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Not in-sourced here! When does external technology sourcing yield familiar versus novel solutions?

Thomas Klueter[1] | **Anindya Ghosh**[2] | **Lori Rosenkopf**[3]

[1]IESE, Barcelona, Spain

[2]Tilburg University, Tilburg, Netherlands

[3]The Wharton School, University of Pennsylvania, Philadelphia, Pennsylvania, USA

Correspondence
Thomas Klueter, IESE Barcelona, Spain.
Email: TMKlueter@iese.edu

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Abstract

Research Summary: When established firms source technology from specialized technology firms, extant research has typically assumed that this in-sourced technology is *novel*. We test this assumption by modeling in-sourcing decisions using a problem-solution lens wherein firms choose from available external technological solutions to solve their market problems. Since the locus of identification, evaluation, and selection of external solutions remains internal to the firm's R&D personnel, we argue that they frequently prefer *familiar* over *novel* solutions. We identify two factors that help firms overcome this preference for familiarity: when top managers focus their attention on the market problem or when they receive feedback from unexpected failures to solve that problem. Our case control analysis of 715 in-sourced emerging technological solutions in the biopharmaceutical industry offers broad support to our theoretical framework.

Managerial Summary: Established firms are commonly advised to source novel technologies

externally. Yet since this sourcing process is driven by in-house R&D personnel, we suggest that a firm's choice of external technology solutions may still tend toward familiar ones. We confirm this preference by examining in-sourcing events of emerging technological solutions by established firms in the biopharmaceutical industry. Despite this preference, we then show that increased top management attention toward a market problem and experiencing unexpected failures in bringing products to market catalyze a receptiveness to novel technological solutions. Our findings help managers in established firms recognize that their claims or intentions to seek novel technology are not always consistent with actual in-sourcing choices, and suggest when firms can overcome this tendency.

KEYWORDS

partnering, problems and solutions, technology sourcing, top management attention, unexpected failure experiences

1 | INTRODUCTION

Corporate entrepreneurship relies on exploration for new technologies to develop and introduce new products that solve market problems (Agarwal & Helfat, 2009; Katila & Ahuja, 2002; Roberts, 1999; Rosenkopf & McGrath, 2011). Established firms often struggle to pursue new technologies internally due to the constraints of existing processes, routines and managerial beliefs that tend to favor the familiar (Benner & Tripsas, 2012; Gavetti & Levinthal, 2000; Helfat, 1994; Leonard-Barton, 1992). To counter these tendencies, established firms with downstream complementary assets frequently seek technological solutions and opportunities outside their boundaries by partnering with smaller specialized technology firms (Anand et al., 2010; Bhattacharya et al., 2015; Eklund & Kapoor, 2022; Tyler & Caner, 2016). External technology sourcing allows established firms to add technological knowledge from specialized firms that work at the technology frontier, which can ultimately improve their innovative and financial performance (Hagedoorn & Schakenraad, 1994; Nicholls-Nixon & Woo, 2003; Stuart, 2000; Wadhwa & Kotha, 2006).

While prior research suggests that external technology sourcing enables access to novel technological knowledge from specialized technology firms (Klueter & Monteiro, 2017; Leiponen & Helfat, 2010; Phene et al., 2012; Rosenkopf & Almeida, 2003), the assumption that in-sourcing yields novelty requires more systematic analysis. Since prior studies typically study partnerships formed for in-sourcing without explicitly identifying the specific technological opportunities that are available to established firms (Diestre &

Rajagopalan, 2012; Rothaermel & Boeker, 2008), it is difficult to determine whether the solutions available from specialized technology firms are novel or familiar to the established industry players.

Therefore, we shift the unit of analysis from partnerships to technological opportunities, modeling in-sourcing as a consequence of organizational search where established firms with market *problems* look for and select external technological opportunities from specialized new technology providers offering potential *solutions* to these problems (Berchicci et al., 2019; Dutt & Mitchell, 2020).[1] Separating spaces of problems and solutions closely aligns with seminal work in behavioral theory (Cohen et al., 1972; March & Simon, 1958) and allows us to distinguish novel solutions not previously used by an established firm in the problem space from familiar ones. Further, by acknowledging that the problem space is oriented toward market needs and the solution space centers on technologies that help fulfill those needs, we can move beyond a unitary characterization of the firm as the decision maker for in-sourcing by identifying different functional actors predominant in each space. Specifically, market-oriented top managers have greater weight in the problem space, while specialist R&D personnel have the most influence in the solution space, allowing us to delve into the consequences for in-sourcing decision-making involving multiple actors (Ghosh & Klueter, 2022).

We contend that the cognitive and experiential forces that promote familiar solutions in internal R&D activities (Gavetti & Levinthal, 2000; Katz & Allen, 1982) are also prominent when sourcing technologies externally because the locus of identification, evaluation and selection of external solutions remains with in-house R&D personnel. Despite this R&D-driven tendency toward familiar solutions, we explore two factors driven by market-oriented top managers that can increase the tendency of firms to in-source novel technological solutions. First, when managers *focus* on a problem space by devoting more attention to it, R&D personnel may consider a broader range of solutions beyond the ones that are habitual (Ghosh & Klueter, 2022; Li et al., 2013; Ocasio, 1997; Piezunka & Dahlander, 2015). Second, we posit that unexpected failures in the problem space provide *feedback* (e.g., Eggers, 2016; Haunschild & Sullivan, 2002; Kim et al., 2009; Madsen & Desai, 2010; Tzabbar et al., 2023) that increases scrutiny of how problems are solved, challenging the status quo and making novel external technology sourcing more likely.

We test our theoretical framework in the context of the global biopharmaceutical industry between 1995 and 2015, a period in which in-sourcing technological opportunities from specialized technology firms was highly prevalent and important (Bhattacharya et al., 2015). We focus on the most common in-sourcing events, including licensing, alliance agreements and acquisitions, where we track technologies accessed through in-sourcing agreements. We construct a solution space of 1613 unique emerging technological opportunities offered by 480 specialized technology firms and examine which of these opportunities established firms ultimately pursued through 715 external technology sourcing events. While our findings show a clear preference for familiar solutions to problems, we then illustrate how top management focus on problems, as well as feedback from unexpected failures in bringing products to markets, can increase firms' preferences for novel technological opportunities in external technology sourcing.

[1]In this article, established firms in an industry have an existing product portfolio on the market. Conversely, startups attempt to enter the industry by offering both complementary and novel products and services.

2 | THEORY AND HYPOTHESES

2.1 | External technology sourcing by established pharmaceutical firms: A quest for novelty?

Recent studies have positioned in-sourcing as a key approach by which established firms discover and incorporate emerging technological opportunities from specialized nascent firms in a variety of industries (Anand et al., 2010; Kapoor & Klueter, 2015; Titus Jr et al., 2017; Wadhwa & Kotha, 2006). In particular, in industries in which existing technologies are quickly rendered obsolete or competitive advantages are temporary due to the expiration of patents, established industry players need to continuously replenish their pipeline of future products (Bierly & Chakrabarti, 1996; Eklund & Kapoor, 2022). Here, external technology sourcing is an important strategy as it allows firms to access readily available external R&D solutions (Moreira et al., 2020). As an example, established pharmaceutical firms with a strong presence in downstream product markets and in possession of complementary assets frequently in-source technologies from specialized technology firms (Nicholls-Nixon & Woo, 2003; Rothaermel & Boeker, 2008), often via dedicated units with the mandate to seek and source external technological opportunities (Klueter & Monteiro, 2017; Monteiro, 2015).

Studies of external technology sourcing demonstrate that established firms access technologies from specialized firms that work on scientific and technological frontiers and benefit from crossing organizational boundaries (Anand et al., 2010; Kapoor & Klueter, 2015; Rosenkopf & Nerkar, 2001). They also suggest that these actions provide access to novelty (e.g., Phene et al., 2012; Wadhwa & Kotha, 2006) and help firms counterbalance their entrenchment in familiar technological paths (Anand et al., 2010; Leonard-Barton, 1992; Nicholls-Nixon & Woo, 2003; Rosenkopf & Almeida, 2003; Sørensen & Stuart, 2000; Tyler & Caner, 2016). Since adding new knowledge to a firm's repertoire can complement existing capabilities and improve the potential for knowledge recombination (Cassiman & Veugelers, 2006; Laursen, 2012; Rosenkopf & Almeida, 2003), executives in high technology industries often emphasize the importance of exploring novel technologies and suggest external technology sourcing as a possible strategy, such as Sanofi's former CEO Chris Viehbacher in 2011:

> "There has to be some element of disruptive thinking to have innovation, and I can tell you that big companies do everything to avoid any new thinking in their companies. So, you want to work with companies early that are a little bit more disruptive in thinking, and bring those competencies together."

At the same time, research on external technology sourcing typically centers on partnership formations among firms (Ahuja et al., 2009; Rothaermel & Boeker, 2008), but researchers' inability to systematically discern which technologies are actually accessed hinders identification of whether in-sourced technologies are familiar or novel to established firms.

2.2 | External technology sourcing by established firms: A problem-solution lens

Pioneering work by the Carnegie School studied organizational search by separating problems and solutions into distinct spaces (Cohen et al., 1972; Cyert & March, 1963). Applying this lens

to in-sourcing external technologies, established firms typically start their search with a broad problem definition driven by market needs (Dutt & Mitchell, 2020). Market problems represent key issues top managers consider relevant and help position their organizations within the competitive landscape (Dutton & Ashford, 1993; Park et al., 2002). These issues tend to be the priority for the top management and serve as guides for lower-level managers and the rest of the organization in their pursuit of technological solutions to help solve these problems (Dougherty & Dunne, 2011; Ocasio, 2011).

As an example, in the biopharmaceutical context, established firms are typically embedded in and serve the needs of specialized therapeutic markets representing problems, such as oncology, cardiovascular or neurology (Girotra et al., 2007). In their annual reports, firms separate these therapeutic markets in terms of sales and benchmark each broad area vis-à-vis their competitors (Diestre & Rajagopalan, 2012; Hoang & Rothaermel, 2005). Therefore, these problem areas define where firms compete in the product market and determine a firm's competitive position versus its industry rivals (Moreira et al., 2020; Roberts, 1999). Typically, firms engage in organizational search through evaluating external technological opportunities from specialized technology firms that they could add as possible solutions in these areas (Klueter et al., 2024; Klueter & Monteiro, 2017). It is not known ex-ante which of those technological solutions will succeed, and at what level of payoffs and, thus, established firms typically assess and select among a range of technological opportunities that are available from outside their organization (Monteiro & Birkinshaw, 2017; Rosenkopf & McGrath, 2011).

Importantly, technological solutions comprising the solution space tend to be highly specialized, while managers focus on broader market problems and opportunities (Simons, 1994). In the context of the biopharmaceutical industry, for example, specialized technology firms often work on the scientific frontier of molecular biology, combinatorial chemistry, or pharmacokinetics (Anand et al., 2010). Consequently, the assessment of external in-sourcing opportunities and the evaluation of these potential solutions is typically undertaken by highly specialized internal R&D personnel (Brennecke et al., 2021; Dahlander et al., 2016; Klueter & Monteiro, 2017), while top management teams (TMTs) are more focused on the strategic issues of allocating resources among problem areas. This separation allows us to explore different orientations and goals in the problem and solution spaces due to the relative emphasis of these actors (Gaba & Greve, 2019; Greve & Gaba, 2017).

2.3 | Preferences for familiar solutions in external technology sourcing

Extant studies of internal R&D activity have extensively documented incumbents' tendency toward preferring familiar solutions in internal R&D due to their entrenchment in previously pursued technological paths (Helfat, 1994; Henderson, 1993; Leonard-Barton, 1992). External technology sourcing has been suggested as an antidote to such behavior, especially in the biopharmaceutical industry (Anand et al., 2010; Nicholls-Nixon & Woo, 2003; Tyler & Caner, 2016). At the same time, researchers have documented the "not invented here" syndrome, whereby in-house R&D personnel reject external solutions because they favor familiar internal solutions over those found outside organizational boundaries (Katz & Allen, 1982). Such forces that drive firms toward familiar solutions internally may also apply when firms cross organizational boundaries. Since the locus of identification, evaluation, and selection of external solutions remains inside the organization and typically involves in-house R&D

personnel (Klueter & Monteiro, 2017; Monteiro, 2015), we might expect a reversion to less novel approaches, even when in-sourcing external technologies.

With regard to identifying novel technologies, R&D personnel and R&D managers evolve highly specialized problem-solving competencies that shape their fundamental cause-and-effect representations of how problems and solutions are related (Lei et al., 1996). Following the seminal ideas of Simon (1955), boundedly rational individuals harbor imperfect mental models, causal maps, and beliefs about how their interpretation and choices lead to subsequent outcomes that limit the range of technological alternatives considered feasible as solutions for the firm's problems (Dutt & Mitchell, 2020; Eggers & Kaplan, 2009; Eggers & Kaul, 2018; Kaplan & Tripsas, 2008). When pursuing external emerging technological opportunities, existing mental models likely shape which solutions are articulated to be feasible, particularly when there are many different alternatives (Piezunka & Dahlander, 2015). When R&D personnel use their own knowledge as a reference point to decide which technologies to in-source, that can limit the subset of alternatives they consider feasible to the ones with which they are familiar (Jansen et al., 2005; Monteiro, 2015). In other words, as R&D personnel accumulate experiences on which solutions address problems, they likely perceive those familiar solutions as adequate (Antons & Piller, 2015). This issue of identification is exemplified by the narrative of specialized R&D personnel at Merck with the mandate to source in external technologies.

> There **are a few people that you cannot really have a conversation with**. One said to us: we're looking at tech 1 and 2 to support our internal development. ..., then **the only external technological opportunities** they were interested in were those with tech 1 and 2. They do not want to see anything else. (Merck, Technology Scout, own interview)

With regard to evaluating and selecting novel technologies, researchers have documented that, once identified, external technological opportunities are often evaluated in a biased and economically suboptimal way (Antons & Piller, 2015). This is because information processing relies partly on established cognitive mental maps as to what constitutes acceptable external solutions to solve problems. These solutions are defined as being adequate by in-house R&D personnel, and this can lead to unfavorable evaluations of solutions that are novel and not within the expertise and mental maps of the evaluators (Monteiro, 2015). For example, when contrasting alternatives presented for evaluation at Merck, those technological opportunities that had been put on a "needs list" ex-ante received favorable evaluations by in-house R&D personnel, which reduced Merck's propensity to evaluate favorably a novel technology.

> The fact that **the technology was not on our search list** may make it more interesting because **it's novel and people haven't really considered it yet**. This is **very frustrating** as this means **if it's not in our list, we should not pursue it** (Merck, Director, World Wide Licensing, own interview).

Issues of evaluations and selection are exacerbated as firms accumulate experiences in R&D over time, which are often encoded and retained into routines (Gavetti & Levinthal, 2000). When considering the in-sourcing of external technologies such routines may make firms perceive emerging external technological solutions as being more predictable when they are familiar compared to opportunities that are novel. For novel technological solutions, estimating future resource needs to commercialize is more uncertain and likely more costly as firms

cannot rely on established and predictable internal routines (Katz & Allen, 1982; Titus Jr et al., 2017). This is in sync with the observation that resource allocation routines make firms more hesitant to invest in projects with high technological uncertainty (Oriani & Sobrero, 2008), and less likely to commit to the development of projects utilizing novel technologies (Arora et al., 2009).

Moreover, as both quotes from Merck highlight, in-house R&D scientists may prefer that external technology sourcing serves as an extension and reinforcement of their existing internal R&D projects (Eggers & Kaul, 2018; Levinthal & March, 1993). Typically, in the context of established firms in high technology industries, R&D personnel are incentivized by their expertise and the specialized knowledge they have accumulated over their careers, and, in contrast to managers, predominantly receive fixed and not variable pay (Galbraith & Merrill, 1991). As such, R&D personnel may be inclined to maintain and reinforce the internal solutions they have experiences with, even when crossing organizational boundaries. In sum, cognitive factors and mental maps, as well as organizational routines, shape the identification and evaluation of external novel technological opportunities so that when exposed to a range of external opportunities, firms may tend to select those which are more familiar with respect to their previous problem-solving attempts. Therefore:

> **Hypothesis 1.** (H1) When in-sourcing external technologies for a problem area, firms are more likely to select familiar solutions than novel ones.

2.4 | Factors encouraging the in-sourcing of novel external technologies

Hypothesis 1 establishes the baseline tendency of established firms for the familiar, suggesting that firms disproportionately end up choosing familiar solutions to their problems, although they often frame their external technology sourcing initiative as a "quest for novelty." This disconnects between the rhetoric of novelty and the reality of a tendency toward the familiar motivates the important follow-on question of when firms do actually in-source novel technological solutions. We therefore pivot our attention to factors that would drive firms to in-source *novel* technological solutions despite the prevailing tendency toward the familiar. Our argumentation in Hypothesis 1 has been limited to R&D personnel working directly in the solution space without examining the influence of top managers who are oriented toward markets and the related problem space. We examine two specific factors in the problem space—"focus" and "feedback"—that allow top managers to direct and redirect R&D personnel working in the solution space toward more novel technological solutions. First, to incorporate the high-level strategic priorities of the firm, we examine the key problem areas and agendas on which top management focuses their attention (Ghosh & Klueter, 2022; Monteiro, 2015; Ocasio, 2011). Second, to incorporate feedback, we examine the effect of experiencing unexpected failures in a problem area (Lampel et al., 2009; Madsen & Desai, 2010; Wooten & Ulrich, 2017). We argue that both focus and feedback in the problem space will shape mental models and organizational routines (Christianson et al., 2009; Eggers & Kaplan, 2009; Kaplan, 2008; Lampel et al., 2009; Tzabbar et al., 2023), ultimately determining if firms in-source novel technological solutions.

2.4.1 | Focus of TMT

Top management decisions about how to allocate limited attention across problem areas communicate key priorities shaping the overall strategic agenda and priorities for business units, R&D personnel, and employees throughout that organization (Helfat & Peteraf, 2015; Klueter et al., 2017; Li et al., 2013). Since prior studies have shown the profound influence of management cognition and attention on strategic change (Eggers & Kaplan, 2009; Kaplan, 2008; Kaplan et al., 2003; Ocasio, 2011), it follows that management attention toward problems may shape the technological solutions firms pursue when in-sourcing external technologies.

When top managers devote more attention toward a particular problem area, this extra scrutiny makes R&D personnel active in the solution space more accountable, driving them to identify a broader range of solutions to that problem beyond the ones that are habitual to them (Li et al., 2013).[2] More managerial attention toward a problem increases deliberation and the cognitive resources dedicated to it, which in turn can help scientists to "see" additional dimensions of the solutions space (Gavetti & Levinthal, 2000). When R&D personnel become more mindful and deliberative, it can change their mental maps of how problems and solutions are interrelated, thus reducing the likelihood that they operate with automatism when in-sourcing technological solutions (Haleblian & Finkelstein, 1993). Mindful focus of attention on R&D projects has also been shown to increase the impact of such R&D projects due to a better understanding of their causal effects (Ghosh et al., 2014). Thus, increased attention from managers toward a problem can lead to increased attention in the solution space, allowing R&D personnel to cast a wider net and identify a broader set of solutions, including those they have not previously pursued internally (Kaplan & Tripsas, 2008).

Furthermore, when top management attention communicates organizational priorities, it also determines resource allocations when evaluating solutions. Problem areas receiving less attention from managers may allow R&D personnel to follow predictable routines and pursue previously agreed-upon paths when evaluating and allocating resources for technology in-sourcing since there is little scrutiny (March & Simon, 1958). However, when top managers focus on specific problems, evaluation is more commonly done on a case-by-case basis and is likely to be more comprehensive (Kaplan & Tripsas, 2008). Hence, solutions that generally would not receive favorable evaluations due to their novel nature are likely to come under consideration, thus increasing their chances of being selected. In sum, when top management attention toward a problem is high, it is more likely that firms will consider solutions that require a departure from status quo routines and automated evaluation models, thereby facilitating the selection of novel technological solutions.

> **Hypothesis 2.** (H2) The likelihood that a firm in-sources a novel technological solution for a problem area increases with more TMT attention directed toward that problem.

[2]We make the assumption that TMT is finite, which means that paying more attention to one problem area comes at the expense of attention given to other problems (Ocasio, 1997). Put differently, TMT attention is relative in that more attention in one area typically less attention toward other areas.

2.4.2 | Feedback from unexpected failures

A second impetus that increases managerial scrutiny of the solution space is salient negative feedback arising from an attempt to solve a market problem, particularly when this feedback is unexpected. When a firm has committed substantial resources to a potential solution that unexpectedly falls short of the firm's market goals, that attempt represents an advanced-stage failure (Shepherd et al., 2011). These failures are difficult to conceal (Madsen & Desai, 2010) and therefore engender pressure from stakeholders. It stands to reason that such pressure will also be translated internally toward the R&D personnel focusing on the solution space and may require that they reevaluate the status quo.

Negative feedback and failures have long been connected to adjustments in subsequent firm behavior (e.g., Haunschild & Sullivan, 2002; Kim et al., 2009; Lampel et al., 2009; Madsen & Desai, 2010; March et al., 1991). According to behavioral theory, failures induce change as they provide feedback challenging the prevailing mental maps connecting problems and solutions (Billinger et al., 2014; Greve & Gaba, 2017). Research shows that failures in problem-solving can lead firms to seek external help from partners with whom they have had no previous contact (Baum et al., 2005). Furthermore, highly salient unexpected failures can "unfreeze" established routines within an organization and lead to the updating of mental models as managers pass on failure-induced pressures to their scientific teams, challenging those teams' mental models about which solutions are adequate and which ones are not (Christianson et al., 2009; Wooten & Ulrich, 2017). Failures also induce change in mental models as they reveal inconsistencies (Vosniadou, 1994) and uncover inadequacies in the internal logic used by R&D personnel to relate problems with solutions (Jansen et al., 2005; Lampel et al., 2009). This can create pressure on R&D personnel to depart from their own reference points in subsequent technology in-sourcing and seek solutions that depart from previously tried paths.

Finally, failures can also alter routines and resource allocation during evaluation and selection of external opportunities (Eggers, 2016), instigating changes in resource allocation (Levinthal & March, 1993) due to direct pressure from stakeholders. Failures alert organizations that their prior solutions were not effective, reducing resource allocation to familiar initiatives (Girotra et al., 2007). Moreover, such shortfalls can weaken the influence of entrenched resource allocators who were responsible for pursuing the failed internal R&D in the first place (Noda & Bower, 1996). It follows that, after unexpected failures, managers reexamine existing budgets and resource allocation processes, which makes it more likely that internal R&D personnel responsible for technology in-sourcing departs from predictable paths and, ultimately, becomes more receptive to in-source novel external technological solutions.

> **Hypothesis 3.** (H3) The likelihood that a firm in-sources a novel technological solution for a problem area increases after unexpected failures with prior problem-solving attempts.

3 | METHODS

3.1 | Setting

We test our hypotheses in the pharmaceutical industry. Established firms in the industry must continuously explore new opportunities because rapid technological advances generate new

and better solutions while existing products lose their advantage as their patent protection expires (Anand et al., 2010; Bhattacharya et al., 2015; Moreira et al., 2020; Tyler & Caner, 2016). Over the last several decades, many established pharmaceutical firms with a strong presence in downstream product markets and predominantly chemistry-based drug development capabilities have increased their in-sourcing of technologies from specialist technology firms (Nicholls-Nixon & Woo, 2003; Rothaermel & Boeker, 2008). Many leading firms have even established dedicated organizational units with the mandate to seek and source-in novel technological opportunities, explicitly acknowledging the limitations of internal R&D in incumbent firms:

> "We've come to the point where internal discovery can no longer sustain companies of our size. We have to get better at leveraging the external environment...there's disruptive innovation out there and we just have to learn to be externally focused and tap into emerging opportunities! (Merck Executive 2011—Worldwide Licensing, own interview)"

Importantly, the detailed data available in the pharmaceutical context allow us to separate problem and solution spaces, as per our theoretical setup. Specifically, established pharmaceutical firms serve specialized *therapeutic areas* (e.g., cancer or cardiovascular disease) that comprise the problem space (see details in Appendix A). Further, we can track the *compounds in development* offered by specialized technology firms, which provide solutions that established firms may in-source to address their particular therapeutic problems (see Appendix B). There are two reasons that these technological solutions are readily communicated by specialized technology firms to the established industry players: Intellectual property protection in the industry is strong, and the specialized firms lack complementary assets to commercialize their solutions on their own (Moreira et al., 2023; Rothaermel & Boeker, 2008). We combine data on therapeutic compound development using Informa's Pharmaprojects and on in-sourcing initiatives using Deloitte's/Thomson One's Recombinant Capital (ReCap) database (e.g., Hess & Rothaermel, 2011; Kapoor & Klueter, 2015; Schilling, 2009) to link therapeutic problems to the set possible solutions in the form of compounds in development and to determine the technological solutions that are ultimately in-sourced by the established firms.

3.2 | Sample

We focus on established firms with drug development capabilities predominantly rooted in chemistry, such as Pfizer, Novartis, and Takeda. These firms represented the largest (by sales) biopharmaceutical firms worldwide, as documented in the Pharmaceutical Executive Top 50 reports of 1999 to 2000. They were also all founded prior to the biotechnology "revolution" (Arora et al., 2009; Rothaermel & Boeker, 2008).[3]

An important requirement for our study is the visibility of technological solutions for therapeutic problems from which established firms select. We represent these technological solutions by new products across the stages of drug development: preclinical (lead candidate selection

[3]Typically, the emergence of specialized biotechnology firms is demarcated through the founding of Genentech in 1976. Due to the usual data limitations of private firms, we excluded two firms (Boehringer Ingelheim and Purdue Pharma), leaving 48 established firms. Three of the sampled firms (Altana-Byk Gulden, Daiichi Pharmaceutical, and DuPont Pharmaceuticals) did not have a qualifying in-sourcing event, reducing the final sample to 45 firms.

TABLE 1 Sample.

MoA-based sample	Partner/ license	Acquisition	Total
Realized transactions for technologies for a main therapeutic problem	827	111	938
Realized with multiple technologies	22	37	59
Realized with main technology	805	74	879
No concrete MoA	148	16	164
Total realized in-sourcing in sample	657	58	715
Technologies with MoA flagged as available for in-sourcing (additional control cases)			898

and investigation of a new drug preparation), Phase I trials (evaluation of drug stability, side effects, and dosage), Phase II trials (efficacy), and Phase III trials (large-scale clinical testing and regulatory submission) that have not yet reached commercial markets.

During these stages of development, technological opportunities for established firms are clearly visible in the form of compounds in development. For our sampled firms, we collected each in-sourcing agreement between 1996 and 2015 and mapped the ReCap in-sourcing transaction to the compounds in development found in Pharmaprojects (Hess & Rothaermel, 2011). Since our theory is about solutions to specific problems in a therapeutic area, we focused on in-sourcing deals addressing a problem within a main therapeutic area.[4] Following this procedure, we were able to match ReCap and Pharmaprojects for 938 in-sourcing deals that targeted a main therapeutic problem area, as documented in Table 1.

Further, within a therapeutic problem area, we sometimes encountered an in-sourcing transaction with multiple technologies, obscuring our ability to precisely match problems and solutions (and their novelty) within these deals. In such cases, we examined the associated press releases and Pharmaprojects and documented whether a specific technology was the focal point of the transaction. For 59 transactions (see Table 1), there was more than one main technology in-sourced and it was unclear which underlying technological solutions the firm ultimately targeted. Hence, we focused on those in-sourcing events for which we could identify a unique underlying technology that was in-sourced by the established firm. This led to 879 opportunities originating from 554 new technology firms. A final sampling criteria stems from data availability. As explained in Appendix B, not all technologies in Pharmaprojects have a valid mechanism of action. That reduced the final sample to 715 in-sourcing events.

To construct a risk set of possible technological opportunities available to established firms in a given year, we first assumed that the 715 realized technological opportunities from the specialized technology firms were available in the year prior to the actual external technology-sourcing deal. For example, if an established firm in-sourced a technological opportunity from a specialized firm in year t, we assumed that specialized firm A's opportunity was available in year t-1. We then expanded the set of opportunities by tracking drug development by the 554 specialized technology firms in Pharmaprojects and identifying all compounds flagged as

[4]As an example, Roche's in-sourcing agreement with Inovio in 2013 included compounds for both prostate cancer and hepatitis B—such deals without clear main therapeutic area are excluded from our analysis. In a similar vein, larger acquisitions like Norvartis acquiring Chiron in 2006 evolved around multiple therapies. Including such in-sourcing events would create ambiguity around measures of our independent variables.

licensing opportunities in our sample years.[5] This way, we tracked 898 additional technological opportunities from new technology firms fulfilling our sampling criteria that were flagged in Pharmaprojects as being available but that were not part of a realized in-sourcing deal of the established pharmaceutical firms. Overall, all those sampling criteria resulted in 1613 total technological opportunities from 480 new technology firms at risk of being in-sourced by established firms during the window of interest. Our approach is consistent with studies on partnership formation that considered all possible firms' dyads as a possible risk set (Mindruta et al., 2016; Mitsuhashi & Greve, 2009; Rothaermel & Boeker, 2008) and led to 59,236 possible combinations of technological opportunities available to established firms, of which 715 technological opportunities were ultimately in-sourced.

3.3 | Measures

We fit regression models with two different dependent variables to test Hypothesis 1 versus Hypotheses 2 and 3 in accordance with our theoretical framing above. Since Hypothesis 1 examines whether the technologies firms in-source out of a range of technological solutions available from specialized technology firms in year t are predominantly familiar, we regress whether or not a firm in-sourced a solution to a problem area as a function of whether this solution is familiar. In contrast, for Hypotheses 2 and 3, we model in-sourcing of a novel technology. Accordingly, we first present the key variables for the models to test H1, followed by the variables for the models to test Hypotheses H2 and H3.

3.3.1 | Dependent variable H1 technology in-sourcing

The binary-dependent variable *Technology In-Sourcing* takes the value of 1 if an established firm in-sourced a technological opportunity to solve a problem in year t and 0 otherwise.

3.3.2 | Independent variable H1—Familiarity

To test Hypothesis 1, we need a robust approach to capture familiarity of solutions with respect to the therapeutic problems firms try to solve. We use fine-grained product development data from Pharmaprojects and assess familiarity of a technological opportunity for an established firm by comparing its mechanism of action to those already applied by the firm to the same therapeutic problem in the prior 10 years (e.g., Diestre & Rajagopalan, 2012). The mechanism of action is defined as the "biochemical mechanism through which the interactions between the drug and its target(s) result in a response, which shapes both drug efficacy and safety" (Swinney & Anthony, 2011, p. 508).[6] We contracted with an associate professor of chemistry

[5]Pharmaprojects reports a licensing opportunity if it has received information from a press release, annual reports, conferences or direct communication that a compound is available for partnering, licensing or in-sourcing in general.

[6]In some cases, these codes are classified through subcategories while, in other cases, they are not, which would impede making adequate comparisons. To help with classification, the expert used Pharmaprojects' pharmacology codes related to the mechanisms to group them. For example, the mechanisms "Hyaluronate lyase inhibitor (LY-HYAL-)," "Lyase inhibitor LY-," "Lyase unspecified inhibitor (LY-U-)," and "Sphingosine-1-phosphate lyase inhibitor (LY-S1P-)" and "17,20 lyase inhibitor (LY-1720-)" were classified under "lyase inhibitors (LY-)." This categorization was validated by another practitioner doctor of medicine and is available from the authors.

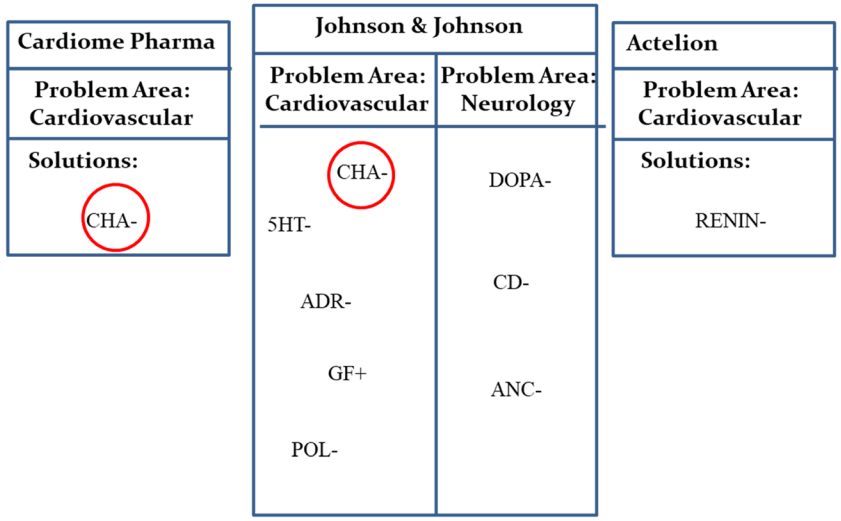

FIGURE 1 Operationalization familiarity: Example Johnson & Johnson.

and chemical biology with an industrial background in medicinal chemistry to categorize the mechanism of actions to make them comparable. We also learnt from the expert's coding that some mechanisms are not valid such as the ones coded as "unknown," "anticancer," or immunostimulants. These compounds were excluded from the analysis, as shown in Table 1. The binary variable *Familiarity* is coded 1 for opportunities with a familiar mechanism of action and 0 for those that are novel.

To illustrate, in Figure 1, Johnson & Johnson has a history of attempting drug development using different mechanisms of action in the therapeutic areas of cardiovascular and neurology. It can observe different technological opportunities for in-sourcing from specialized firms. Channel antagonists (mechanism CHA− in Figure 1) offered by Cardiome Pharma are one possible solution as they lower blood pressure by limiting the amount of ions that enter heart cells (Polidoro & Theeke, 2012). Johnson & Johnson had their own channel blocker R&D initiatives (Toh & Polidoro, 2013), signaling familiarity with this emerging technological opportunity from Cardiome Pharma. On the other hand, Johnson & Johnson has no history of using Renin Inhibitors (RENIN−) that can block the enzyme renin that helps regulate blood pressure. Thus, Actelion's technology would be considered novel for Johnson & Johnson.

Appendix C provides a simple descriptive and statistical analysis of using alternative factors for the operationalizations of familiarity (patents and technology classes underlying compounds in development, the Gene ID, the chemical structure, and the compound's origin of material), which shows very similar patterns in terms of the effect of familiarity in in-sourcing technologies.[7]

[7]We thank an anonymous reviewer for raising the important issue that there are indeed multiple technological dimensions, which we contrast in in Appendices B and C. There, we also provide broad justification for the use of the mechanism of action as a measure distinguishing familiarity versus novelty for the rest of the analysis.

3.3.3 | Dependent variable H2 and H3—Novel technology in-sourcing

Given the expected prevalence of familiar solutions and our interest in identifying factors encouraging the less-prevalent in-sourcing of novel solutions (Hypotheses 2 and 3), we construct a different dependent variable that addresses the specific selection of novel technological solutions. To that end, we take into account whether a given solution was novel or familiar. Specifically, *Novel Technology In-Sourcing* takes the value of 1 if firms in-source a novel technology and 0 for all remaining observations (i.e., either not in-sourcing a solution or in-sourcing a familiar solution).[8]

3.3.4 | Independent variable H2—TMT attention

Following prior research, we used the established firm's annual report to shareholders to measure top management attention on the therapeutic area addressed by the focal opportunity (Eggers & Kaplan, 2009; Kaplan & Tripsas, 2008). Annual reports include the shareholder letter and outlook, which signal the major topics and themes top managers consider strategically important. The annual report texts were preprocessed using standard procedures utilized in text mining employing the R package *tm*, which included removal of punctuation and numbers and changing the text to lowercase. Next, we eliminated stop words (common words such as "the"). Finally, we stemmed all words, which meant converting words to their base or root forms. We identified a list of keywords associated with each therapy associated with the specialized firm's technological opportunities (e.g., cancer and oncology are keywords related to the anticancer therapeutic area) and then systematically searched for the stem of the keywords in the annual report (Ghosh & Klueter, 2022). For each therapeutic area k of the firm in a given year, we counted the number of mentions of therapeutic area based on these keywords in the annual report, N_k. *TMT attention* of a therapy area k in the firm was then calculated as $\frac{N_k}{\sum_j N_j}$, (j reflecting all possible therapeutic areas in which the firm was active) and took values from 0 to 1. This gives a relative measure of attention toward a problem (i.e., the share of a particular therapy) and is consistent with the idea that if firms pay attention to one problem, they may not be able to pay attention to other ones (Ocasio, 1997; Shepherd et al., 2017).

3.3.5 | Independent variable H3—Failures

Using each established firm's history of drug development, we determined whether they had experienced salient *Failures* in the therapeutic area of the focal technological opportunity. Given that firms ultimately abandon most attempts in R&D, we took the perspective that salient failures should represent attempts to which established firms had already committed substantial resources and time, but that ultimately failed to get launched on the market (Shepherd et al., 2011). These commitments are particularly large once pharmaceutical firms start efficacy and large-scale clinical testing in Phase 3 of the drug development process and file for submission to government agencies (Girotra et al., 2007; Hermosilla, 2021). Failures from Phase

[8]Accordingly, when testing *Novel Technology In-Sourcing*, the independent variable *Familiarity* is no longer included in the regressions as it is incorporated in this second dependent variable.

3 onward are rare, representing only about 2% of all drug development initiatives by the established firms in our sample. Further, such failures are relatively unexpected as the conversion rate from this stage to approval is greater than 50% on average (DiMasi et al., 2016). Thus, it is likely that failures from Phase 3 onward provide salient feedback. We used Pharmaprojects and Adis Insights to code the year of the failure. "*Failures*" is a 2-year count of the number of failures by the established firm within the therapeutic area of the focal opportunity.[9]

3.3.6 | Control variables

Our control variables cover a broad range of variables to control for alternative explanations at different levels, including the opportunity, therapeutic area, mechanism of action, the focal and specialized firm and their dyadic relationship. Table 2 provides a detailed explanation of the controls.

3.4 | Empirical specification

Since the overall likelihood of a technology selection is relatively low at about 1.2%, we use the matched case–control approach of Sorenson and Stuart (2001). For every realized case, we sampled four matching controls from those not selected for external technology sourcing using a nearest neighbor algorithm, which is the standard matching mechanism when creating a matched sample in a variety of techniques, including propensity score matching for treatment effects (de Figueiredo Jr et al., 2019; Mitsuhashi & Greve, 2009). We created a matched sample for our case–control analysis using the nearest neighbor algorithm to select four controls for each in-sourced case. For each in-sourcing event, we selected up to four other opportunities (in the same year, at the same stage, and same category of either biotech or non-biotech) that the established firm did not select. Beyond these fixed parameters, we used the distance from each realized case to possible control cases using all variables associated with the technology itself (*Opportunity Gene ID*, *MoA Alternatives*), the capabilities of the specialized technology firm (*Specialized Firm Patents and NPD*), and dyadic factors (*Common Citations*, *Combined Centrality*, *Age Difference*, *and Prior Ties*) so that each realized cased is matched to the nearest control cases.

The matched case–control approach resulted in a sample of 3560 observations (about 3.98 control cases for each realized transaction).[10] To demonstrate that our matching creates more comparable opportunities, in Appendix D, we report the means of the variables in the in-sourced group and the matched control cases group using the nearest neighborhood approach. Given our binary-dependent variable and matched control design, we utilized a logistic regression approach (Stata: relogit) that takes into account rare events and a matched control case design (King & Zeng, 2001). All independent and control variables were lagged by 1 year.[11]

[9]Results are qualitatively similar using a 3-year window for failures.

[10]For a few cases, we did not have sufficient neighbor sets, which is why the final sample is 3560 and not 3575.

[11]To mitigate the effect of outliers, we winsorized independent variables.

TABLE 2 Control variables.

Level	Variable	Description	Source
Opportunity	Clinical	Coded as one if the technology was already tested in clinical trials, zero for preclinical only.	Pharmaprojects
Opportunity	GeneID	EntrezGeneid (unique integer identifier for genes in organisms) not available in Pharmaprojects (one) vs. available (zero).	Pharmaprojects
Opportunity	Biotech	Origin of material code—Biotech (one) vs. chemistry/natural products (zero).	Pharmaprojects
Therapy (problem)	Patent Share	Research importance: Patents of firm in the therapeutic area divided by the total patenting of the firm across all therapeutic areas.	Derwent
Therapy (problem)	NPD Share	Total number of firm projects in preclinical and clinical development in the therapeutic area of the opportunity divided by the sum of the firm's overall drug development activities.	Pharmaprojects
Therapy (problem)	Sales Share	Sales in the therapeutic area of the technological opportunity divided by the sum of the firm's overall therapeutic sales.	Evaluate Pharma
Therapy (problem)	Prior In-Sourcing	Count of all in-sourcing events undertaken by the focal firm in the therapeutic area of the opportunity.	ReCap
Therapy (problem)	Successes	Tracking the number of drugs receiving approval in the therapeutic area addressed by the focal technological opportunity in the last 2 years.	Pharmaprojects
Therapy (problem)	Industry Market Size	Total sales in industry in therapeutic area relative to sales in all therapeutic areas (based on Top 50 firms worldwide).	Evaluate Pharma
Therapy (problem)	Known Indication	The therapeutic indication is a sub area of the therapeutic problem area, such as the Alzheimer's indication within Neurology. The variable is coded as 1 if the firm has previously had drug development in the indication of the opportunity, 0 otherwise.	Pharmaprojects
Therapy (problem)	Revenue Growth	Year-over-year growth of sales in the therapeutic area in the industry.	Evaluate Pharma
Therapy (problem)	Known Origin of Material	The origin of material is distinguished broadly as synthetic chemistry, natural products or variants of biologics (protein-antibodies, recombinants, etc.). This variable captures familiarity (flagged as one if previously used) with the material within the therapeutic area of the opportunity. This also helps control for familiarity with underlying biotechnologies, including monoclonal antibodies or RNA interference.	Pharmaprojects
MoA (solution)	Alternatives	Number of drugs in development in the whole market with the same mechanism addressing a therapeutic problem in a given year.	Pharmaprojects
MoA (solution)	Failures	Failures in same MoA but outside the therapeutic area of the technological opportunity in the last 2 years	Pharmaprojects

TABLE 2 (Continued)

Level	Variable	Description	Source
MoA (solution)	Successes	Successes in same MoA but outside the therapeutic area of the technological opportunity in the last 2 years	Pharmaprojects
Focal firm	R&D TMT	Is R&D personnel represented in the firm's top management team (one if yes, zero if not).	Annual Reports
Focal firm	Novelty Propensity	Tendency of firms to source-in novel over familiar technologies based on mechanisms of action over a 10-year period.	ReCap, Pharmaprojects
Focal firm	NPD concentration	Concentration of new product development by therapeutic classes using a Herfindahl index.	Pharmaprojects
Focal firm	Size	Total assets	Compustat
Specialized firm	Patents	Patent applications in a year (logged).	Derwent
Specialized firm	NPD	New Product Development portfolio count in a year.	Pharmaprojects
Dyadic	Prior Ties	Prior in-sourcing agreement (yes-one, no-zero).	ReCap
Dyadic	Combined Centrality	Combined centrality of the firm using the approach of Polidoro et al. (Ahuja et al., 2009).	ReCap
Dyadic	Age Difference	As differences in age can play a role in in-sourcing relationships (Sørensen & Stuart, 2000), we controlled for the age difference between the focal firm and the specialized technology firm based on their founding years (logged).	Web Searches
Dyadic	Common Citations	Common citation count (Rothaermel & Boeker, 2008) specialized firm and focal firm.	NBER Patent File

TABLE 3 Descriptive statistics familiar versus novel.

	MoA (full sample)		MoA (matched sample)	
	Available	Selected	Available	Selected
Familiar in TA	14,165	306 (2.2%)	1259	306 (24.3%)
Novel in TA	45,071	409 (0.9%)	2301	409 (17.8%)

4 | RESULTS

4.1 | Preliminary evidence for a preference for the familiar

Table 3 displays the patterns of in-sourcing familiar and novel technological solutions for the full sample and the matched sample. We see that, by a pure count of technological opportunities available, there are more novel than familiar solutions. However, once we account for the much smaller set of opportunities that are selected for in-sourcing, we also observe that the likelihood of selecting a familiar technological solution is more than double in the full sample (2.2% vs. 0.9%) and about 36% higher in the matched sample (24.3% vs. 17.8%). This provides some preliminary evidence supporting our initial hypothesis that, contrary to the conventional

assumption, established pharma firms actually have the tendency to pursue familiar technological opportunities over novel ones from specialized technology firms.

4.2 | Descriptive statistics and results matched sample

Table 4 displays the descriptive statistics and the bivariate correlation matrix for all variables in the matched control sample, and Table 5 shows the regression results for the matched case sample using the rare event logit specification. In Model 1, we examine the effects of the control variables on the likelihood of selecting a technology. Focusing on those within a p-value of equal or less than 5%, we observe that *Prior Ties* has a positive association ($\beta = .444$, $p = .001$) with in-sourcing a technological opportunity. A known therapeutic indication is positively associated with in-sourcing ($\beta = .287$, $p = .009$). We also see a positive association of *Sales Share* ($\beta = .918$, $p = .001$) and *Patent Share* ($\beta = 1.932$, $p = .029$) on technology in-sourcing. Finally, *TMT Attention* has a positive association with technology in-sourcing ($\beta = 1.029$, $p = .017$).

Model 2 in Table 5 tests H1 by adding the *Familiarity* measure based on the mechanism of action in a therapeutic area. We see a positive association of *Familiarity* on in-sourcing ($\beta = .307$, $p = .002$). Comparing the difference in log likelihoods of the restricted (Model 1) and unrestricted Model (Model 2) also allows us to conclude that adding *Familiarity* improves the model ($p = .002$). Using the adjusted odds ratio, we observe a 31% higher odds of in-sourcing a familiar technological solution over a novel one. These results support Hypothesis 1.

Next, we move to testing Hypotheses 2 and 3 where we focus on in-sourcing novel technological opportunities as the dependent variable. Model 3 includes the controls. In Model 4, we examine the effect of *TMT Attention* on in-sourcing novel technological solutions. We observe a positive association on TMT Attention ($\beta = 1.640$, $p = .002$) suggesting that higher *TMT Attention* toward the therapeutic area in which the new technology firm's solution falls is associated with a greater likelihood to in-source a novel solution. This is corroborated using a likelihood ratio (LR) test using Model 3 as a baseline ($p = .002$). Examining the marginal effects of increasing *TMT Attention* by one standard deviation above the mean increases the probability of in-sourcing a novel technology by approximately 20%. Overall, this corroborates our prediction in Hypothesis 2.

Next, we add *Failures* in Model 5, which has a positive association on in-sourcing a novel technological solution ($\beta = .285$, $p = .016$; LR test compared to Model 4: $p = .022$). Using the adjusted odds ratio with the coefficient of *Failures* suggests a 29% increase in the odds of in-sourcing a novel technological solution for an additional failure. These results provide support for Hypothesis 3.

As a post hoc analysis, in Model 6, we investigate whether *TMT Attention* and *Failures* would also predict *Familiar Technology In-Sourcing*. This alternative dependent variable takes the value of 1 if firms in-source a familiar technological solution and 0 for all remaining observations (i.e., either not in-sourcing a solution or in-sourcing a novel solution). Neither *TMT Attention* nor *Failures* in Model 6 have associations with *p*-values less than 10% on *Familiar Technology In-Sourcing*. This distinction clarifies that TMT attention and failures only predict the choice of novel technological solutions.

4.3 | Robustness tests

We provide several additional analyses to ensure the robustness of our findings. Models 1 and 2 provide an alternative specification, where we retain our original dependent variable of

TABLE 4 Summary statistics and correlations.

	n-3560	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Technology In-Sourcing	1.00																											
2	Novel Technology In-Sourcing	0.72	1.00																										
3	Opportunity_Gene_ID	0.00	0.00	1.00																									
4	MoA_Alternatives	0.02	−0.09	−0.04	1.00																								
5	Firm_ R&D TMT	0.00	−0.02	−0.03	0.01	1.00																							
6	Firm_Size	0.00	−0.02	−0.09	0.10	0.13	1.00																						
7	Therapy_Firm_Prior_In_Sourcing	0.03	0.00	−0.03	0.22	0.04	0.29	1.00																					
8	Specialized_Firm_Patents	0.02	0.01	−0.03	0.00	−0.06	−0.10	−0.02	1.00																				
9	Specialized_Firm_NPD	−0.02	−0.07	0.01	0.20	0.07	0.02	0.15	0.21	1.00																			
10	Dyadic_Combined_Centrality	0.00	−0.02	−0.09	−0.02	0.12	0.03	0.05	0.43	0.23	1.00																		
11	Dyadic_Common Citations	0.04	0.04	−0.07	0.00	0.04	0.14	0.06	0.40	0.09	0.27	1.00																	
12	Dyadic_Prior_Ties	0.07	0.03	−0.06	0.03	0.02	0.09	0.06	0.21	0.07	0.35	0.23	1.00																
13	Dyadic_Age Difference	0.00	−0.01	0.00	0.04	0.02	0.45	0.08	−0.12	−0.03	0.06	0.05	0.02	1.00															
14	Therapy_Firm_Patent Share	0.06	0.03	0.01	−0.03	0.08	−0.12	0.05	0.01	0.03	0.01	−0.02	−0.02	−0.04	1.00														
15	Therapy_Firm_NPD Share	0.08	0.00	0.04	0.17	0.00	−0.05	0.28	−0.03	0.20	−0.05	−0.03	−0.02	−0.08	0.28	1.00													
16	Therapy_Firm Sales Share	0.12	0.08	−0.01	0.01	0.03	0.00	0.19	−0.03	0.05	−0.02	0.02	0.04	−0.06	0.29	0.38	1.00												
17	Firm_Novelty_Propensity	0.00	0.00	0.01	−0.03	−0.05	−0.12	−0.08	0.03	−0.02	−0.03	−0.05	−0.03	0.00	0.04	−0.02	0.01	1.00											
18	Firm_NPD_Concentration	0.00	0.03	0.00	−0.03	0.02	−0.36	−0.13	0.01	−0.01	−0.18	−0.08	−0.08	−0.36	−0.02	0.07	0.03	0.05	1.00										
19	Therapy_Firm_Successes	0.03	0.01	−0.01	0.05	0.05	0.18	0.25	−0.02	0.04	0.04	0.02	0.00	0.10	0.06	0.20	0.22	−0.11	−0.11	1.00									
20	MoA_Firm_Successes	0.00	−0.04	−0.03	0.15	0.03	0.05	0.06	0.00	0.00	−0.01	0.03	0.02	0.05	−0.01	0.02	0.05	−0.03	−0.05	0.15	1.00								
21	Moa_Firm_Failures	−0.01	−0.01	0.01	0.12	0.02	0.09	0.03	−0.02	0.01	−0.01	0.00	−0.01	0.04	0.00	0.02	−0.01	−0.01	−0.02	0.05	−0.01	1.00							
22	Therapy_Firm_Known Ind.	0.05	−0.03	0.06	0.13	0.05	0.20	0.18	−0.05	0.13	0.06	0.03	0.04	0.18	0.04	0.20	0.09	−0.06	−0.24	0.11	0.07	0.03	1.00						
23	Therapy_Firm_Known OoM	0.04	−0.04	0.02	0.10	0.07	0.15	0.18	−0.01	0.15	0.03	0.01	0.03	0.07	0.08	0.17	0.08	−0.03	−0.12	0.12	0.07	0.01	0.16	1.00					
24	Therapy_Ind._Rev. Growth	0.01	0.00	0.00	0.09	0.08	−0.09	0.03	0.07	0.11	0.07	0.05	0.00	0.00	0.08	0.10	0.02	0.02	−0.02	−0.01	0.04	0.01	0.06	0.04	1.00				
25	Therapy_Industry_Market Size	0.00	−0.03	0.00	0.08	0.00	0.05	0.23	−0.09	0.14	−0.09	−0.04	−0.05	0.01	0.24	0.36	0.26	−0.01	−0.02	0.14	0.03	0.04	0.11	0.18	0.03	1.00			
26	Therapy_TMT Attention	0.08	0.06	−0.03	0.19	0.02	−0.01	0.29	0.00	0.13	0.00	−0.01	0.01	−0.05	0.31	0.45	0.39	0.03	0.04	0.08	0.02	0.01	0.14	0.12	0.10	0.09	1.00		
27	Therapy_Failures	0.02	0.02	0.00	0.08	0.06	0.24	0.21	−0.03	0.05	0.02	0.00	0.03	0.10	0.05	0.17	0.08	−0.01	−0.09	0.19	0.02	0.09	0.06	0.10	0.00	0.15	0.05	1.00	
28	Opportunity_Familiarity	0.08	−0.27	0.02	0.32	0.10	0.14	0.18	−0.01	0.13	0.06	0.02	0.07	0.08	0.04	0.18	0.09	−0.04	−0.14	0.14	0.14	0.07	0.23	0.22	0.05	0.09	0.10	0.06	1.00
	mean	0.20	0.11	0.19	27.57	0.71	405	1.10	1.30	3.00	0.11	3.72	0.12	4.49	0.10	0.14	0.14	0.58	0.16	0.29	0.02	0.01	0.73	0.72	1.08	0.10	0.13	0.18	0.35
	sd	0.40	0.32	0.39	75.09	0.45	369	1.74	1.17	2.88	0.10	10.93	0.32	0.42	0.05	0.12	0.17	0.31	0.05	0.62	0.15	0.12	0.44	0.45	0.11	0.04	0.13	0.48	0.48
	min	0.00	0.00	0.00	0.00	0.00	5.96	0.00	0.00	1.00	0.00	0.00	0.00	2.40	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.47	0.01	0.00	0.00	0.00
	max	1.00	1.00	1.00	523	1.00	2129	12.00	5.39	18.00	0.76	112	1.00	5.42	0.75	0.80	0.95	1.00	0.44	4.00	1.00	2.00	1.00	1.00	1.47	0.18	0.95	3.00	1.00

TABLE 5 Results—Matched sample relogit estimates.[a,b]

	(1) Technology in-sourcing	(2) Technology in-sourcing	(3) Novel tech. in-sourcing	(4) Novel tech. in-sourcing.	(5) Novel tech. in-sourcing.	(6) Fam tech. in-sourcing
Opportunity_Gene_ID	0.013	0.007	0.069	0.069	0.063	−0.085
	(0.114)	(0.114)	(0.139)	(0.139)	(0.140)	(0.170)
MoA_Alternatives	0.001	0.000	−0.011	−0.011	−0.011	0.004
	(0.001)	(0.001)	(0.006)	(0.006)	(0.006)	(0.001)
Firm_ R&D TMT	−0.065	−0.092	−0.064	−0.082	−0.090	0.097
	(0.100)	(0.100)	(0.124)	(0.125)	(0.125)	(0.154)
Firm_Size	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Therapy_Firm_Prior_In_Sourc.	0.021	0.015	0.043	0.038	0.029	0.010
	(0.027)	(0.027)	(0.036)	(0.036)	(0.036)	(0.036)
Specialized_Firm_Patents	0.038	0.038	0.012	0.008	0.007	0.085
	(0.045)	(0.045)	(0.055)	(0.056)	(0.056)	(0.070)
Specialized_Firm_NPD	−0.026	−0.027	−0.051	−0.051	−0.051	0.011
	(0.018)	(0.018)	(0.028)	(0.028)	(0.028)	(0.022)
Dyadic_Combined_Centrality	−0.650	−0.694	−1.204	−1.170	−1.232	0.200
	(0.555)	(0.557)	(0.716)	(0.716)	(0.728)	(0.763)
Dyadic_Common Citations	0.006	0.006	0.011	0.011	0.012	−0.003
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Dyadic_Prior_Ties	0.444	0.436	0.355	0.373	0.376	0.440
	(0.136)	(0.137)	(0.172)	(0.173)	(0.173)	(0.195)
Dyadic_Age Difference	0.092	0.093	0.060	0.081	0.073	0.149
	(0.127)	(0.128)	(0.168)	(0.167)	(0.168)	(0.169)
Therapy_Firm_Patent Share	1.932	1.952	0.076	−0.243	−0.319	3.706

TABLE 5 (Continued)

	(1) Technology in-sourcing	(2) Technology in-sourcing	(3) Novel tech. in-sourcing	(4) Novel tech. in-sourcing.	(5) Novel tech. in-sourcing.	(6) Fam tech. in-sourcing
	(0.886)	(0.903)	(1.187)	(1.174)	(1.203)	(1.062)
Therapy_Firm_NPD Share	0.708	0.609	−0.096	−0.677	−0.787	2.511
	(0.458)	(0.466)	(0.565)	(0.579)	(0.590)	(0.649)
Therapy_Firm_Sales Share	0.918	0.930	1.433	1.004	1.014	0.303
	(0.273)	(0.274)	(0.324)	(0.337)	(0.339)	(0.387)
Firm_Novelty_Propensity	−0.001	−0.001	−0.012	−0.038	−0.048	0.062
	(0.141)	(0.141)	(0.177)	(0.178)	(0.179)	(0.202)
Firm_NPD_Concentration	−0.077	0.096	0.919	0.526	0.525	−1.138
	(1.158)	(1.158)	(1.286)	(1.358)	(1.355)	(1.804)
Therapy_Firm_Successes	−0.017	−0.030	0.024	0.035	0.012	−0.074
	(0.076)	(0.077)	(0.097)	(0.098)	(0.098)	(0.109)
MoA_Firm_Successes	−0.185	−0.244	−0.659	−0.660	−0.655	0.200
	(0.299)	(0.298)	(0.608)	(0.608)	(0.609)	(0.350)
Moa_Firm_Failures	−0.074	−0.114	0.134	0.110	0.069	−0.086
	(0.382)	(0.378)	(0.569)	(0.575)	(0.578)	(0.482)
Therapy_Firm_Known Ind.	0.287	0.242	−0.053	−0.073	−0.058	1.051
	(0.111)	(0.111)	(0.129)	(0.129)	(0.130)	(0.217)
Therapy_Firm_Known OoM	0.161	0.112	−0.177	−0.188	−0.192	0.745
	(0.107)	(0.108)	(0.125)	(0.126)	(0.126)	(0.186)
Therapy_Ind._Rev. Growth	0.224	0.225	0.146	0.179	0.138	0.334
	(0.438)	(0.439)	(0.563)	(0.572)	(0.570)	(0.647)
Therapy_Industry_Market Size	−4.746	−4.424	−2.301	−2.648	−2.420	−6.150
	(2.710)	(2.713)	(3.306)	(3.300)	(3.294)	(3.491)

TABLE 5 (Continued)

	(1) Technology in-sourcing	(2) Technology in-sourcing	(3) Novel tech. in-sourcing	(4) Novel tech. in-sourcing.	(5) Novel tech. in-sourcing.	(6) Fam tech. in-sourcing
Therapy_TMT Attention	1.029	1.002		1.640	1.675	−0.162
	(0.431)	(0.436)		(0.519)	(0.516)	(0.594)
Therapy_Failures	0.085	0.094			0.285	−0.174
	(0.097)	(0.097)			(0.118)	(0.147)
Opportunity_Familiarity		0.307				
		(0.099)				
Constant	−5.407	−5.424	−4.136	−4.313	−4.235	−7.604
	(0.832)	(0.830)	(1.037)	(1.060)	(1.065)	(1.200)
Observations	3560	3560	3560	3560	3560	3560
Log likelihood	−1725	−1720	−1207	−1202	−1199	−944
LR test		$p = .002$		$p = .002$	$p = .022$	

Note: Coefficient and robust standard errors.

[a]Results using relogit do not generate log likelihood summary statistics. The ones reported correspond to uncorrected logit models.

[b]Matched sample, indicators of firm, year, biotech, clinical are not included in the models.

Technology In-Sourcing and then interact *Familiarity* with *TMT Attention* and *Failures*. This allows us to explain how TMT attention and failures moderate the preference for the familiar we verified originally. Model 1 shows a negative association of the interaction of *Familiarity* with *TMT Attention* ($\beta = -1.422$, $p = .019$, LR test compared to Model 2 in Table 5: $p = .019$), suggesting that higher *TMT Attention* negatively attenuates the positive relationship of *Familiarity* and *Technology In-Sourcing*. The interaction is graphically displayed in Figure 2. It shows that at low levels of *TMT Attention* the preference for familiar over novel solutions is meaningful (i.e., both lines and their confidence intervals do not intersect). However, under conditions of greater *TMT Attention*, firms become indifferent between in-sourcing a novel or familiar solution (the lines and intervals overlap). Likewise, Model 2 adds the interaction of *Familiarity* with *Failures*, yielding a negative association of the interaction ($\beta = -.457$, $p = .016$, LR test compared to Model 1 in Table 6: $p = .008$) suggesting that experiencing failures in the therapeutic area will attenuate the positive direct effect of *Familiarity* on *Technology In-Sourcing*. This can be seen graphically in Figure 3. Model 3 further validates those results when both interactions are estimated jointly.

Next, we include the full risk set without a matched case design in Models 4 and 5. Here, we use a firthlogit estimation which helps account for imbalanced datasets due to rare events (Firth, 1993). In Model 4, we see that the unmatched coefficients of *Specialized Firm NPD* ($\beta = -.042$, $p = .011$) are negatively associated with technology in-sourcing while *Common Citations* ($\beta = -.009$, $p = .008$), *Prior Ties* ($\beta = -.412$, $p = .000$), and *Age Difference* ($\beta = 1.213$, $p = .008$) all have a positive association. At the same time, we observe consistent results to the ones in the matched sample with *Familiarity* predicting in-sourcing a technology (Model 4: $\beta = .378$, $p = .000$), and *TMT Attention* (Model 5: $\beta = 1.310$, $p = .005$) and *Failures* (Model 5: $\beta = .248$, $p = .019$) predicting the in-sourcing of a novel technology. Finally, Models 6 and 7 report the second stage regressions of Heckman selection models in which we first estimate that firms in-source a technology in a given year. The results of Models 6 and 7 are again consistent with results reported in Table 5, albeit weaker for *Failures* in Model 7 ($\beta = .004$, $p = .087$). To strengthen our inferences, we report several additional tests in Appendix E to consider alternative measurements and examine factors driving *TMT Attention* to rule out reverse causality.

5 | DISCUSSION

While extant research primarily positions technology sourcing as a means of accessing novelty, our examination of incumbent firms in the biopharmaceutical context using a problem-solution lens demonstrates the reverse—familiar solutions are more likely to be chosen over novel ones. Building on studies systematically distinguishing problems and solutions and the roles different actors in each space assume in external technology sourcing (Berchicci et al., 2019; Dutt & Mitchell, 2020), we argue that this tendency toward familiarity results from R&D personnel responsible for identifying and selecting external *solutions*. Indeed, our findings comport with prior studies that have documented similar tendencies by in-house R&D personnel tasked with seeking external knowledge (Katz & Allen, 1982; Leonard-Barton, 1992; Tripsas & Gavetti, 2000). At the same time, acknowledging the role of top managers in the strategic direction of the *problem* space, we suggest two factors that may propel the firm toward novel solutions: TMT attention (focus) toward a market problem and feedback from unexpected failures in solving such problems. Overall, these insights complement existing theory of problem-solving and search (Cohen et al., 1972; Simon, 1955) by emphasizing the predominant actors in form of

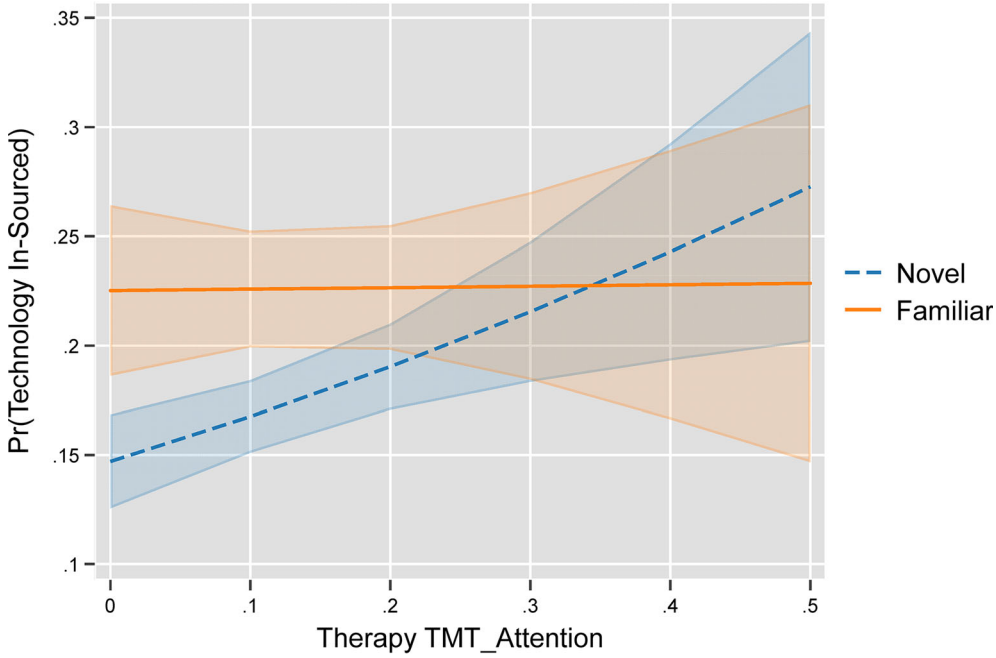

FIGURE 2 Interaction familiarity—Top management team (TMT) attention.

top managers in the problem space and R&D scientists in the solution space that shape a firm's receptivity toward novel external technologies.

Our work, also, extends the research on external technology sourcing (e.g., Rothaermel & Boeker, 2008; Tyler & Steensma, 1995) by importing themes from organizational search and managerial cognition. Specifically, by making explicit the connection of top management attention toward a problem to in-sourcing novel technological solutions, our work complements studies that have documented the role of top management attention both in adapting internally to technological change (Eggers & Park, 2018; Eggers & Kaplan, 2009; Kaplan & Tripsas, 2008; Levinthal & March, 1993; Ocasio, 2011) and in managing relationships with external partners (Ghosh & Klueter, 2022; Walter et al., 2012). Further, by demonstrating that firms in-source novel solutions following unexpected feedback from failures in the problem space (i.e., the therapeutic area), our work adds to the general understanding of how salient failures and negative events can alter organizational decision making and enable firms to change direction (Baum & Dahlin, 2007; Christianson et al., 2009; Lampel et al., 2009; Madsen & Desai, 2010; Tzabbar et al., 2023). This helps distinguish the role of unexpected failures from mere trial and error, which is commonplace in the solution space, to help demonstrate that more dramatic (e.g., later-stage) failures in solving market problems can provide an impetus for firms to become more receptive to the in-sourcing of novel technological solutions.

Methodologically, we move away from the traditional analysis of partner selection (e.g., Li et al., 2008; Rothaermel & Boeker, 2008; Yayavaram et al., 2018), which has been limited by the implicit assumption that firms gain access to the full set of opportunities of the specialized firms without distinguishing the technological context of solutions that are contractually in-sourced. In contrast, our focus on the choice between specific technological solutions enables a more accurate measurement of the novelty of the solutions that are accessed.

TABLE 6 Robustness tests.

	(1) Tech. in-sourcing Relogit	(2) Tech. in-sourcing Relogit	(3) Tech. in-sourcing Relogit	(4)[a] Tech. in-sourcing Firthlogit	(5)[a] Nov. tech. in-sourcing Firthlogit	(6)[b] Tech. in-sourcing selection	(7)[b] Novel tech. in-sourcing selection
Opportunity_Gene_ID	0.016	0.012	−0.003	0.013	0.016	0.000	0.000
	(0.114)	(0.114)	(0.112)	(0.104)	(0.134)	(0.002)	(0.002)
MoA_Alternatives	0.001	0.001	0.001	0.000	−0.009	−0.000	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.000)	(0.000)
Firm_ R&D TMT	−0.088	−0.085	−0.069	0.360	0.226	0.006	0.002
	(0.100)	(0.101)	(0.099)	(0.168)	(0.219)	(0.003)	(0.003)
Firm_Size	−0.000	−0.000	−0.000	0.000	0.001	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Therapy_Firm_Prior In_Sourc.	0.020	0.020	0.028	0.036	0.061	0.001	0.001
	(0.027)	(0.027)	(0.028)	(0.027)	(0.037)	(0.001)	(0.001)
Specialized_Firm_Patents	0.040	0.039	0.036	0.027	0.000	0.001	−0.000
	(0.045)	(0.045)	(0.045)	(0.042)	(0.055)	(0.001)	(0.001)
Specialized_Firm_NPD	−0.025	−0.027	−0.025	−0.042	−0.073	−0.001	−0.001
	(0.018)	(0.018)	(0.018)	(0.017)	(0.025)	(0.000)	(0.000)
Dyadic_Combined_Centrality	−0.739	−0.699	−0.768	−0.667	−1.493	−0.027	−0.026
	(0.559)	(0.557)	(0.534)	(0.526)	(0.725)	(0.014)	(0.010)
Dyadic_Common Citations	0.007	0.006	0.007	0.009	0.016	0.000	0.000
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.000)	(0.000)
Dyadic_Prior_Ties	0.444	0.451	0.463	0.412	0.417	0.012	0.006
	(0.137)	(0.137)	(0.135)	(0.117)	(0.160)	(0.004)	(0.003)
Dyadic_Age Difference	0.091	0.075	0.107	1.213	0.594	0.022	0.008
	(0.127)	(0.128)	(0.127)	(0.455)	(0.559)	(0.009)	(0.008)

TABLE 6 (Continued)

	(1) Tech. in-sourcing Relogit	(2) Tech. in-sourcing Relogit	(3) Tech. in-sourcing Relogit	(4)[a] Tech. in-sourcing Firthlogit	(5)[a] Nov. tech. in-sourcing Firthlogit	(6)[b] Tech. in-sourcing selection	(7)[b] Novel tech. in-sourcing selection
Therapy_Firm_Patent Share	2.102	1.965	1.914	2.318	0.763	0.063	−0.000
	(0.889)	(0.906)	(0.900)	(0.798)	(1.174)	(0.030)	(0.019)
Therapy_Firm_NPD Share	0.664	0.598	0.745	0.975	−0.145	0.021	−0.002
	(0.460)	(0.469)	(0.468)	(0.418)	(0.557)	(0.011)	(0.008)
Therapy_Firm_Sales Share	0.899	0.871	0.825	1.153	1.397	0.035	0.024
	(0.273)	(0.276)	(0.280)	(0.257)	(0.332)	(0.008)	(0.006)
Firm_Novelty_Propensity	0.001	−0.005	−0.010	0.060	−0.040	−0.005	−0.005
	(0.141)	(0.142)	(0.139)	(0.131)	(0.177)	(0.003)	(0.002)
Firm_NPD_Concentration	0.142	0.148	0.613	1.065	0.790	0.020	−0.001
	(1.160)	(1.154)	(1.137)	(1.464)	(1.710)	(0.030)	(0.026)
Therapy_Firm_Successes	−0.030	−0.011	−0.008	−0.004	0.044	−0.000	0.000
	(0.076)	(0.077)	(0.075)	(0.064)	(0.087)	(0.002)	(0.002)
MoA_Firm_Successes	−0.267	−0.271	−0.264	−0.150	−0.489	−0.003	−0.007
	(0.299)	(0.301)	(0.306)	(0.257)	(0.528)	(0.007)	(0.004)
Moa_Firm_Failures	−0.113	−0.042	−0.061	−0.317	−0.232	−0.008	−0.004
	(0.377)	(0.375)	(0.391)	(0.356)	(0.510)	(0.009)	(0.006)
Therapy_Firm_Known Ind.	0.245	0.243	0.217	0.254	0.036	0.004	−0.000
	(0.112)	(0.111)	(0.109)	(0.102)	(0.122)	(0.002)	(0.002)
Therapy_Firm_Known OoM	0.111	0.100	0.100	0.268	0.015	0.006	0.000
	(0.109)	(0.108)	(0.105)	(0.105)	(0.130)	(0.002)	(0.002)
Therapy_Ind._Rev. Growth	0.180	0.199	0.215	0.344	0.169	0.005	0.001
	(0.441)	(0.438)	(0.431)	(0.440)	(0.541)	(0.008)	(0.006)

TABLE 6 (Continued)

	(1) Tech. in-sourcing Relogit	(2) Tech. in-sourcing Relogit	(3) Tech. in-sourcing Relogit	(4)[a] Tech. in-sourcing Firthlogit	(5)[a] Nov. tech. in-sourcing Firthlogit	(6)[b] Tech. in-sourcing selection	(7)[b] Novel tech. in-sourcing selection
Therapy_Industry_Market Size	−4.064	−4.436	−4.178	−3.434	−1.632	−0.076	0.008
	(2.725)	(2.715)	(2.640)	(2.494)	(3.245)	(0.057)	(0.044)
Therapy_TMT Attention	1.499	0.984	1.520	0.885	1.310	0.017	0.021
	(0.472)	(0.435)	(0.472)	(0.380)	(0.471)	(0.009)	(0.007)
Therapy_Failures	0.086	0.307	0.290	0.099	0.248	0.002	0.004
	(0.098)	(0.123)	(0.117)	(0.084)	(0.106)	(0.003)	(0.002)
Opportunity_Familiarity	0.520	0.396	0.608	0.378		0.010	
	(0.128)	(0.105)	(0.134)	(0.088)		(0.002)	
Opportunity_Familiarity × TMT Attention	−1.422		−1.527				
	(0.606)		(0.639)				
Opportunity_Familiarity × Failures		−0.457	−0.470				
		(0.189)	(0.181)				
Constant	−5.529	−5.358	−2.687	−11.671	−8.110	−0.106	−0.022
	(0.832)	(0.829)	(0.815)	(2.235)	(2.757)	(0.043)	(0.037)
Observations	3560	3560	3560	59,236	59,236	59,236	59,236
Log likelihood	−1717	−1717	−1714	−3334	−2080	−15,034	−4617
LR test	$p = .019$	$p = .008.$	$p = .017$				

Note: Coefficient, robust standard errors.

[a]Includes firm, year effects, and biotech, clinical indicators.

[b]Second-stage base on 32,031 firm-year observations in which firms in-sourced a technology.

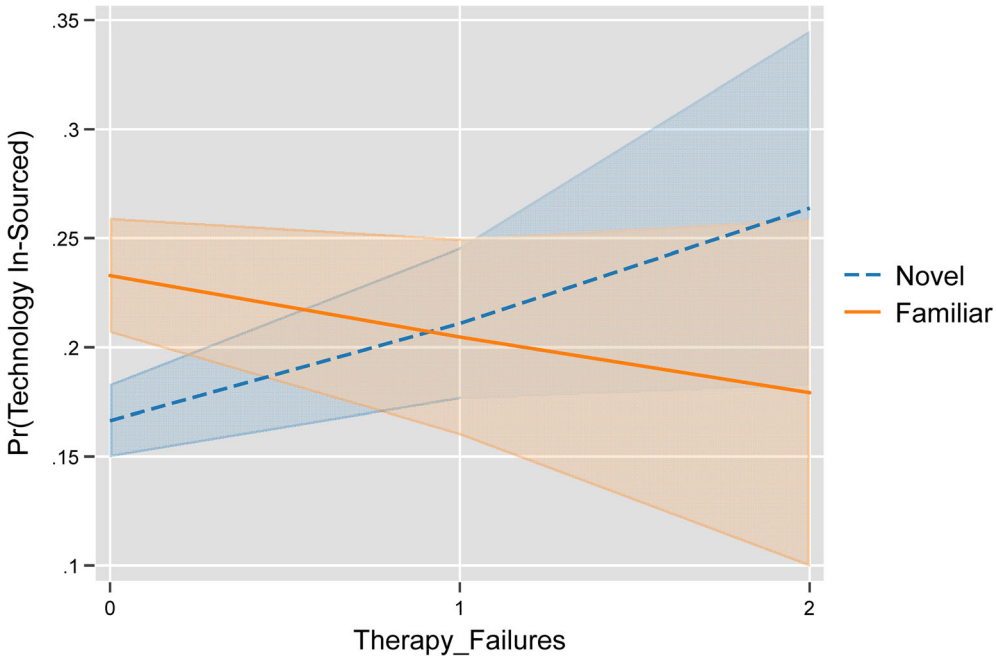

FIGURE 3 Interaction familiarity—Failures.

While the unique features of our research context and sample selection allow a deeper dive into novelty-seeking via external technology sourcing, they also generate limitations that should be addressed in future research. First, while our reliance on in-sourcing limited to a single technology in development clarified the novelty of the technology for the established firm, it excluded contracts encompassing broader portfolios. Such in-sourcing, for example, through larger equity alliances and larger acquisitions that span multiple therapeutic areas and products in development may be motivated by competitive assessments that we were unable to capture with our methods. Future research can examine press announcements and management comments regarding the in-sourcing activities of such larger transactions, as well as utilizing other methods such as surveys (Van de Vrande, 2013) to pinpoint whether specific technological solutions were the targets of in-sourcing.

Second, the sourcing events we observed in this study only constitute a subset of all events in which established firms engage. We do not capture very early-stage discovery technology sourcing (such as access to databases or research on scientific insights), as we cannot unambiguously identify what comprises a technological opportunity as there is no compound yet available. We also do not capture the sourcing of products that are already on the market; the dynamics may differ as the firm owning the product may itself have developed complementary assets, which changes the relationship between the firms. Nonetheless, future research can expand the study of novelty-seeking to the broader portfolio of value chain activities. In a similar vein, limiting our sample to the Top 50 firms, while aligned with our theoretical framework, does not include other types of firms. Therefore, it would be interesting to expand our framework to those firms that less frequently engage in in-sourcing with external partners or that do not work on as broad a portfolio of therapies as our sample firms.

Third, we also acknowledge that while we include supplementary analysis explaining the determinants of TMT attention, additional work is needed to address endogeneity inherent in

this factor. More concretely, researchers are encouraged to track TMT attention more systematically beyond annual reports, such as through interviews, press releases and other data and complement our approach with more rigorous statistical analysis, including finding instruments to further rule out endogeneity.

Finally, beyond the uniquely suited context of biopharmaceuticals for exploring problems and solutions, questions of generalizability of the results to other industries are germane. Despite the challenge of replicating our exact methods in other contexts in which problem-solution correspondences may be less clear, our expectation is that the dynamics we have observed are most likely to pertain to industries with technologically intensive development cycles. In addition, a growing stream of research has made clear that searching for external technologies and using external novel solutions may not always be beneficial for organizations, in particular when attempting to address operational problems (Berchicci et al., 2019; Patel & Pavitt, 1997). It is conceivable that a problem-solution lens applies to such settings, and it would be worthwhile to examine the factors encouraging novelty in product development in such operational contexts.

6 | CONCLUSION

Using a problem-solution lens, our analysis of external technology sourcing in the biopharmaceutical industry demonstrated a pervasive tendency toward familiar technologies while also highlighting two key factors associated with the pursuit of novelty. As the external sourcing of novel technology is a common prescription for incumbent firms attempting to embrace more radical innovation and is often thought to serve as the motivation for spanning external boundaries, our findings can help decision-makers in established firms recognize that their intention to seek novel technological solutions may not always be consistent with their actual in-sourcing choices.

At the same time, we outline when established firms seem more receptive to in-sourcing novel technologies due to TMT focus and feedback from unexpected failures. Awareness of these factors is also useful for specialized technology firms, which depend on established industry players to develop and commercialize their solutions. For example, specialized technology firms could target those therapeutic areas to which the top management of the established firm devotes greater attention. Similarly, strategic outreach by specialized startups of incumbents with recent unexpected failures in related problem areas may be fruitful.

Ultimately, our study only scratches the surface as to when firms pursue novel technological solutions when crossing organizational boundaries. Much work remains to assess proactive measures that managers can undertake to determine when novelty is most desirable and how to activate that pursuit.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from RECAP, Pharmaprojects, Evaluate Pharma, and ADIS Insights. Restrictions apply to the availability of these data, which were used under license for this study.

ORCID

Thomas Klueter https://orcid.org/0000-0002-3169-5488
Lori Rosenkopf https://orcid.org/0000-0001-5646-9164

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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