeanGen
CB	-0.453***	-0.437***	-0.171***
	(0.0564)	(0.0700)	(0.0245)
Post	-0.0648	-0.481***	-0.164***
	(0.0532)	(0.0781)	(0.0256)
PostCB	-0.0982	-0.0888	-0.0434
	(0.0689)	(0.0958)	(0.0297)
Observations	1,483	1,481	1,508
Number of UniqueID	131	130	156
Event Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Columns 1 and 2 were estimated using a conditional negative binomial with firm-year fixed effects and bootstrapped standard errors to correct for serial autocorrelation. Columns 2 and 3 were estimated using OLS with firm-year fixed effects and bootstrapped standard errors. We observe a [-4,4] window around the merger year. We control for lagged number of patents, number of inventors and the lagged number of patent classes and the size of the assets of the target firm.