Inventor Commingling and Innovation in Technology Startup Mergers & Acquisitions*

Qingqing Chen, David H. Hsu & David Zvilichovsky

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Abstract: How does inventor team "commingling" (containing inventors from the acquiring and acquired firms) in technology acquisitions relate to innovation outcomes? Commingling reflects collaboration benefits and costs of integrating human resources across organizational boundaries. We study technology firms experiencing a merger, some of which also had prior R&D collaboration with the acquirer. Innovation outcomes (patent counts, forward citations, and patent scope) increase post-merger for firms with more intensive inventor commingling, especially when firms commingle post-M&A. We exploit direct flights between the M&A parties to instrument for endogenous commingling, and find robust results and support for causality. We further show that the effect of commingling is significant and distinct from team knowledge diversity and third-party collaboration. Post-M&A commingling increases individual inventor's innovation output more than commingling under pre-M&A alliances.

Keywords: technology acquisitions; inventor commingling; innovation; patents.

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1. INTRODUCTION

Technology acquisitions have been the overwhelmingly dominant mode in which venture capital-backed enterprises achieve liquidity over the past quarter century (Aggarwal & Hsu, 2014). Similarly, established industry incumbents are increasingly reliant on inter-organizational relations with innovative new ventures to develop new lines of business or to advance established ones (e.g., Puranam, Singh & Zollo, 2006). Despite these aligned motivations on both sides of the market, a long-standing literature suggests disappointing post-merger innovation outcomes (e.g., Hitt, Hoskisson & Ireland 1990; Kapoor & Lim, 2007). Two broad explanations have been offered for the performance shortfalls within the management-based acquisitions literature: issues with selecting firms with the most appropriate technological knowledge with which to combine (e.g., Ahuja & Katila, 2001) and post-merger integration and assimilation-based issues (e.g., Haspeslagh & Jemison, 1991).

The first literature finds the empirical regularity of an inverted-U shaped relationship between technology overlap among the acquired and acquiring parties and innovation outcomes, with the interpretation that an intermediate amount of technical novelty is important for recombination-based innovation (and that too much overlap reduces the innovation benefits of acquisition). One common theme of the second literature is that organizational design, such as structural integration, can aid in successful post-merger integration. We aim to contribute to the second literature on post-merger integration (while capitalizing on the central idea from the first literature regarding recombination as a key driver of innovation) by developing the concept that literal recombination of inventive staff from the acquired and acquiring organizations—what we term "*commingled*" inventor teams—is associated with (and may cause) innovation outcomes.

We believe this advances the literature in two ways. First, while others have recognized the importance of the need to "unstick" tacit information in order to assimilate and exploit knowledge in different domains (e.g., von Hippel, 1994), examining the micro-foundations of that process has not received much attention at the organizational and especially inter-organizational level, particularly in broad sample empirical work (perhaps because of data challenges). At the same time, since we are the first to introduce commingled inventor teams to the literature, we wish to examine how this aspect of team design compares to established constructs such as team diversity and third-party inventor collaboration. Second, the effectiveness of inventor commingling may depend on the organization of collaboration between entities, and so studying inventor output under an M&A setting, where the inter-organizational relationship changes, represents a window into how such collaboration regime changes matter.

Starting from individual-level origins, we conceptualize and align our empirical measurement of inventor commingling to address a multi-level conceptualization and dynamic treatment of this organizational investment in human capital integration. We pose the following two linked research question in this study: (1) what are the firm-level innovation implications of inventor commingling on the innovation output of the acquired firm? (2) how does post-acquisition individual inventor commingling innovation output compare to output by (the same) inventors commingling under a pre-M&A regime?

Our empirical analysis uses a broad-based sample of technology venture acquisitions (not conditioned on receiving venture capital), which also contains approximately 30% non-US acquisitions. All ventures in the sample have at least one US patent, which we impose in keeping with the concept of a technology related acquisition, as well as for measurement-oriented reasons. We find that the degree of post-acquisition firm-level inventor commingling is positively related to innovation output (as measured by granted patents and forward citation weighted patents) and exploration (patents with new-to-the-firm technology classes). We then address the issue that unobserved and unmeasured business policy and managerial choices likely shape the degree of inventor commingling. We investigate whether our main results hold once we adjust the estimates by exploiting the exogenous introduction of direct flights between acquirer and acquired entities. Such flights exogenously shift the cost of commingling, allowing us to construct an instrumental variable for commingling (note that the acquisition event itself is still exogenous to our analysis; again we aim to contribute to the literature on post-merger integration rather than the merger selection literature). We find that our original results are sustained. A further analysis exploits the fact that commingling and third-party collaboration occurs in our sample prior to some acquisitions. This allows us to examine innovation outcomes of (the same) inventors under different inter-organizational cooperation structures. We find that both firm-level and inventor level innovation outcomes are higher when commingling under the acquisition structure, which suggests an explanation for a puzzle identified by Dyer, Kale & Singh, (2004) regarding "targeted" cooperative organization. We further show that the effect of commingling with acquiring entity inventors is significant and distinct from the effect of team diversity and third-party inventor collaboration. We end with a discussion of implications and future directions.

2. BACKGROUND & LITERATURE

In this section, we briefly discuss two literatures and topics as background on the relationship between inventor team commingling and organizational innovation outcomes. We first review the literature on knowledge access via inter-organizational collaboration, and particularly the literature on the various modes of organizing cooperative relationships. This allows us to segue into identifying and developing concepts which provide further insights on the interaction between cooperative R&D form and innovation output. We embed in this discussion a review of the relevant technology M&A literature. A final section connects inventor commingling to the equation, paving the road for our empirical analysis.

2.1 Modes of inter-organizational cooperation for innovation. Accessing knowledge outside of an organization's boundaries can be instrumental to its competitiveness (e.g., Cohen & Levinthal, 1990), especially when the requisite knowledge for innovation is not entirely resident in the focal firm. As Rosenkopf & Almeida (2003: 762) succinctly note: inter-firm knowledge transfer can "effectively fill in holes in [the focal firm's] knowledge landscapes." Of course, the form and efficacy of inter-firm knowledge transfer to induce innovation has been the subject of enduring interest in the literature, with arm's length technology licensing, strategic alliances, and mergers/acquisitions representing these modes from least- to most-integrated forms.

However, *comparatively* assessing such modes has only received light attention in the literature. This knowledge shortfall leads Dyer, Kale & Singh (2004) to pose a puzzle: why are inter-organizational collaborations not more "targeted" in the sense of balancing the expected knowledge benefits of each cooperative mode with the costs of organizing and governing each mode? Dyer et al. (2004) report that based on a survey of 200 U.S. companies, managers report that 82% believe that decision makers should consider acquisitions and alliances as two different ways of achieving the same growth goals. Yet, only 14% of managers stated that their company has developed specific policy guidelines or criteria for choosing between forming an alliance with and acquiring a potential partner. While such disparities are only suggestive, we contend that we do not have a fulsome answer to the original puzzle.

The prior literature has only rarely examined cooperative R&D mode choice, and within that literature, cooperative mode choice is not directly connected to innovation outcomes. Aggarwal & Hsu (2009) propose that there are two drivers of cooperative mode choice at the organizational (not transactional) level, from the standpoint of the startup venture: appropriation environment and governance capabilities. However, these authors do not consider the full span of cooperative forms (acquisitions are not considered in their analysis). The role of ownership was analyzed by Villalonga & McGahan (2005) in their study of US Fortune 100 companies. In particular, they relate ownership (by insiders, blockholders, and institutions) to mode choice, but in addition to the incumbent's standpoint, they do not examine the innovation implications of ownership.

In the M&A for innovation context, most of the prior work examines either partner selection or partner integration. Overwhelmingly, the perspective in this literature is from the point of view of the acquiring firm. One influential set of studies assesses the pool of organizational knowledge, both the levels and the potential complementarity with the counterparty organization, as key factors in post-merger innovation success (Ahuja & Katila, 2001; Cassiman, et al., 2005; Cloodt, Hagedoorn & Van Kranenburg, 2006; Guadalupe, Kuzmina & Thomas, 2012). This line of literature identifies partner and technology selection (as well as treatment effects) as important in post-merger innovation success.

This literature has also examined a wide-range of other organizational characteristics for knowledge assimilation and integration, such as the length and quality of acquirer experience (Puranam &

Srikanth, 2007), the structural form of the combined organization (Puranam, Singh & Zollo, 2006), informal coordination mechanisms (Puranam, Singh & Chaudhuri, 2009), sustained corporate venturing programs for acquisition target selection (Benson & Ziedonis, 2009), and the presence of dedicated integration units with codified knowledge (Zollo & Singh, 2004). Neither the partner selection branch of the literature, nor the organizational design and integration / internal organization branch of the literature links targeted R&D collaboration forms with innovation outcomes, especially at the micro (inventor) level, however. By contrast, in our empirical work, we track firm- and inventor-level innovation creation and output under two distinct control and collaboration regimes, pre- versus post-M&A.

2.2 Inventor commingling to "unstick" knowledge in M&A contexts. A separate literature emphasizes the role of individuals and their knowledge, but is less sharp on the role of organizational boundaries. The individual-level process of "unsticking" tacit knowledge is a complex one (e.g., Von Hippel, 1994), and there are important interactions of that process with organizational routines for knowledge storage and recombination, as has been highlighted in the knowledge-based view of the firm (e.g., Kogut & Zander, 1992; Grant, 1996).

Unsticking individual-level knowledge is an important first step to knowledge assimilation, and we argue that one specific means of doing so is by forming commingled inventor teams. Alongside the great benefit of potentially unsticking tacit information in the process of innovative production, inventor commingling is likely to entail a range of costs. such as coordination, and so the net benefits may be uncertain. In the realm of inter-organizational R&D relations, Aggarwal & Hsu (2009) document the negative valuation consequences of switching R&D cooperation modes into one in which the focal organization is less experienced. This suggests the presence of organizational costs associated with reconfiguring operations and/or building competence in identifying, governing, and otherwise implementing alternative forms of inter-organizational cooperative R&D relations.

Control and authority of technical human capital could be an overriding benefit, however, of the M&A channel as compared to alternative R&D cooperation modes, especially in circumstances in which close knowledge sharing may be important for realizing synergies (Dyer, Kale & Singh, 2004). Within this context, the notion of "unsticking" knowledge for both knowledge sharing (Szulanski, 1996) and especially for knowledge creation is important. Von Hippel (1994), building on considerable prior work on tacit knowledge, argues that sticky information is costly to acquire, transfer and use, especially when the innovation task environment is complex. This is due to the nature of the information itself, the amount of information that must be transferred, and/or attributes of the seekers and providers of the information. Co-locating problem solvers can help unstick such tacit knowledge (Kogut & Zander, 1993; von Hippel, 1994), though there can be tremendous variation in the costs of knowledge transfer across domains (Teece, 1977).

Managerial fiat prevails under common ownership, and so merged organizations in which there are higher degrees of inventor commingling may provide evidence of more targeted inter-organizational arrangements. Our discussion yields two testable empirical hypotheses:

- **Hypothesis (H1).** *Acquired firms which commingle more intensively are associated with more favorable innovation outcomes.*
- **Hypothesis (H2).** *Inventors will be more innovative when commingling under a post-merger R&D regime as compared to a pre-acquisition (less integrated) regime.*

3. DATA, VARIABLES AND EMPIRICAL STRATEGY

To test these predictions about innovation and inventor commingling, we first describe the data construction process. We then preview our main variables, which are at both the firm-year and inventor-year levels of analysis. We end the section with a short discussion of our empirical strategy.

3.1 Data construction. We start with the set of ventures listed in Crunchbase, a crowdsourced platform, which were listed as acquired between the years 1970 and 2014 (since our measure of innovation quality is based on forward patent citations in the 4 years post grant, we stop the analysis window before the data end in 2018). This yields a list of 44,834 acquired companies. Since a Crunchbase listing is not dependent on receiving venture capital funding nor conditional on being US-based, we believe that this database allows us to cover a broader sample of startup firm acquisitions.[1]

We then use the set of acquired firms to build a longitudinal database at both the acquired firm and inventor levels. To do so, we make use of the PatentsView dataset provided by the United States Patent & Trademark Office (UPSTO). If an acquired firm does not have any granted patents between 1976-2014 as listed in PatentsView, we drop those firms. This helps us focus on acquisitions that have a higher probability of being driven by technology-centric motivations (while acknowledging that we might miss non-patented knowledge, such as that protected by trade secrecy). There is also a pragmatic reason in that our key empirical variables are derived from patent information, as we discuss below. We fuzzy match (using the

[1] We compare the Crunchbase data to two datasets to assess coverage quality. First, we examine the overlap between Crunchbase listings of ventures acquired from Israel to an Israeli data source of venture capital-backed startups in Israel, known as the IVC Research Center database. Since Israel is well-represented in technology acquisitions of technology-centric startups, we believe that this comparison is worthwhile. We find that the Crunchbase data is quite comprehensive in its coverage (by comparison, established venture capital data sources such as Thomson One do not systematically cover international transactions). Second, we compare Crunchbase coverage of technology acquisitions to SDC Platinum, a standard dataset used for acquisition data. We find that the SDC coverage skews toward larger firms and misses many smaller firm acquisitions, which is of particular relevance to us. To further compare the quality of these two databases, we examine the listed acquisition data in each database as compared to that contained in the IVC data for the set of Israeli acquisitions (with the assumption that the local data provider, IVC, is most likely to be a “gold standard” on data quality). We find that the Crunchbase dataset dramatically outperforms the SDC dataset in this comparison.

Stata 15 built-in "reclink2" software package) acquired firm names from Crunchbase with patent firm assignees listed in PatentsView. We find an overlap of 7,404 firms in both databases. Finally, we exclude multiple acquisition situations of the same firm to ease interpretation. This leaves a final sample of 6,478 acquired firms in our analysis.[2]

We then gather a list of all the inventors whose patents were assigned to the focal acquired companies using the unique inventor identifiers contained in the PatentsView database. This allows us to build a history of patenting of each inventor over her/his career, both before and after patenting in the focal firm, if applicable. These inventor- and patent-level data are crucial for measuring the key constructs, such as inventor commingling (as we explain in the next section). Of course, patent assignment records can only indicate inventors' employers (via the patent assignee or patent owner field) in years where patent applications are observed. In the absence of other intervening assignees, we assume that an inventor continued his or her employment with the same employer during the period spanning consecutive patent applications. An inventor is considered to have switched employers in the year s/he is associated with a patent application assigned to a different employer. Integrating the inventor-employer affiliations with the acquired-firms patent records identifies 717 firms that practiced commingling, of which 557 created commingled patents after the acquisition date.

3.2 Constructed variables

3.2.1 Outcome variables. *Firm patent stock* is defined as the cumulative number of patent applications which are ultimately successful up to a given year, aggregated to the firm-year or inventor-year level of analysis (*inventor patents stock*). These are measures of innovation quantity commonly used in the literature. To measure innovation quality, we follow the convention in the innovation literature by weighting the patent grants by the number of forward patent citations over the following four years post patent grant (and calculating the stock), resulting in the variable, *firm forward citations stock*.[3] Again, we aggregate this variable to the firm-year level of analysis, and examine the variable at the inventor-year level as well (*inventor forward citations stock*). Finally, to measure innovative activity broadening, we construct the variable, *firm cumulative patent classes*, which is a cumulative count of the number of main (3-digit) patent classes up to a given year (for analysis at the firm level), or at the inventor level (*inventor cumulative*

[2] In the interest of space, we do not provide a "thick" description of the overall data, but consider the following facts: (1) acquisition events become much more prevalent as we approach the present; (2) the top three industries of the acquired firms are: communications (23%), health and medical-related (19%), and motor vehicle-related (7%); (3) the top four nations of the acquired firms are: US (71%), UK (6%), Germany (3.6%), and Canada (3.4%); (4) within the US, the top three states of venture location are: California (31%), Massachusetts (8.5%), and Texas (6.1%); and (5) the top three acquiring firms in our sample are: Microsoft (0.58%), IBM (0.57%), and Cisco (0.41%).

[3] Our data analysis spans M&A transactions through 2014 and the associated patent data up to 2018, given the time lapse between patent filing and grant, and the four-year moving window used for forward citation tracking.

patent classes). Given the count nature of these outcome variables, our main specifications are fixed effects conditional Poisson regressions (though the results are robust to OLS estimation as well). Core variable definitions and summary statistics are contained in Table 1, while correlations are in Table 2.

---TABLES 1 & 2 ABOUT HERE---

3.2.2 Explanatory variables. We define a commingled patent as one which is produced by inventors coming together from the acquired and acquiring firms. While most commingled patents are produced after an acquisition event (6.6% of patents post-acquisition are commingled), commingling can also occur before an acquisition (in our sample, 1.1% of pre-acquisition patents are commingled). *Firm commingling intensity* is the share of the acquired entity's cumulative patent stock invented by commingled teams (*inventor commingling intensity* is similarly constructed).[4] *Post-acquisition* is a dummy variable indicating years after the acquisition. With a difference-in-differences specification, our key variable is *commingling intensity, post-acquisition*, to test the prediction relating firm-level inventor commingling with innovation outcomes.

To test our second prediction that inventor commingling is more productive under a more integrated post M&A regime, we narrow our sample to the set of 493 companies where we have evidence of pre-M&A commingling. We select all of the inventors employed by these firms before the acquisition who stayed with the focal acquired firm at least 5 years after the acquisition. These criteria are guided by the comparison we wish to make, which is inventor innovation in a more integrated regime (post-acquisition) as compared to less integrated pre-M&A cooperative modes (such as alliances). The *inventor commingling intensity* variable is defined as the share of patents in inventor *j*'s patent stock which were invented by a commingled team. The unit of analysis is an inventor-year. Note that the pre-M&A commingling criteria is applied at the firm level, thus this analysis includes variation in inventor-level commingling pre-M&A.

3.2.3 Control variables. At the firm-year level, we construct a number of variables that control for various aspects of the acquired firm's patent position and inventor experience. *Firm team knowledge diversity* is the within-team knowledge diversity across all inventor teams which have patented for the focal firm before the focal year.[5] *Firm technology concentration* is a Herfindahl index of 3-digit (main) patent classes in the firm's patent stock up to year *t* (higher values indicate more concentration of patent classes).

[4] To construct the measure of commingling, we take the pool of patents assigned to the acquired firm (329,504 patents) and compile the associated inventors (a total of 233,011 inventors). We then construct for this total inventor group the history of inventor-employers (using a similarity score of 0.8 as a threshold for matching and uniquely identifying employers). A commingled patent is one in which inventor-employers come together from the acquired and acquiring employers (not necessarily after an acquisition). Using this definition, 7,932 patents are invented by a commingled team in our dataset.

[5] Within-team knowledge diversity is defined following Jaffe (1986) and Aggarwal, Hsu & Wu (2020) as the average of the angular distance between the knowledge experience of each pair of inventors on a team were experience is measured by patent class experience vectors.

The variable, *firm-inventors*, gives a count of the number of distinct inventors at the firm in year *t*. The final three control variables in this series give firm cumulative averages of inventor innovation activity (*firm inventor avg cumulative patent counts*, *firm inventor average cumulative fcitation*, and *firm inventor avg cumulative patent classes*), somewhat akin to lagged outcome variable controls. Finally, two variables control for the acquired firm's investor base and external funding activity: *firm cumulative funding rounds* and *firm cumulative VC investors*, in each case, up to the focal year. Acquirer and acquiree firm fixed effects are also included in the specifications

At the inventor-year level of analysis, aside from acquiree-inventor fixed effects, we construct a measure of *inventor-team knowledge diversity* defined as the average angular distance between the knowledge experience of the focal inventor and that of other inventors who have co-invented with her. We further control for *inventor co-located*, an indicator for whether the inventor's most recent residential address (as listed in PatentsView) is located within a 100km distance from the acquirer's R&D center (see the next section for method), as it represents an alternative means of unsticking tacit knowledge.

Finally, to compare the effect of commingling to third party R&D collaboration, we classify acquired firm's patents into four types: (1) invented solely by inventors working for the acquired firm; (2) invented by inventors from the acquired and acquiring entity with no other collaborators (termed "commingled-only" patents); (3) invented by inventors from the acquired firm together with third party inventors that are not from the acquiring entity ("collaboration-only" patents); and (4) invented by inventors from the acquired and acquiring entity together with other third party collaborators ("commingling with collaboration" patents). We compute collaboration specific intensity variables for both firm-year and inventor-year constructs using the above classification and repeat the econometric analysis described above with these additional collaboration intensity variables added to the model.

3.2.4 Instrumental variable. The first step is to determine the R&D locations of the acquired firms. Since our aim is to construct an instrumental variable for firm commingling, we focus on the 717 acquisitions in which commingling ever occurred. If we simply constructed direct flight information from listed firm headquarters, we would miss the geographically distributed R&D activities which are common for many technology-oriented ventures. As a consequence, we take advantage of inventor residential address information (from PatentsView) to examine the geographic location of their firm's R&D activities. For each acquired firm, we gather the list of addresses of the inventors who patented before the acquisition. We first cluster these addresses at the patent level, aggregating to a circle with a radius of 50 kilometers (km). We then group these clusters based on their center so that all circles for which the center can be placed within a circle with a radius of 50 km will be considered part of the same R&D location. We define the center of each of these resulting clusters as an R&D location of the acquired firm. We keep the top 50 R&D

locations of each acquired firm, ranked by innovation intensity. Some acquired firms have multiple (and distributed) R&D locations, which we do not want to miss. Through this process, we identify 7,499 R&D locations associated with the 717 focal acquired companies, spread across 69 countries. Approximately 35% of the acquired companies have a single R&D location; however, some have many locations which are geographically dispersed. On average, each acquired company has 10.4 R&D locations (the median is 1 location). We use the same procedure to construct the R&D locations of the acquiring firms. Since some acquirers are very large, we keep the top 100 R&D locations for this group. We identify 20,231 R&D locations in 114 countries of 521 acquiring firms.

We then construct a reference dataset in which on a longitudinal basis, we record the number of direct flights which connect R&D centers *a* and *b* for the dyadic pairing of acquirers-acquired firms. We use the Air Carrier Statistics database, also known as the T-100 data bank, from the US Bureau of Transportation Statistics to measure the direct flights (this is a standard data source in the literature which uses direct flights as an instrumental variable to address the endogenous choice of geographic location). The database contains monthly reports from 1980 to 2018 for all flight routes of certified US air carriers which have at least one point of service in the US or its territories. For the 6,519,684 dyads of acquired firm R&D location-acquiring firm R&D location, we first find all airports within 100 km to the center of the focal R&D locations (which rests on an assumption of household commuting distance to the relevant airport). We aggregate the monthly data to the annual level on direct flights, by location dyad. If there is at least one route operating in a given year between the airports serving the focal R&D centers, we say those R&D centers are connected by direct flight.

With that background, we construct at the R&D center level the innovation outcome variables akin to our three main outcome variables: *location patents stock*, *location forward citations stock*, and *location cumulative patent classes*. The endogenous variable in this set up is *R&D location commingling intensity*, which is analogous to the other commingling intensity variables, though the unit here is an R&D location. The instrumental variable is *location connectedness* (defined as the number of acquirer's R&D locations which have direct flights to location *l* in year *t*) in the *post acquired* period. Finally, *location knowledge relatedness* is a control variable for the share of knowledge base overlap between the acquirer and location *l*, following Ahuja & Katila (2001). We further construct our patent controls per R&D location, akin to the firm level controls discussed above but limited to the specific R&D location data (see Table 1).

3.3 Empirical specification. Our main empirical specifications use difference-in-differences (DiD) designs.[6] To test our first prediction that post-merger integration involving a higher degree of commingling

[6] Graphical analysis suggests no evidence for pre-trends (available on request from the authors).

will be associated with improved innovation outcomes, we compare firm innovation profiles before and after the merger, as well as stratified by firms which have a higher versus lower level of commingled inventor teams. Our analysis is at the firm-year level of analysis. Since our innovation outcome variables are count variables, our main specifications use Poisson models. In addition to the main DiD variables of interest, we include a host of controls for firm and inventor composition variables, as well as several fixed effects. Since post-merger integration is certainly not randomly determined, we interpret these results as correlational. Our controls also include a measure for inventor team diversity; this is intended to test whether commingling has an independent effect beyond increased team diversity.

To assess the degree to which the results might be driven by selection (rather than treatment) effects, we exploit an exogenous shift of the costs of firm-level commingling. The introduction or removal of direct flights between the location of the acquiring and acquired firms is a decision outside of managerial control. In a two-stage least squares regression, we use direct flights between the location dyad, post-acquisition, to instrument for the potentially endogenous variable, *R&D location commingling intensity*.

Finally, to examine the prediction that commingled inventors will be more productive post M&A compared to their own commingling outcomes under alliance (pre-M&A) forms, we switch to the inventor-year level of analysis. We examine the inventor-level analogs of the innovation-level outcomes, and use a similar DiD approach, again in a Poisson regression framework given the count nature of the outcomes.

We are concerned with the potentially confounding effect of post-M&A inventor selection, as inventors or inventor teams successfully commingling pre-M&A are potentially more valuable to the post M&A entities and would have a higher representation in the post-M&A cohort of inventors. We re-run the above specifications limiting our sample to inventors who did not commingle prior to the acquisition date (for the inventor-year analysis) and to acquired-firms that started commingling only after the acquisition date (for the firm-year analysis). This analysis also allows us to verify the effect of post-M&A commingling without the potential persistence effect of pre-M&A commingling intensity on post-M&A innovation.

Finally, to examine if the effect of commingling in an M&A setting is different from that of third-party R&D collaboration, we analyze a set of models similar to our main empirical specifications with the addition of the *third-party collaboration intensity* variables described above.

4. RESULTS

Table 3 empirically tests hypothesis 1, in which our expectation is that there will be a positive relation between firm-level inventor commingling and innovation outcomes.

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The unit of analysis is a firm-year in these regressions. For each of our outcome variables, *firm patents stock*, *firm forward citations stock*, and *firm cumulative patent classes*, we present three specifications: one with just the key DiD variables (with fixed effects for year, acquiree and acquiror in all models); a second which adds to the specification the set of firm-level control variables listed in Table 1; and a third where we exclude all firms that commingled pre-acquisition. The estimation method is a conditional Poisson regression, since the outcomes are all non-negative counts (integers). The reported estimates are all expressed as incident-rate ratios (IRR), which exponentiates the estimated coefficient, and so can be interpreted relative to the number 1.0. Values above 1.0 which are statistically significant (t-statistics are included in parentheses in the tables) correspond to positive effects, while values below 1.0 correspond to negative effects. The IRR helps interpret the economic significance of the estimates: a unit increase in an independent variable scales (multiplies) the dependent variable by the estimated coefficient. Because our key variable, commingling intensity, is expressed as a ratio but does not (in our data) span the entire distribution from zero to one, we express the economic effects throughout this section as the innovation effect of a standard deviation change in commingling intensity from the mean of the variable's distribution. We only report the estimates of the key DiD variables throughout our tables, as those are the theoretical variables of interest.

In Table 3, we note that the *post-acquisition* dummy is significantly negative (IRRs below 1.0) in a few of the specifications, most robustly as related to *firm cumulative patent classes*, but also as related to *firm patents stock* when the set of firm level controls is omitted. This pattern fits with the prior literature: at the organizational level, there are two categories of cost which arise after an acquisition: (1) disrupted team standard operating procedures and routines, and (2) enhanced coordination costs. These often result in decreased post-M&A innovation output.[7]

Across all the specifications, *firm commingling intensity* is strongly positive, both in statistical and economic significance. The key variable of interest, however, in the DiD specification is *firm commingling intensity* * *post-acquisition*. This variable is also strongly positive in statistical significance (at least $p<0.01$ in all cases). To illustrate the economic significance, when all variables on the right-hand side are kept at their mean after the acquisition, the predicted patent stock = 28.0, forward citation stock = 109.0, and cumulative patent classes = 4.5. For a standard deviation increase in firm commingling intensity after the acquisition, the corresponding increases for each of these innovation outcome variables are: 16.1%, 13.6%, and 5.0%, respectively.

[7] To the first domain, Kogut & Zander (1992) propose organizational capabilities in knowledge sharing and transfer which spans both information and know-how, and transcends the associated individual knowledge. A logical consequence of M&As is comprehensive disruption of these organizational processes and domains (Ranft & Lord, 2002). Kapoor & Lim (2007) find empirical evidence consistent with this notion of disrupted organizational routines at the inventor level following M&A, though this is mitigated with time. The second cost, coordination costs, are due to unfamiliar shared norms (Haspeslagh & Jemison, 1991) and the lack of shared common ground.

Columns (7) through (9) report the results when excluding acquired firms that commingled pre-acquisition. The coefficient for *firm commingling intensity* are strongly positive and statistically significant, with $p<0.001$, across all three innovation outcome variables. We also report the positive and statistically significant coefficients for the control variable *firm team knowledge diversity* to emphasize that the effect of commingling is distinct and goes beyond team diversity.

We then move to Table 4, where we use an instrumental-variables approach in recognition of the possible endogenous process of firm commingling associated with the results from Table 3. While our approach does not address the firm-level selection of target firm, or the matching process between acquiror and acquired firms (again, our focus is on the post-merger integration literature rather than the M&A partner selection literature), we focus on the introduction (or removal) of direct flight between the two firms as an exogenous shock (outside of managerial control) to the cost of R&D collaboration. Specifically, we use *location connectedness* * *post-acquisition* as an instrument for the endogenous commingling variable (*location commingling intensity*).

---TABLE 4 AROUND HERE---

In the first two columns, we show that there is a positive and significant relation between the instrumental and endogenous variables. This is the first stage of the two stage least squares (2SLS) regression. Over the following three pairs of columns, for each of the three firm-level innovation outcome variables, we compare the OLS (un-instrumented) estimates in the odd columns with the 2SLS estimates in the even ones. The robust positive coefficient of the *location commingling intensity* in the 2SLS estimates suggests that the prior commingling intensity result is not entirely driven by commingling selection effects, but instead points to a commingling treatment effect on innovation.

Having found support for our first hypothesis, we move to testing our second prediction, that inventor commingling intensity post-M&A is associated with higher innovation performance as compared to the effect of commingling under pre-M&A (alliance) organization. In Table 5, not only do we shift the analysis to the inventor-year level, we match our sampling strategy to test the hypothesis. Specifically, inventors in our sample are those who stayed at the merged firm at least 5 years after the M&A (following Kapoor & Lim, 2007) from firms which have coinvented patents with their acquirers before the acquisition (and so all of the inventors in the sample worked at firms with commingled patents). In this sample, we can compare inventor innovation profiles under an integrated regime (after the M&A) as compared to their own output under a pre-M&A regime (3,030 out of the 43,936 inventors in this sample commingled with the acquirer's inventors before acquisition).

---TABLE 5 AROUND HERE---

Due to the count nature of the innovation outcomes, we return to Poisson estimation with a variety of fixed effects. All estimates are again expressed as IRRs, with values above 1.0 corresponding to positive effects and those below 1.0 associated with negative effects. Each specification in Table 5 contains acquiree-inventor fixed effects as well as year fixed effects. The odd columns omit the control variables, while the even specifications contain those controls.

The key variable of interest in the DiD specification is *inventor commingling intensity * post - acquisition*. This variable is strongly positive and significantly different than zero statistically (at least $p<0.001$ in all cases). To illustrate the economic significance, when all variables on the right-hand side are kept at their mean after the acquisition, the predicted patent stock = 6.0, forward citation stock = 34.8, and cumulative patent classes =2.7. For a standard deviation increase in inventor commingling intensity after the acquisition, the corresponding increases for each of these variables are: 14.0%, 2.4%, and 5.8%, respectively, in innovation outcomes. These results are consistent with the prediction contained in hypothesis 2.

To address post-M&A inventor selection, as well as possible pre-M&A commingling effects on post M&A innovation outcomes, we exclude inventors who had commingled-innovation-outcomes pre-M&A (columns (7) through (9)). The coefficients for *inventor commingling intensity* indicate a strong positive commingling effect, and are statistically significant ($p<0.001$) across all innovation outcomes.

Table 6 compares the effect of commingling intensity to that of innovation collaboration with other third parties under an M&A setting. Results are consistent with those reported in the main analysis with positive and highly significant coefficients ($p<0.001$) for *commingling intensity* and *commingling intensity * post acquired* at both the firm and investor level analysis. Interestingly in this M&A setting, collaborating with inventors from third parties other than the acquiring entity inventors significantly decreases innovation outcomes, with the exception of *inventor cumulative patent classes* which increase with third-party collaboration intensity.

---TABLE 6 AROUND HERE---

5. DISCUSSION & CONCLUSION

We introduce the concept of post-merger inventor commingling as a means of improving innovation outcomes and show that post-M&A commingling increases patent output and scope, supporting enhanced innovation for both the acquired firm and the individual inventor. We further show that the effect of commingling is significant and distinct from the effect of team knowledge diversity and third-party collaboration. We also provide evidence that in M&A settings of technology-oriented ventures, inventor innovation outcomes improve when a given inventor is in a post-M&A commingling regime as compared to when that inventor is in a less integrated pre-M&A alliance regime.

Within the broader literature on post-merger integration for innovation, we share the thesis that organizational design choices matter significantly for M&A success. While the prior literature has focused on what might be thought of as centralized corporate policy action such as dedicated alliance integration departments, codifying knowledge via manuals, and more generally when to structurally integrate the target entity with the acquirer (as we briefly reviewed in our literature discussion), our focus is more at the production of innovation level. We believe this focus on literal knowledge recombination at the inventor and production team level is novel to the post-merger integration literature (and is a separate construct from the typical (R&D production) team composition one, e.g., Aggarwal, Hsu & Wu (2020)). Of course, broader corporate policies such as structural integration as well as the mode or form of R&D cooperation certainly influence the degree of post-merger commingling.

By defining the commingling construct and evaluating its effects under a change in the integration and control regime, we hope we have laid the groundwork for extensions and new avenues for research. Before we discuss a few such possibilities, we would also like to call attention to a number of limitations and interpretational issues with the study. First, our analysis of inventor-level innovation output under different modes of organizing R&D (including alliance activity with or without the eventual acquirer) are all conditioned on a longitudinal sample of inventors who all eventually experienced an acquisition event. This is an opportunity for future research to strengthen the generalizability of the results reported here by undertaking a sampling strategy which does not have this dependence. To understand possible selection effects or boundary conditions, future research would ideally draw from a broader sample of inventors to better understand the role of commingling. Doing so may entail matching individuals and firms on observables to build counterfactual samples for comparison.

Another set of inherent limitations stem from using patent data. Not only is there the well-known censoring issue associated with not observing patent applications which were not granted (and therefore the distribution of patent inventor composition necessary to measure commingling), there is likely a complex process shaping the antecedents of firm and inventor commingling identified from the patent data. In the present analysis, we take as given inventor stayers and leavers post-acquisition. The process governing this choice is clearly intentional and multifaceted (involving the inventor and/or the acquiring firm), and of course the employment contract(s) are unobserved. Among the stayers, organizations may target certain individuals for commingling in ways which are unobserved and unmeasured. More generally, commingled teams may result from serendipity or from managerially-placed organizational design choices (some of which have been discussed in the literature). Future research in this domain would ideally improve our understanding of the antecedents of inventor commingling. Doing so would also help build a bridge between the two main branches of the technology M&A literature: partner selection versus post M&A integration studies.[8]

With these caveats in place, we would like to end by discussing a related topic which we hope future researchers will tackle: drawing a more definitive link between authority and control associated with M&A (which was unobserved to us) to innovation outcomes, especially as it relates to alternative but less integrated cooperative forms. Without full ownership, as would be the case in strategic alliances, the counterparties must contractually specify the boundaries of the joint development, and incur transaction and governance/oversight costs in the arrangement. For example, in technology development alliances, contractual covenants specifying technical staff (even the exact identity of such individuals) is relatively common (Ryall & Sampson, 2009). In addition, because alliances are often *project*-level collaborations (unlike mergers/acquisitions), no firm-level control rights are typically allocated (Robinson & Stuart, 2007). Both of these challenges are mitigated under an M&A setting. Our hope is that the concepts developed here will open new avenues for subsequent work on post-merger technology integration, as well as more broadly on modes of R&D cooperation.

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[8] More generally, there are a number of selection issues at work on both sides of the acquisition market which makes this bridge work challenging. Consider organizing for innovation from the perspective of the acquirer. There are a host of internal conditions and choices which shape the degree to which the potential acquirer looks to the external environment for R&D collaboration of any sort (including acquisitions). Some of these conditions are unobserved and unmeasured, such as incumbent manager expectations about the pace of innovation in a given domain, the value of control under different states of the world (e.g., Forbes & Lederman, 2009) and more generally the rationale for undertaking inter-organizational R&D work in the first place (e.g., Cunningham, Ederer & Ma, forthcoming).

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TABLE 1: Focal variable definitions and summary statistics

Variable	Definition	Mean	SD
Firm-year level of analysis			
Firm patents stock	Stock of patents of acquired firm *i* in year *t*. A patent filed before year *t* will be included in firm *i*'s patent stock if (i) the patent was directly assigned to firm *i* , or (ii) the patent was filed after the acquisition, assigned to the acquirer, and had at least one inventor from firm *i*	32.44	393.10
Firm forward citations stock	Forward citations to firm *i*'s stock of patents within 4 years since patent grant	99.95	1315.1
Firm cumulative patent classes	Number of distinct 3-digit (main) technology classes for firm *i*'s patent stock	4.22	6.76
Firm commingling intensity	Share of patents which were invented by commingling teams in firm *i*'s patent stock $Firm\ commingling\ intensity = \frac{cumulative\ \#\ of\ patents\ invented\ by\ commingling\ teams\ by\ year\ t}{firm\ i's\ patent\ stock\ in\ year\ t}$	0.013	0.076
Post-acquisition	Dummy=1 if *t* >= acquired year	0.29	0.45
Firm team knowledge diversity	Average within-team knowledge diversity across all inventor teams which have patented for firm *i* before year *t*. Within-team knowledge diversity is defined following Jaffe's (1986) similarity measure and Aggarwal, Hsu, and Wu (2020).	0.18	0.17
Firm cumulative funding rounds	Cumulative # of funding rounds the firm has received up to year *t*	0.44	1.15
Firm cumulative VC investors	Cumulative # of venture capitalists who have invested in the firm up to year *t*	0.44	1.30
Firm technology concentration	Herfindahl index of firm *i*'s patent distribution among 3-digit (main) patent technology classes $Firm\ technology\ concentration_{it} = \sum_{s=1}^{N}(\%\ of\ patents\ in\ tech.\ class\ s\ in\ firm\ i's\ current\ patent\ stock)^2$	0.45	0.34
Firm inventors	Number of inventors working for firm *i* in year *t*	17.54	129.8
Firm inventor avg cumulative patent counts	Average patenting experience (cumulative patent counts) among firm *i*'s inventors	5.37	6.26
Firm inventor avg cumulative fcitation	Average patenting experience (cumulative patent counts weighted by forward citation) among firm *i*'s inventors	33.53	69.15
Firm inventor avg cumulative patent classes	Average patenting experience (cumulative patent class counts) among firm *i*'s inventors	2.76	1.71
Inventor-year level of analysis			
Inventor patents stock	Inventor *j*'s patent stock in year *t*	5.74	12.22
Inventor forward citations stock	Forward citations to inventor *j*'s patents stock within 4 years since patent grant(s)	30.04	112.10
Inventor cumulative patent classes	Number of distinct 3-digit (main) technology classes to inventor *j*'s patent stock	2.63	2.23
Inventor commingling intensity	Share of patents in inventor *j*'s patent stock which were invented by a commingling team	0.022	0.13
Inventor team knowledge diversity	The average angular distance between the knowledge experience of the focal inventor and that of other inventors who have co-invented with her	0.22	0.20
Inventor co-located	Dummy=1 if the inventor's current address (registered on the most recent patent document) is located within 100km of the acquirer's R&D center	0.24	0.42
R&D location-year level of analysis			
Location patents stock	An R&D location is defined as a 100km-radius cluster of inventors (addresses) who worked for firm *i* before the deal. Inventor *j* works in location *l* if her residential address locates in this 100km-radius cluster. Location *l*'s patent stock is the pool of patents which are invented by inventors working in location *l* and filed before year *t*.	17.25	111.3
Location forward citations stock	Forward citations to location *l*'s patent stock within 4 years since patent grant(s)	56.72	458.4
Location cumulative patent classes	Number of distinct 3-digit (main) technology classes for location *l*'s patent stock	3.94	4.70
Location commingling intensity	Share of patents in location *l*'s patent stock which were co-invented by inventors of firm *i* working in location *l* and inventors from the acquirer	0.038	0.16
Location team knowledge diversity	Average within-team knowledge diversity across all teams associated with the location *l*'s current patent stock	0.23	0.17
Location connectedness	Number of acquirer's R&D locations which have direct flights to location *l* in year *t*.	18.99	19.96
Location knowledge relatedness	*Relatedness = overlapped-knowledge-base / total knowledge-base of acquired R&D location* Knowledge base is defined following Ahuja & Katila (2001).	0.13	0.29

TABLE 2: Correlation matrix

FIRM YEAR LEVEL VARS		1	2	3	4	5	6	7	8	9	10	11	12	
1	*Firm patents stock*	1.000												
2	*Firm forward citations stock*	0.934	1.000											
3	*Firm cumulative patent classes*	0.467	0.406	1.000										
4	*Firm commingling intensity*	0.002	0.004	0.014	1.000									
5	*Post-acquisition*	0.016	0.012	0.137	0.096	1.000								
7	*Firm team knowledge diversity*	0.029	0.021	0.203	0.064	0.020	1.000							
6	*Firm cumulative funding rounds*	-0.015	-0.007	-0.032	0.057	0.120	0.050	1.000						
8	*Firm cumulative VC investors*	-0.013	-0.006	-0.028	0.049	0.105	0.052	0.793	1.000					
9	*Firm technology concentration*	-0.033	-0.020	-0.181	0.003	0.181	-0.244	0.146	0.136	1.000				
10	*Firm inventors*	0.824	0.713	0.568	-0.002	0.027	0.047	-0.022	-0.019	-0.037	1.000			
11	*Firm inventor avg cumulative patent counts*	0.044	0.050	0.073	0.083	0.027	0.173	0.097	0.089	-0.035	0.019	1.000		
12	*Firm inventor avg cumulative fcitation*	0.024	0.062	0.008	0.081	0.023	0.072	0.146	0.134	0.045	-0.000	0.664	1.000	
13	*Firm inventor avg cumulative patent classes*	0.009	0.005	0.173	0.011	-0.045	0.321	-0.031	-0.032	-0.389	0.002	0.553	0.266	1.000

INVENTOR YEAR LEVEL VARS		1	2	3	4	5	6
1	*Inventor patents stock*	1.000					
2	*Inventor forward citations stock*	0.567	1.000				
3	*Inventor cumulative patent classes*	0.512	0.278	1.000			
4	*Inventor commingling intensity*	0.056	0.054	0.039	1.000		
5	*Inventor team knowledge diversity*	0.076	0.016	0.334	0.036	1.000	
6	*Inventor co-located*	-0.021	-0.021	-0.012	-0.068	-0.068	1.000

TABLE 3: Estimated effects of commingling on firm innovation

	Full sample						Excluding firms that commingled pre-acquisition		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Firm patent stock		Firm forward citations stock		Firm cumulative patent classes		Firm patent stock	Firm forward citation stock	Firm cumulative patent classes
*Firm commingling intensity * post-acquisition*	2.423*** (8.39)	2.045*** (8.00)	2.063*** (4.47)	1.590** (3.11)	1.319*** (5.73)	1.224*** (6.34)			
Post-acquisition	0.962* (-2.17)	1.002 (0.18)	0.966 (-1.51)	0.999 (-0.04)	0.987*** (-3.80)	0.995 (-1.94)	1.021 (0.97)	1.053* (2.19)	1.004 (1.26)
Firm commingling intensity	5.630*** (12.20)	4.667** (12.04)	4.694*** (6.37)	1.590*** (3.11)	1.469*** (5.65)	1.559*** (9.82)	9.218*** (16.04)	5.277*** (10.23)	2.329*** (15.61)
Firm team knowledge diversity		2.571*** (6.24)		1.355 (1.50)		1.479*** (13.70)	3.013*** (12.07)	2.087*** (6.04)	1.550*** (15.42)
Firm level controls	N	Y	N	Y	N	Y	Y	Y	Y
Acquiree/Acquirer/Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	101,250	84,442	91,685	77,597	101,250	84,442	76,554	69,756	76,554

*Notes: This table reports exponentiated coefficients in incidence-rate ratios (values greater (less) than 1.0 represent positive (negative) effects) and t-statistics (in parentheses) from conditional Poisson regressions at the firm-year level. Standard errors are robust. * p<0.05, ** p<0.01, *** p<0.001. Firms in the firm-year panel are target companies in the Crunchbase M&A database who are also listed in the PatentsView database and were acquired before 2014. The control variables are listed in Table 1.*

TABLE 4: Estimated effects of team commingling on innovation - IV regressions at the R&D location level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1st stage regression		OLS versus 2SLS IV regressions					
	Location commingling intensity		Log (location patents stock+1)		Log (location forward citations stock+1)		Log (location cumulative patent classes+1)	
Regression model			OLS	IV	OLS	IV	OLS	IV
*Location connectedness * post-acquisition*	0.000194*** (3.85)	0.000151** (3.01)						
Location connectedness	-0.0000634 (-0.48)	-0.000143 (-1.05)						
Post-acquisition	0.00209 (1.77)	-0.00114 (-0.94)	-0.00173 (-0.25)	-0.0142 (-1.36)	-0.0159 (-1.70)	-0.0273* (-2.23)	-0.00739 (-1.91)	-0.0168* (-2.45)
Location commingling intensity			0.804*** (7.67)	7.663* (2.48)	1.049*** (6.54)	7.339* (2.24)	0.181*** (3.06)	5.351** (2.68)
Controls	N	Y	Y	Y	Y	Y	Y	Y
Location & Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	102,864	80,176	80,176	80,209	80,176	80,209	80,176	80,209

*Notes: This table reports coefficients and t-statistic (in parentheses) from OLS/2SLS regressions at the R&D location-year level. Standard errors are robust. * p<0.05, ** p<0.01, *** p<0.001. A firm's R&D location is defined as a 100km-radius cluster of the residential addresses of inventors who patented for the firm before the acquisition. Control variables are listed in Table 1.*

TABLE 5: Estimated effects of commingling on inventor innovation

	Full sample						Excluding inventors who commingled pre-acquisition		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Inventor patent stock		Inventor forward citations stock		Inventor cumulative patent classes		Inventor patent stock	Inventor forward citations stock	Inventor cumulative patent classes
*Inventor commingling intensity * post-acquisition*	1.880*** (17.00)	1.625*** (14.67)	1.735*** (12.63)	1.386*** (8.27)	1.168*** (8.85)	1.174*** (9.19)			
Post-acquisition	1.028*** (10.91)	1.042*** (18.09)	0.944*** (-7.97)	0.959*** (-6.25)	1.011*** (13.56)	1.018*** (22.75)	1.044*** (18.43)	0.976 (-2.90)	1.019*** (24.1)
Inventor commingling intensity	4.347*** (27.92)	3.482*** (25.29)	2.731*** (15.3)	2.541*** (15.73)	1.968*** (26.89)	1.785*** (21.35)	11.270*** (37.81)	4.177*** (21.24)	2.521*** (31.03)
Firm and inventor controls	N	Y	N	Y	N	Y	Y	Y	Y
Acquiree-Inventor fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	634,079	588,867	568,510	528,912	627,429	582,704	574,270	514,599	568,312

*Notes: This table reports exponentiated coefficients in incidence-rate ratios (values greater (less) than 1.0 represent positive (negative) effects) and t-statistics (in parentheses) from conditional Poisson regressions at the inventor-year level. Standard errors are robust. * p<0.05, ** p<0.01, *** p<0.001. Inventors are from 493 acquired companies which collaborated with the acquirer in R&D on at least one patent prior to the acquisition. Total number of inventors working for these acquired entities (based on patent filings) is 54,559, of which 7,118 joined after the transaction and 3,515 started to patent for another company within 5 years after the M&A. Full sample includes 43,936 inventors observed as working for the acquired pre-and post-deal. For subsample regressions (columns 7-9), we exclude inventors who commingled with the acquirer prior to the acquisition. Control variables are listed in Table 1.*

TABLE 6: Commingling versus third party collaboration

	(1)	(2)	(3)	(4)	(5)	(6)
	Firm patent stock	Firm forward citations stock	Firm cumulative patent classes	Inventor patent stock	Inventor forward citations stock	Inventor cumulative patent classes
Post-acquired	0.998 (-0.13)	0.990 (-0.54)	0.995 (-1.84)	1.039*** (16.86)	0.956*** (-6.75)	1.017*** (21.45)
*Post-acquired * firm/inventor commingled-only patent intensity*	2.189*** (8.39)	1.731** (3.18)	1.215*** (5.69)	1.358*** (11.69)	1.288*** (8.89)	1.096*** (10.05)
Firm/inventor commingled-only patent intensity	4.032*** (11.11)	2.634*** (3.80)	1.560*** (9.27)	2.594*** (16.53)	2.086*** (13.40)	1.541*** (18.81)
Firm/inventor collaboration-only patent intensity	0.190*** (-10.72)	0.185*** (-8.27)	0.783*** (-9.46)	0.925 (-1.07)	1.068 (0.57)	1.214*** (6.02)
Firm/inventor commingled with collaboration patent intensity	5.104*** (3.91)	7.034** (2.60)	1.465** (2.93)	4.063*** (13.44)	3.682*** (10.10)	1.611*** (10.54)
Observations	84,442	77,597	84,442	588,867	528,912	582,704

*Notes: This table reports exponentiated coefficients in incidence-rate ratios (values greater (less) than 1.0 represent positive (negative) effects) and t-statistic (in parentheses) from conditional Poisson regressions at the firm-year level. Standard errors are robust. * p<0.05, ** p<0.01, *** p<0.001. Models study four inventor collaboration types: Patents invented solely by inventors working for the acquired firm, patents having inventors from the acquired and the acquiring firm, but not other inventors (commingled-only patents), patents having inventors from the acquired firm and from third parties other than the acquirer (collaboration-only patents) and patents having inventors from the acquired firm, the acquiring firm, and other third parties (commingled with collaboration patents). The intensity of each of the patent types is defined as the share of each patent type (based on the commingling and/or collaboration classification) in the firm's or inventors current patent stock. Firms included in these specifications are the same as those reported in the full sample columns of Tables 3 & 5. All regressions control for year fixed effects, firm level controls (listed in Table 1). Regressions in columns (1)-(3) control acquiree fixed effects, and regressions of columns (4)-(6) control acquiree-inventor fixed effects and other inventor-level controls.*