DOES M&A DIVERSIFICATION IMPROVE POST-DEAL TECHNOLOGICAL PERFORMANCE?

Abstract

Firms often choose to grow and diversify via mergers and acquisitions (M&A) because acquiring and integrating an ongoing entity is perceived to be a fast and less risky means of entering desirable markets, gaining new knowledge and new capabilities, or adding to the firm’s product line. In this paper, we analyzed the effects of diversifying via M&A on post-deal technological performance in the U.S. communication services sector. Seeking patterns of whether the more-diversified firm draws upon a broader range of technological domains in its post-acquisition, subsequently-patented inventions, we observe patterns of changing patenting activity into related technological classes, and with various patterns of patenting lags.

Keywords: M&A, diversification, technological performance, patents, innovation, communication industry.

JEL Classification: L96, M13, O32, L21
Introduction

In an increasingly competitive market, growth is considered an imperative for all companies. Firms often choose to grow via mergers and acquisitions (M&A) because acquiring and integrating an existing entity is perceived to be faster and less risky than organic growth through internal innovation would be as a way of entering desirable markets (Brakman, Garretsen, & Van Marrewijk, 2013; Chevalier, 2004), gaining new knowledge and new capabilities (Ahuja & Katila, 2001; Cloodt, Hagedoorn, & Van Kranenburg, 2006; Cefis, 2010), or adding to the firm’s product lines. Firms often seek collaboration with outsiders to access capabilities beyond those mastered internally (Rigby & Zook, 2002), and in this context, M&A represent a strategic and faster means to increase firm’s efficiency (Cassiman, Colombo, Garrone, & Veugelers, 2005) by improving technological performance through economies of scale and scope (Henderson & Cockburn, 1996; Chiu, Lai, Lee, & Liaw, 2008), and directly reducing the risks related to internal investments in R&D (Hitt, Hoskisson, Ireland, & Harrison, 1991). Even firms with low in-house, innovative capabilities may enhance their technological performance by acquiring more-innovative firms to exploit their new and complementary resources (Barkema & Vermeulen, 1998) and enhance their respective absorptive capacity (Cohen & Levinthal, 1989). It is even hoped that the merging of firms’ different technological capabilities can increase the opportunities for synergies between the involved firms (Cloodt, Hagedoorn, & Van Kranenburg, 2006).

Of particular interest in studying M&A is the effect of diversification on inventive output. Does diversification via M&A help or hinder firms’ technological performance? Although scholars recognize the central role of diversification on innovation performance, they have shown inconclusive results concerning its directionality. Hitt, Hoskisson, Ireland, & Harrison, (1991) provided strong negative support—highlighting the negative relationship between diversified acquisitions and R&D outputs or patents. Ahuja & Katila (2001)
classified acquisitions into two categories (technological and non-technological) and their results indicated a positive impact on the magnitude of knowledge per innovation output base—but only for the technological acquisitions. For non-technological acquisitions, they observed no significant impact on subsequent inventive output. When Cloodt, Hagedoorn, & Van Kranenburg, (2006) built on the results of Ahuja & Katila (2001), they found that non-technological M&A had a negative effect on innovation performance; they found a temporary pattern whereby the absolute size of the acquired knowledge base showed a positive effect initially which became negative after the first few years. In pharmaceutical acquisitions, Valentini (2012) found that diversification via M&A positively affected the quantity of output but not its quality.

Growth through acquisitions facilitates the combining of organizations in order to experience both iterative and serendipitous learning processes that may yield novel solutions to perceived and yet-unarticulated customer needs. The ability to innovate effectively is crucial to enjoying annually-occurring, revenue enhancement synergies (Hall & Ziedonis, 2001). Firms seek such benefits by integrating their acquisitions in ways that will allow organizational learning to foster innovation and create valuable inventions that will increase their corporate family’s profitability and subsequent market value (Deng, Lev, & Narin, 1999; Hall, Jaffe, & Trajtenbrg, 2005; Trajtenberg, 1990).

1. Theory and Hypotheses

We examined the experience of U.S. communication services firms in order to understand the dynamics of innovation when firms grow via M&A. Our research design facilitated comparisons of innovative outputs that occurred before and after diversification via acquisitions; we searched for evidence that the post-acquisition, combined firm subsequently improved its technological performance. In particular, we sought patterns
within combined firms’ patents that the more-diversified firm drew upon a broader range of technological antecedents in their subsequently patented inventions. Our research design facilitated the examination of patterns indicating changes in patenting activity, changes in the variety of technological classes built upon, and changes in the speed with which various patterns of patenting activity became apparent.

1.1. **M&A Diversification stimulates inventive output**

Although the effects on firm performance of growing through M&A diversification have been debated in the strategy literature for many decades (Rumelt, 1982; Palepu, 1985; Montgomery & Wernerfelt, 1988; Hoskisson, Hill, Johnson, & Moesel, 1993; Ramanujam & Varadarajan, 1989) interest in how diversification via M&A has affected technological performance and output is more recent (Ahuja & Katila, 2001; Cloodt, Hagedoorn, & Van Kranenburg, 2006; Di Guardo & Valentini, 2007; Valentini, 2012). Patent output has been the primary performance measure favored by scholars of innovation; technological performance has been measured by using patents as proxies for the fruits of firms’ R&D outlays and inventive activity.

Analyses of patent content—insights that capture both the depth and the breadth of engendered technological knowledge (Moorthy & Polley, 2010) — have been used as a meaningful and reliable measure of firms’ innovative performance and quality (Ahuja & Lampert, 2001; Fleming, 2001; Rosenkopf & Nerkar, 2001; Nerkar, 2003; Miller, Fern, & Cardinal, 2007; Trajtenberg, 1990; Hagedoorn & Cloodt, 2003; Hall, Jaffe, & Trajtenberg, 2001). Cloodt, Hagedoorn, & Van Kranenburg (2006) showed that post-M&A innovative performance improves if the firm is able to exploit its new sources of externally-derived knowledge properly. Leiponen & Helfat, (2010) showed that technological diversification is an important way of broadening firms’ knowledge bases, if operating under uncertainty.
Valentini (2012) showed that diversification via M&A positively affects inventive output in terms of quantity. Moreover, technological diversification can increase the firms’ inventive search possibilities (Valentini & Di Guardo, 2012), and consequently stimulate the generation of more diverse ideas by affecting the firms’ knowledge-base resources. Successful knowledge transfers between dissimilar corporate family members can yield new practices or products that could be delivered to customers faster or at a lower cost—provided that not-invented-here (NIH-type) impediments can be overcome quickly enough to overcome the short-term integration costs that neutralize expected combinatorial gains from cross-fertilizing innovations and knowledge transfers within diverse corporate families.

Does broad technological diversification encourage more profuse patenting activity? Our first tranche of hypotheses argues that broad diversification combines diverse knowledge bases and stimulates a greater net increase in patenting activity than do acquisitions of less-diversified firms. Increases in post-acquisition patenting activity are expected to be greater where broadly-diverse knowledge bases have been integrated than where the acquisition is closely-related in scope.

**Hypothesis 1a:** The number of patent applications made after broadly diversifying acquisitions will increase – albeit slowly to reflect the greater time needed to assimilate diverse knowledge bases.

**Hypothesis 1b:** The number of patent applications made after narrowly diversifying acquisitions will remain constant (or decline during difficult economic times).

### 1.2. Diversifying acquisitions integrate diverse stimuli
Exposure to new and diverse technological capabilities and knowledge bases was particularly of interest when evaluating post-acquisition innovation performance (Ahuja & Katila, 2001; Cloodt, Hagedoorn, & Van Kranenburg, 2006). During the post-acquisition period, the combination of the acquiring firm’s existing technological knowledge with that of the target firm allows for the generation of new capabilities (Kogut & Zander, 1992) and successful integration of firms’ knowledge bases is a key concern for firms involved in M&A (Ahuja & Katila, 2001; Haspeslagh & Jemison, 1991; Child, Faulkner, & Pitkethly, 2001; Cloodt, Hagedoorn, & Van Kranenburg, 2006). Integration of inventive activity must occur quickly in order to enhance the potentially-stimulating benefits given by the “shock” occurring after a diversified deal occurs. Karim & Kaul (2013) argue in favor of a positive impact on innovation that will generate unexploited knowledge synergies following the structural recombination of two unified knowledge bases. When an acquiring firm has successfully assimilated the target organization’s deep problem-solving knowledge with its own, the corporate family was expected to develop hybrid competencies that would broaden the organization’s knowledge base, thereby increasing the breadth of resources that it might subsequently build upon (Kogut & Zander, 1992; Winter, 2003).

The synthesis of divergent ideas has been of particular interest because it is considered to be characteristic of research that is highly original and hence also basic (Trajtenberg, Henderson, & Jaffe, 1997). When scoring the content of patents, the “originality” of an invention indicates the extent to which that innovation synthesizes knowledge from across scientific and technological fields that can be identified using patent classification; a patent’s originality score stems from the breadth of search demonstrated in the citations appearing in its patent application (Hall, Jaffe, & Trajtenberg, 2001) and the diversity of knowledge bases that a firm has synthesized when patenting inventions is
reflected in the variety of technological classes that the firm has cited in its patent applications.

We expected that a firm’s breadth of diversification would be reflected in the breadth of diverse technological fields that were cited when its claims of originality (as manifested in the granting of a patent) were accepted by the Patent Office; broadly-diversified firms were exposed to more diverse bodies of knowledge and were expected to have a greater likelihood of incorporating diverse ideas into their inventive activities. Because knowledge has been considered to be a crucial input to the inventive process (Ahuja & Katila, 2001; Moorthy & Polley, 2010), and an essential ingredient needed to activate the processes of organizational learning successfully, we focused on the content of knowledge in firms’ patents in our analysis.

Patents grant their owners exclusive monopoly power over the use of the novel, non-obvious and industrially-applicable invention covered by their claims. Because patenting is a time-consuming and costly activity (Ernst, 2001), firms try to protect the use of their highest-value technologies (Archibugi & Pianta, 1996), particularly those inventions which can generate future rents from their commercialization (Bessen, 2009). Rochina-Barrachina & Sanchis (2014) suggested that patent applications are able to decrease the level of competition in the sector. Analysis of the “prior art” cited in patent applications revealed the most-strategic technologies that patents were able to build upon and these citations reflected the firms’ inventive capabilities. Patent applications provided useful information about the antecedents of an invention (Belenzon & Pataconci, 2013) which facilitated better understanding of the core technologies of a firm (Wu, Chen, & Lee, 2010). Scores built by weighting the content of patent citations allow us to measure the value of the knowledge
being generated (Karim & Kaul, 2013) both before and after diversification via M&A has occurred.

Patent citations are a useful way to track knowledge antecedents because—when seeking patent protection for their inventions—firms are required to cite all germane, previously-granted patents that have made similar technological claims of originality and thus the originality of an invention can be measured by considering the pattern of diverse technology classes that a patent application cites as pre-existing art (Hall, Jaffe, & Trajtenberg, 2001). ¹ When examining how the originality of a firm’s patents changes after integrating an acquisition, one identifies the diversity of incrementally-added knowledge bases in the variety of technological classes that the firm subsequently synthesizes in its patent applications. In our second tranche of hypotheses, patterns of backward citations are used to describe the breadth of technological fields that have been considered in order to create a particular invention (Harrigan & Di Guardo, 2014) and we expected broadly-diversified firms to exhibit greater originality in their patent applications.

**Hypothesis 2a:** Patent applications made after broadly diversifying acquisitions will invoke a wider range of knowledge bases than the combined firm’s historical knowledge core.

**Hypothesis 2b:** Patent applications made after narrowly diversifying acquisitions will invoke a range of knowledge bases closer to the combined firm’s historical core.

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¹ Patent examiners maintain the integrity of a patent’s novelty claims by verifying that the required list of references to pre-existing patents is complete before a patent can be issued. Since inventors can only claim patent rights to the unique aspects of their inventions, the backward patent citation requirement establishes the scope of a patent under examination and the breadth of technological classes extended by an invention’s claims reflects the range of knowledge bases that the firm is conversant in.
1.3. **Diversifying acquisitions reach more diverse technological markets**

When considering the influence that inventions may have on users of technology, we expected that combining more diverse post-acquisition knowledge bases would increase the likelihood that firms’ inventions would be cited in a broader array of subsequent patent applications. Knowledge is an important resource that allows firms which have knowledge assets to achieve a competitive advantage in the marketplace (Karim & Kaul, 2013) and expand their business advantageously (Dibiaggio, Nasiriyar, & Nesta, 2014). Given the pace of technological change and increasing complexity of product configurations, innovative products often require novel inputs from a broader arena (Ernst, 2001; Granstrand, Patel, & Pavitt, 1997; Moorthy & Polley, 2010).

Innovation scholars have long measured patent success by the number of citations that they garner; the “generality” measure of Trajtenberg, Henderson, & Jaffe (1997) indicates its applicability across scientific and technological fields that can be recognized by the pattern of forward citations in diverse technological fields that a particular invention garners. Patent generality—which indicates a patent’s impact as well as breadth of citations—helps firms in the exploitation of real options in an uncertain technological context and fosters new product development (Novelli, 2011). Because more diverse customers and geographies will be served when firms diversify, new capabilities will be needed and new competitors will be encountered. Inventive outputs will be noticed by these new players and knowledge will be built upon by this wider audience—resulting in a broader network of knowledge that may be characterized by examining a patent’s forward citation patterns. We expect that positive changes in post-acquisition patterns concerning the number of diverse technological classes that cite an invention will indicate that an acquiring firm has subsequently enjoyed benefits from its broader diversification.
Hypothesis 3a: Patent applications made after broadly diversifying acquisitions will be cited for use in a wider range of technological classes than the combined firm’s historical core.

Hypothesis 3b: Patent applications made after narrowly diversifying acquisitions will be cited for use in a range of technological classes closer to the combined firm’s historical core.

2. Methods

Evidence of benefits from M&A diversification on technological performance was sought by examining the content of granted patents of U.S. communications services firms making acquisitions during the eight-year period from 1998 through 2005. U.S. communications services encompassed voice-, data- and video-transmission—all sent over the same conduit, but the technology was not always so. To accelerate technological progress, the formerly-regulated monopolist (AT&T) was split into several standalone companies in 1984. Communications service technologies evolved rapidly thereafter as it became possible to digitize and transmit voice, data and video over one network. Many firms made acquisitions in the late 1990s to enter the communications services industry or to supplement their internal technology gaps. Over time the former patenting virtuosity of Bell Labs was supplanted (and sometimes surpassed) by new communications companies who rose to prominence vis-à-vis patent applications in new communications service technologies, as did Qualcomm Wireless, Hughes Electronics and Time Warner Communications, among others; meanwhile past technological leaders sometimes waned in their innovative productivity for creating communications services inventions for a variety of internal reasons.
The choice to examine the communication services sector was driven by four main reasons: first, the high-density of patent activity (Hall & Ziedonis, 2001; Ziedonis, 2004); second, the importance of innovation in order survive in the highly-competitive markets (Danguy, de Rassenfosse, & van Pottelsberghe de la Potterie, 2013); third, patent analysis is effective if applied to this industry (Breitzman & Thomas, 2002); and last, this is a knowledge intensive sector (Krafft, Quatraro & Saviotti, 2014). Hence, this industry seems very interesting and suitable to be analyzed more in-depth.

2.1. Data sources

Thomson One’s SDC Platinum (2013) database listed 6,823 entities that participated in the U.S. communications services industry during the years of 1998 and 2005.\(^1\) Approximately 55 percent of those entities were single-business firms; 79 percent of them were engaged in at least two SIC-defined lines of business and 90 percent of them were engaged in at least three lines of business when the observed acquisitions occurred. During this era, Thomson One recorded 2,028 transactions in which 928 different U.S. communications firms acquired at least 50 percent of the shares of a target company. Longitudinal financial data from COMPUSTAT (2013) were available for 837 of those transactions (representing 259 different firms) for as long as those acquirers remained standalone firms (up to 2012). Post-acquisition performance was tracked for some acquirers for as many as fourteen years.

Patenting activity, originality and generality variables were calculated using patent application data available from the Derwent Innovation Index database (2013)—including

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\(^1\) Defined as SIC codes 4812, 4813, 4822, 4841 and 4899 and including listed subsidiaries of diversified firms such as AT&T, the former Bell operating companies, Cablevision, CBS, Charter Communications, Comcast, Mediacom, Nextel, Time Warner, Verizon, and other carriers of voice, data and/or media communications.
U.S. Patent and Trademark Office technology class codes which matched the information contained in the National Bureau of Economic Research (NBER)’s U.S. Patent Citations Data File that was used by Hall, Jaffe, & Trajtenberg (2001) to report results. Using the DII for patent citations facilitated comparability with earlier studies of patent citation patterns while also providing activity updates through 2012.

Our sample included acquiring firms who reported R&D expenditures but granted no patents as well as acquiring firms with U.S. granted patents who did not report their annual R&D expenditures to the SEC (making their R&D data absent from COMPUSTAT). We tracked content patterns for their patent applications for the seven years before an acquisition was made (to provide our pre-acquisition, comparison measures). The patents of interest (the post-acquisition content patterns) were those granted in the window period of 1999 through 2005—starting with the year after an acquisition was consummated. Activity, originality and generality measures were calculated only for patents that were subsequently granted in the post-acquisition period (and their forward citation patterns were tracked up to 2012 to build a corresponding seven-year measure of post-acquisition citations). Indices of post-acquisition, combined-firm patterns of inventive output were compared with similar pre-acquisition indices of activity patterns that were computed only for the acquiring firms.

2.2. Dependent variable construction

Post-acquisition inventive performance was measured by counting the number of patents granted by the combined firm annually and for the combined seven-year period after an acquisition occurred which is consistent with the practice suggested by Yayavarajam & Ahuja (2008). Post-acquisition inventive performance was compared with the number of patents granted by the same acquiring firm during the seven-year period before the acquisition occurred. The difference between pre-acquisition and post-acquisition inventive
performance provides a crude indicator of whether inventive activity increased (or decreased) following an acquisition. Changes between the pre- and post-acquisition originality and generality scores of a firm’s inventions were deemed to be superior indicators that the benefits of diversification (if any) had been realized after an acquisition was consummated. (Construction of originality and generality followed Trajtenberg, Henderson, & Jaffe (1997) and their details are recounted in sections 2.2.2 and 2.2.3.)

2.2.1. Patterns in post-acquisition patenting activity

Changes in the rate of post-acquisition patenting activity were measured using changes in the counts of annual patents granted (as compared with the numbers of granted patents in the pre-acquisition period). The U.S. communications services industry is an example of disruptive technological change in which older technologies (e.g., wireline services) faced a declining demand environment (Christensen, 1997; Harrigan, 2003) while new technologies (e.g., wireless and internet services) faced demand that increased at an increasing rate. There were numerous new entrants – often enjoying only short lifespans before they themselves were acquired. Despite the many new industry entrants, the industry structure consolidated from 1998 through 2012 due to competitive shakeout from numerous subsequent acquisitions of observed firms by competitors, as well as many bankruptcies and liquidations. We expected that if innovative activity increased within surviving firms during this period when environmental and financial conditions were otherwise hostile to making continuing investment in research and development, their positive activity pattern would indicate the enjoyment of greater benefits from technological diversification via M&A.

Examination of longitudinal patterns of firms’ patent filings illuminated whether there was any positive feedback effect occurring after their acquisitions have been integrated—a pattern whereby firms’ past successes in innovation might accelerate the rate of patents being
subsequently granted if indeed diversification enhanced innovative productivity after the research organizations had been combined. (Alternatively the pattern of innovative activity may have indicated a negative feedback effect after integration was been completed—which would show a decreasing pattern of patent applications.)

2.2.2. Innovation originality: Breadth of antecedents cited

Originality in the breadth of technological knowledge bases that were synthesized when a firm made patent applications was measured following Trajtenberg, Henderson, & Jaffe (1997) as:

\[
\text{Originality}_i = 1 - \sum_{j=1}^{n_i} s_{ij}^2
\]

where \( s_{ij} \) indicated the proportion of the citations \textit{made} by firm’s patent \( i \) to preceding patents that belonged to various technological classes \( j \) out of \( n_i \) patent technological classes. The originality index was calculated such that if a particular patent \( i \) cited mostly antecedent patents that belonged to a narrow set of technological classes, patent \( i \)’s originality score would be low; if a patent, cited precedent patents from several different technological classes, patent \( i \)’s originality score would be higher. Hall, Jaffe, & Trajtenberg (2001)’s adaptations of the technological classifications of the U.S. Patent and Trademark Office were used to obtain a manageable number of categories for comparisons across technology classes. Two originality measures—for pre- and post-acquisition innovation activity, respectively—were calculated in order to reflect any differences that might have existed in the originality of patent applications made before and after an acquisition occurred.
2.2.3. Depth of impact: Breadth of technology classes citing firm’s patents

Generality in the breadth of technological classes that cited a firm’s patent, -- an additional indicator of how widely the impact of patent, had influenced subsequent inventors in their respective patent applications -- was measured following Trajtenberg, Henderson, & Jaffe (1997) as:

\[ \text{Generality}_i = 1 - \sum_{j=1}^{n} t_{ij}^2 \]

where \( t_{ij} \) indicated the percentage of citations received by patent, that belonged to patent class\( j \), out of \( n \) patent technological classes. The generality index was calculated such that if a particular patent \( i \) was cited by subsequent patents that belonged to a broad variety of technological fields, the measure would be high; if most citations of a particular patent, were concentrated within a few technological classes, the measure of generality would be close to zero. Briefly, a high generality score suggested that a patent had an impact that influenced subsequent innovations in a widespread variety of technological fields.

Two generality measures—for pre- and post-acquisition citations of the firm’s patents, respectively—were calculated in order to reflect any differences that might exist in the pattern of patent citations occurring before and after a particular acquisition occurred.

2.3. Independent variable construction

Measures of diversification breadth were constructed by building an index that summed and squared North American Industrial Classification System (NAICS) distance measures in a methodology that was similar in spirit to a Herfindahl-Hirschman Index. Because the NAICS System grouped similar lines of business into taxonomies of proximate numerical families, indications of broad diversification could be constructed by calculating
differences between their six-digit “Primary NAICS Codes” (which were reported by Thomson One for acquiring firms and target firms). Thomson One reported six-digit NAICS codes for each of the several business units in each firm’s respective corporate family; diversification scores were calculated for the acquiring firm (alone), the target firm (alone), and the combination of acquiring and target firm (after netting out duplicate NAICS codes).

2.3.1. Heterogeneity in acquiring firm’s lines of business

Acquirer heterogeneity represented the breadth of different lines of business that an acquiring firm engaged in when the acquisition occurred. Acquirer heterogeneity was measured as:

\[
Acquirer\ Heterogeneity_i = \frac{\sum_{j=1}^{I} g_{ij}}{\sum_{j=1}^{I} d_{ij}}
\]

where \( g_{ij} \) indicated the distance between the acquiring firm\(_i\)’s primary NAICS code and the firm’s other NAICS codes\(_i\) -- where \( i = 1, 2, 3 \ldots n \). If the acquiring firm was broadly diversified before the acquisition, the heterogeneity measure was high, but if the acquiring firm was narrowly diversified into NAICS code industries in the same line of business family the measure of heterogeneity was close to zero. Acquirer heterogeneity\(_i\) was normalized by dividing the calculated distances for each NAICS-defined line of business by the acquiring firm’s primary NAICS code. Diversity in the acquiring firm’s lines of business was also measured by multiplying the heterogeneity index by a simple count of the number of distinct lines of NAICS-defined businesses that the firm was in at the time of the acquisition. (A similar methodology was employed to calculate several indices of the heterogeneity of target firms in the year when the acquisition was consummated. In quadratic specifications that
were used to test diversification’s non-linear effects on patent traits, the distance measures were squared.)

2.3.2. *Heterogeneity in resulting businesses after target firm is acquired*

Measures of combined firm heterogeneity included the breadth of different lines of business that the target firm was engaged in when the acquisition occurred. The target firm’s NAICS codes were added to those of the acquiring firm to calculate resulting, combined firm heterogeneity. Subsequent, combined firm heterogeneity was measured as:

\[
\text{Combined Firm Heterogeneity}_i = 
\]

where \( h_i \) indicates the distance between acquiring firm’s primary NAICS code and the combined firm’s other NAICS codes, \( j = 1, 2, 3 \ldots n \). If the combined firm was broadly diversified, the heterogeneity measure was high, but if the resulting combined firm was still narrowly diversified into NAICS-defined industries that were in the same lines of business, the measure of heterogeneity was close to zero. Combined firm heterogeneity, \( i \), was normalized by dividing the combined firm’s calculated measure by the acquiring firm’s primary NAICS code. Diversity in the combined firm’s lines of business was also measured by multiplying the combined firm heterogeneity index by a simple count of the number of distinct lines of NAICS-defined businesses that the combined firm was in after the acquisition. In quadratic specifications that were used to test diversification’s non-linear effects on patent traits, the distance measures were squared.
2.4. Control variables

Firms’ innovative performance may be explained by additional factors that were included in specifications as control variables: size, productivity, capital intensity, leverage or intangible assets (which may have represented extant patents or unamortized acquisition premiums). Size was represented by the logarithm of total assets or total revenues and was included in specifications as an indicator of the critical organizational mass that would be needed to realize scale economies when pursuing innovation activities. Productivity was represented by the sales-per-employee ratio and was included in specifications as an indicator of employees. Capital intensity was represented by the assets-per-employee ratio and was included in specifications to indicate the productivity of capital assets that were needed to provide communications services. The intangibles variable (the ratio of intangible assets to total assets) was specified as a control variable to represent the potential existence of extant intellectual property. Research and development expenditures (as a percentage of sales or assets) represented the firm’s commitment to funding technological innovation. R&D expenditure variables were tested in all model specifications but none were included in the results reported herein because few firms in our sample reported R&D expenses separately (and hundreds of degrees of freedom were lost with their inclusion).

3. Specifications and Results

For specifications of phenomena occurring in year_{t+1} innovation measures pertaining only to the acquiring firm were used (i.e., the number of patents granted in the seven years before the acquisition occurred). Two models were tested for each diversification variable

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2 Originality and generality for acquiring firms’ patents were calculated for the seven-year period before each acquisition under observation was consummated as well as for the seven-year period after the acquisition was completed.
that was specified – one with control variables and the other model without them. Control variable values for year \( t+1 \) were used in pre-acquisition specifications to reflect the lag time required for the benefits of having valuable patents to be recognized. For specifications of phenomena occurring in year \( t+7 \), innovation measures pertaining to the combined firm were used (i.e., the number of patents granted in the seven years after the acquisition occurred). Control variable values for year \( t+7 \) were used for post-acquisition specifications as well as for models where change variables were tested as dependent variables. All models used ordinary least-squares specifications with quadratic variables added to capture non-linear effects in the tests of technological diversification’s benefits.

3.1. Effects of M&A diversification on technological performance

Table 1 reports results for tests of Hypothesis 1 concerning the effect of diversification on the firm’s number of patents. Inclusion of squared diversification variables produced models with concave results that suggested an inverted U-shaped pattern existed between diversification and patents with the benefits of diversity plateauing beyond some level.
Table 1: Effect of Breadth of Diversification on Number of Patents

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*** p<.001 ** p<.01 * p<.05 † p<.10
Exhibit 1 illustrates the pattern of patent applications for highly-diversified firms during the seven years after acquisition.

**Exhibit 1**

**Results for highest diversification**

![Graph of patent applications over years after acquisition]

Chi Square 1=NS; 2=***, 3=***, 4=*****; 5=******, 6=***, 7=**

Although the first year’s pattern is not statistically-significant, possibly due to integration lags incurred by all firms (regardless of their diversification posture), the pattern increases at an increasing rate, as expected in Hypothesis 1a.

Exhibit 2 illustrates the pattern of patent applications for the least-diversified firms during the seven years after acquisition. Their pattern is decreasing at a decreasing rate, as expected in Hypothesis 1b.
In Table 1 coefficients for the breadth of diversification variables were always positive and statistically-significant (but lost statistical significance in the specification that tested post-acquisition changes in the number of patents granted); coefficients for the squared diversification variables were always negative and statistically-significant. There was support for a positive concave relationship between diversification and a firm’s number of patents and Hypotheses 1a and 1b cannot be rejected. Further study is needed of the effects on inventive quality within diversified firms facing declining demand; the communications services industry (and its industrial complements) provide many examples for investigation of this phenomenon.
Table 2 reports results for tests of Hypothesis 2 concerning the effect of diversification on patent originality. The inclusion of squared diversification variables produced mixed results in the pre-acquisition tests of patent originality; the relationship was positive and concave (suggesting that an inverted U-shaped pattern existed) before control depends to a considerable extent on the level of external uncertainty in the target country variables were added. When control variables were added to the specifications, results became negative and concave (suggesting that a U-shaped pattern existed). Signs on the coefficients changed direction in the models testing changes in patent originality. Results support a positive relationship of limited duration between patent originality and breadth of diversification -- which we suspect was idiosyncratic to the many diverse and complementary technologies that firms mastered in order to remain competitive in the communications services industry over time. Additional study of the relationship between diversification and patent originality is needed – perhaps using data from firms in another industry.
Table 2 Effect of Breadth of Diversification on Patent Originality

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***<.001   **<.01   *<.05   †<.10

Table 3 reports results for tests of Hypothesis 3 concerning the effect of diversification on patent generality. The inclusion of squared diversification variables...
produced negative concave patterns in all specifications (suggesting a U-shaped pattern of diminishing generality over time). In all specifications, coefficients for the breadth of diversification variables were negative and statistically-significant; coefficients for the squared diversification variable were positive and statistically-significant. Support was found for a negative concave relationship between patent generality and breadth of diversification which we suspect is idiosyncratic to the rapid pace of technological obsolescence exhibited in the communications services industry over time. The highly-diversified firms had patents that were more-broadly cited in diverse technological classes than did the slightly-diversified firms. The concave results concerning diversification and patents suggest that the greatest benefits of diversification occurred in moderately-diverse corporate families. Competitive success in the communications services industry required firms to adapt quickly to numerous technological generations of product improvements. Chi-square tests of the diversification postures of combined firms (post-acquisition) revealed that a disproportionate number of the slightly-diversified firms were themselves subsequently bought by other acquirers – suggesting the perceived need among acquirers for increased diversification breadth to cope with the volatility of competition in communications services.
In summary, the relationship pattern between diversification and patent originality changed over the fourteen years comprising the window of observation from positive in the pre-acquisition years to negative in the post-acquisition years. There was support for a
negative U-shaped pattern describing the relationship between diversification and having patents cited by diverse technological classes; the diminishing impact of diversification found over time is expected to reflect the increasing technological convergence required as the competitive ticket of admission into a volatile and evolving industry context.

4. Discussion and Conclusions

In this paper we analyzed the effects of M&A diversification on post-deal performance considering two dimensions of patent performance: originality and generality (Fleming, 2001; Trajtenberg, Henderson, & Jaffe, 1997; Argyres & Silverman, 2004; Di Guardo & Harrigan, 2014; Hall & Ziedonis, 2001; Hall, Jaffe, & Trajtenberg, 2001; Novelli, 2011; Trajtenberg, 1990; Valentini & Di Guardo, 2012). Many scholars have pointed out that M&A are a strategic and faster means to acquire new knowledge and to foster technological capabilities (Ahuja & Katila, 2001; Cloodt, Hagedoorn, & Van Kranenburg, 2006; Marin & Alvarez, 2009, Valentini & Di Guardo, 2012) but is the M&A diversification beneficial to firms? Consistently with previous studies (Cloodt, Hagedoorn, & Van Kranenburg, 2006; Ahuja & Katila, 2001) we conclude that diversification is positive after an acquisition has been integrated because the number of patents and their citation patterns increased during the post-acquisition period under observation. We conclude that broader knowledge bases were combined because the originality and generality of subsequent patents increased. We found patterns whereby the combined firm subsequently filed patents not only in its historical lines of business (in the technology classes where the acquired firm previously filed) but also in new markets that were not previously served and explained these patterns as being due to diversification that occurred when firms grew through acquisition. We found that patenting activity initially increased (then tapered off) after an acquisition had been consummated.
The firms who endured after making acquisitions therein produced valuable patents whose impact was evidence by the breadth of knowledge they synthesized in their applications and well as in the broad, user group who cited them. Their successes were helped by technological diversification.

Our research design did not yield information about the how much lag time might reasonably transpire before evidence of novel innovations may be seen after an acquisition. We anticipate that the pattern of most patent filings which occur immediately subsequent to the integration of an acquisition will not diversify significantly from an organization’s previous and ongoing pattern of served markets. In that case, diversifying acquisition of a target firm from a different industry may produce the statistically-significant patterns reported herein.

This study contributes to the existing literature in several ways. First, it sheds more light on the effects of M&A diversification on firms’ performance, contributing to the strategic literature. Second, by analyzing the effects of technological diversification on inventive output, it contributes to the innovation literature. Third, by using patent traits – originality and generality- to analyze technological diversification, it expands previous patent works.

Capturing evidence of benefits from M&A diversification by observing patterns of patent traits is problematical since successful innovation activity cannot be programmed to bear fruit on a predictable and regular timetable. Assuming a positive catalytic result from successfully combining the research personnel of a resulting, corporate family, we acknowledge that successful innovation takes time to gestate after the stimulus of interactions precipitates an idea – perhaps longer than the seven years we have allowed in our research design. Untimely delays in seeing measureable evidence of expected changes could indicate
difficulties in successfully integrating the acquired firm’s research personnel and other innovation resources into the acquiring firm.

Further studies may be deal with the effects on inventive quality within diversified firms facing declining demand; the communications services industry (and its industrial complements) provide many examples for investigation of this phenomenon. Additional study of the relationship between diversification and patent originality is needed – perhaps using data from firms in another industry.

References


