Understanding the Relationship between Divestitures and Innovation: The Moderating Role of Organization Design

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ABSTRACT

This paper investigates a tradeoff that may exist between the quantity and quality of innovation outcomes in divesting firms, as moderated by their organization designs. On one hand, divesting firms would be expected to produce fewer inventions after undertaking divestitures due to the knowledge loss that these transactions may entail. On the other hand, divesting firms would be expected to produce more original inventions and to progress a greater proportion of those inventions into development after undertaking divestitures due to the knowledge recombination and resource reallocation benefits of these transactions. These two innovation benefits of divestitures should be lower for firms with decentralized rather than centralized Research and Development (R&D) units. We find support for these arguments in the context of the global pharmaceutical industry.

Keywords: innovation, invention, corporate strategy, divestitures, organization design

INTRODUCTION

The literatures on innovation and corporate strategy are closely intertwined. Common approaches in managers' corporate strategy toolkits to enhance their firms' innovation outcomes include acquiring other companies (e.g., Ahuja & Katila, 2001; Puranam, Singh, & Chaudhuri, 2009), forming alliances with other entities that have complementary capabilities (e.g., Mowery, Oxley, & Silverman, 1996; Rothaermel & Deeds, 2004) or recombining resources such as knowledge across business units (Argyres, 1996; Karim & Kaul, 2015; Karim & Williams, 2012). Corporate managers pay close attention to these strategies, for example, by having dedicated functions for alliances (Kale, Dyer, & Singh, 2002; Kale & Singh, 2009), mergers and acquisitions (M&A) (Haspeslagh & Jemison, 1991; Trichterborn, Zu Knyphausen-Aufseß, & Schweizer, 2016) and corporate venture capital (Dushnitsky & Lenox, 2005). Thus, much of the literature at the intersection of innovation and corporate strategy suggests that *expansionary* corporate strategies like acquisitions, alliances, joint ventures, and corporate venture capital can help firms innovate by giving them direct access to new technologies, enabling them to develop new capabilities, or allowing them to recombine different pieces of knowledge in novel ways.

Missing from the intersection of the fields of innovation and corporate strategy, however, is an understanding of how *contractionary* corporate strategies—in particular, divestitures—might affect innovation outcomes. This omission is an important one because on their face, divestitures would seem to mechanically result in a loss of important knowledge and capabilities that are relevant to the innovation efforts of firms' remaining businesses (Hitt, Hoskisson, Johnson, & Moesel, 1996). This knowledge may be highly tacit (e.g., Grant, 1996), making it more challenging to access through the open market and potentially limiting the capacity of a firm to address difficult problems (e.g., Macher & Boerner, 2012). Furthermore, divestitures may disrupt organizational

routines, which could limit innovation activities in businesses that exhibit interdependencies with the divested unit (e.g., Feldman, 2013; Natividad & Sorenson, 2015). This suggests that divestitures may hinder innovation outcomes by removing relevant knowledge and capabilities from divesting firms. At the same time, however, divestitures might equally have the potential to improve firms' innovation outcomes, especially by providing a route for firms to focus their efforts. This might manifest itself in multiple ways, in that divestitures have been shown to enable firms to channel more resources into their core businesses (e.g., Helfat & Eisenhardt, 2004; Moschieri & Mair, 2008), to increase managerial attention (e.g., Feldman, 2013; Ocasio, 1997), and to manage a smaller portfolio of activities more effectively (Day, 1977). Ultimately, with increased managerial attention and more resources at hand, firms should be able to innovate more effectively, especially when divestitures facilitate the reallocation of resources across business units and the recombination of knowledge from previously disparate parts of the organization (Capron, Mitchell, & Swaminathan, 2001; Karim & Kaul, 2015).

Given the resource and knowledge-related benefits of divestitures for firms' innovation outcomes, we consider how organization design might influence this relationship. Organization design has been shown to affect resource allocation decisions in the context of innovation (e.g., Bardolet, Lovallo, & Rumelt, 2010; Birkinshaw & Lingblad, 2005; Ghoshal & Nohria, 1989; Rajan, Servaes, & Zingales, 2000), as well as how firms leverage their knowledge to invent (e.g., Argyres & Silverman, 2004; Karim & Kaul, 2015). In particular, the designs of firms' Research and Development (R&D) units may shape the relationship between divestitures and innovation, as these units are at the heart of firms' innovation efforts. R&D units generally define and execute the key innovation activities within firms (DeSanctis, Glass, & Ensing, 2002; Kay, 1988). Firms can either centralize R&D into a single unit reporting to a sole head of R&D or decentralize R&D

into multiple units, or they can create hybrid designs between these two extremes (e.g., Argyres & Silverman, 2004). R&D decentralization may limit the benefits of resource reconfiguration and the recombination of firms' knowledge following divestitures due to competition between business units and information asymmetry vis-à-vis corporate providers of capital (e.g., Bardolet et al., 2010; Karim & Kaul, 2015). By contrast, R&D centralization may accentuate the innovation benefits of divestitures by promoting resource reallocation and knowledge recombination.

Using proprietary data on the divestitures, organization designs, and innovation outcomes of 49 leading companies in the global pharmaceutical industry from 1995 to 2015, we divide innovation into the acts of invention and development in order to provide a more granular perspective on how divestitures can impact firms' innovation outcomes (Kapoor & Klueter, 2015; Schumpeter, 1939). We produce three key findings. First, consistent with the argument that divestitures may remove knowledge and capabilities from divesting firms, we show that the number of inventions produced by divesting firms decreases by more post-divestiture than it does for equivalent non-divesting firms. Second, consistent with the argument that divestitures may promote resource reallocation and knowledge recombination, we find that both the originality of inventions produced by divesting firms and the proportion of their inventions that progress into development increase by more post-divestiture than they do for equivalent non-divesting firms. Third, consistent with the argument that R&D decentralization may limit firms' ability to reallocate resources and recombine knowledge, we show that the innovation benefits of divestitures are smaller for divesting firms with decentralized R&D units than they are for divesting firms with centralized R&D units, both relative to equivalent non-divesting firms.

This paper contributes to the knowledge-based view of the firm by illustrating the tradeoff that firms face with respect to their innovation outcomes when they undertake divestitures:

although the quantity of inventions declines due to the inevitable loss of knowledge that accompanies divestitures, quality improves as a result of the novel recombination of knowledge within the organization. This paper also contributes to the literature at the intersection of corporate strategy and innovation by introducing divestitures into this conversation, to the literature at the intersection of corporate strategy and organization design by highlighting the interdependence between internal and external firm boundary decisions, and to the literature at the intersection of innovation and organization design by illustrating how organization design can shape the critical transition of inventions into development.

THEORY AND HYPOTHESES

Components of innovation: invention and development

In developing our theoretical arguments, we begin by dividing innovation into two key sets of activities. First, there is the act of invention (e.g., Arora, Cohen, & Walsh, 2016; Kapoor & Klueter, 2015). Invention involves the search to solve complex technical problems (e.g., Fleming & Sorenson, 2004). The creation of inventions is a knowledge recombination activity focused on finding solutions to these complex problems (e.g., Fleming, 2001; Fleming & Sorenson, 2004). These solutions are of limited economic value in and of themselves (Schumpeter, 1939). Outcomes associated with invention relate to both the quality and quantity of inventions (e.g., Hall, Jaffe, & Trajtenberg, 2001). The organizational unit responsible for a firm's invention activities is generally the R&D unit (e.g., Fleming & Sorenson, 2004).

Second, the act of development focuses on converting an invention into a final product that is of economic value. Development typically consists of multiple activities, such as addressing any remaining technical issues associated with an invention, refining and supplementing inventions with complementary knowledge, and scaling up for manufacturing (e.g., Mitchell & Singh, 1996;

Zahra & Nielsen, 2002). Development activities are more routinized, with a greater focus on issues such as resource allocation (e.g., Eisenhardt & Martin, 2000). Further, the identity of the final product and its market potential are much clearer at this stage (e.g., Aghion & Tirole, 1994). Development outcomes pertain to the progression of inventions through development (e.g., Chandy, Hopstaken, Narasimhan, & Prabhu, 2006). A key transition point is the handover of inventions from the research function to the development function (Kapoor & Klueter, 2015).

Having delineated the two key sets of activities associated with innovation and articulated each of their main outcomes, we now develop five hypotheses predicting how divestitures may affect invention and development outcomes in distinctive ways.

Divestitures and invention

The most straightforward way in which divestitures may affect invention outcomes is through the loss of some of the divesting firm's knowledge (Hitt et al., 1996). A firm's knowledge is encapsulated in its employees (e.g., Grant, 1996). Divestitures involve the movement of some employees away from the focal (divesting) firm to another entity where their knowledge will no longer be accessible to the divesting firm. This movement may be to an acquiring firm in the case of a sell-off, or to an independent company in the case of a spinoff. This knowledge can therefore not be recombined with the knowledge of the divesting firm's remaining employees. Furthermore, given the highly tacit nature of knowledge, firms may not be able to easily replace the lost knowledge that divestitures entail from other sources like publicly available patents or markets for technology (Hoetker & Agarwal, 2007). Thus, we hypothesize:

> *Baseline Hypothesis: The number of inventions produced by divesting firms decreases by more post-divestiture than it does for equivalent non-divesting firms.*

It is important to emphasize that this baseline hypothesis makes a prediction regarding the *quantity* of inventions produced, not the types of inventions created. But, divestitures would also

be expected to affect the *quality* of inventions that firms produce. It is well-established in the strategic management literature that the act of invention involves the novel recombination of knowledge (e.g., Fleming, 2001; Fleming & Sorenson, 2004**).** Organizations whose inventions draw on a broader body of knowledge have been shown to be more likely to deliver more original inventions (e.g., Hall et al., 2001; Squicciarini, Dernis, & Criscuolo, 2013).

When firms undertake divestitures, they are likely to undergo some form of structural realignment due to the removal of part of their organizations (e.g., Bergh, Johnson, & Dewitt, 2008; Berry, 2010). This realignment can range from formal restructuring all the way to individuals informally moving between different units within the organization (e.g., Agarwal, Ganco, & Ziedonis, 2009; Rosenkopf & Almeida, 2003). Prior work on the recombination of different business units suggests that this provides a route *"to unlock the potential for intra-organizational knowledge recombination"* (Karim & Kaul, 2015). Thus, the realignments that occur following divestitures may lead to novel recombinations of firms' existing knowledge.

The fundamental driver of the knowledge recombination that may occur following divestitures is that elements of the divesting firm's knowledge base residing in disparate parts of the organization may be brought closer together (e.g., Carlile, 2004; Carlile & Rebentisch, 2003). Prior to firms undertaking divestitures, three organizational barriers may limit knowledge recombination. First, both the source and recipient of relevant knowledge may lack the motivation to transfer that knowledge (Szulanski, 1996) due, for example, to competition between business units (Haas & Hansen, 2007; Pfeffer & Sutton, 1999). Second, the highly tacit knowledge associated with the creation and refinement of inventions may require rich and frequent communications between business units that may be organizationally distant from one another (Grant, 1996). This distance can limit the transfer of the tacit knowledge that is associated with the

creation of inventions (Szulanski, 1996). Third, and finally, managers may simply be unaware of the capabilities and knowledge residing in other parts of the organization and thus may not be readily able to access them (e.g., O'dell & Grayson, 1998).

Having said this, the realignments that occur following divestitures should lower the barriers to knowledge recombination. For example, previously-distant scientists may now reside in the same business unit, or the smaller size of the organization following a divestiture may facilitate new interactions among scientists. Thus, following divestitures, firms may be able to recombine a broader array of knowledge, potentially leading to the creation of more original inventions (Hall et al., 2001). Thus, we hypothesize:

> *Hypothesis 1: The originality of divesting firms' inventions increases by more post-divestiture than it does for equivalent non-divesting firms.*

Divestitures and the progression of inventions into development

As mentioned previously, after firms create inventions, these progress into development, ultimately leading to a final, marketed offering. Moving inventions into development is an important milestone within the innovation process (Kapoor & Klueter, 2015). In progressing an invention into development, firms need to resolve a host of technical issues to maximize the viability of an invention, and also to allocate sufficient supporting resources to it. An inability to accomplish these tasks can prevent firms from progressing inventions into development.

Analogously to the process of creating original inventions, divestitures may help firms address the knowledge-intensive task of solving complex technical problems. For example, managers of firms that undertake divestitures may be better able to solve technical problems by accessing a broader knowledge base and therefore developing more creative solutions to problems (e.g., Haas & Hansen, 2005). In addition, the enhanced knowledge flows that occur following divestitures might improve access to best practices (Szulanski, 1996) and help to limit fruitless

work such as “reinventing the wheel” (Hansen, Nohria, & Tierney, 1999).

Divestitures may also improve the allocation of supporting resources to enable the progression of inventions into development. Managers have limited attention that they struggle to allocate across the various businesses within their firms (Joseph & Ocasio, 2012; Ocasio, 1997). Divestitures allow managers to focus their attention on a smaller number of business areas, potentially enabling them to allocate capital and other resources more efficiently (Feldman, 2016). Applying this logic to innovation, divestitures may promote the more effective allocation of resources like cash, physical assets, and human capital to the best innovation opportunities. This can enable firms to cover more territory within a specific search space. For example, greater financial resources could be used to acquire new scientific equipment that permits a firm to screen a larger number of prototype ideas. Alternatively, scientists who used to work in the divested business may be reallocated to other R&D projects in the divesting firm.

As a result of these knowledge recombination and resource allocation benefits, firms may be more effective at progressing inventions into development after they undertake divestitures because they may be better able to address technical issues in and to allocate resources more effectively to their inventions. Thus, we predict:

> *Hypothesis 2: The proportion of divesting firms’ inventions progressing into development increases by more post-divestiture than it does for equivalent non-divesting firms.*

The moderating role of the organization design of firms’ R&D units

As mentioned earlier, innovation tends to occur in firms’ R&D units. The design of firms’ R&D units has been shown to influence how knowledge is accessed and recombined within organizations (Argyres & Silverman, 2004). This suggests that the design of firms’ R&D units may influence knowledge flows within organizations, and therefore moderate the primary relationships about which we have theorized thus far.

Firms' R&D units can vary in their degree of decentralization (e.g., Argyres & Silverman, 2004; Arora, Belenzon, & Rios, 2014; DeSanctis et al., 2002). Some firms may decentralize R&D into multiple standalone units, or into business units that each have their own separate portfolios of inventions. Other firms may have highly centralized R&D units reporting to a single Head of R&D who focuses on single portfolio of inventions. Multiple hybrid forms may exist between these two extremes, in which some aspects of R&D may be more decentralized and others may be more centralized (e.g., DeSanctis et al., 2002).

The canonical representation of a decentralized organization is that of business units in the same company competing with one another. As a result, these business units may fail to share information with each other (e.g., Dougherty, 1992; Kogut & Zander, 1996), and these reduced knowledge flows could impair the ability of divesting firms to recombine knowledge. Furthermore, for firms with decentralized R&D units, a divestiture may simply cleave one R&D unit away from the focal firm, thereby limiting opportunities for new knowledge recombination. Alternatively, any realignment that occurs following divestitures could be limited to one R&D unit within the decentralized R&D organization. These factors would be expected to limit the benefits of knowledge recombination for the entire organization following divestitures.

Additionally, the decentralization of R&D into multiple units is associated with parochialism, which can result in the sub-optimal resourcing of invention projects (e.g., Stein, 1997). Managers in firms with decentralized R&D units may have less awareness of opportunities in other units and greater career concerns due to the success or failure of inventions within their own units (Adner & Levinthal, 2004). As a result, these managers will be highly incentivized to push for resources to be allocated to their units post-divestiture, even if the opportunities in their units are inferior to those in other units. Due to information asymmetry between unit managers

and corporate managers responsible for cross-organizational reallocation of resources following divestitures, unit managers may over-inflate their opportunities, resulting in the inefficient allocation of resources (e.g., Stein, 1997). Thus, in firms with decentralized R&D units, there is likely to be significant competition between units for the resources freed up by divestitures (e.g., Birkinshaw & Lingblad, 2005; Ghoshal & Nohria, 1989; Karim & Kaul, 2015; Rajan et al., 2000). Additionally, managers in charge of reallocating resources may suffer from cognitive biases that could lead to the inefficient allocation of resources across units, regardless of the merits of each unit's inventions (Bardolet, Fox, & Lovallo, 2011).

The above-described limits to knowledge recombination and resource reallocation may be mitigated in firms that have centralized R&D units. When firms with centralized R&D units undertake divestitures, realignment will occur within a single organizational unit, and a single Head of R&D has the discretion to realign inventive resources across the entire firm. These benefits would be expected to facilitate enhanced knowledge flows across the entire R&D unit. Additionally, in firms with centralized R&D units, resource allocation tends to occur at the individual project level, with each invention project assessed on its own merits. This can promote a more effective allocation of resources across projects (e.g., Bardolet et al., 2011; Bardolet et al., 2010), and avoids rent-seeking or lobbying on the part of unit managers.

These arguments suggest that the innovation benefits of divestitures will be smaller for divesting firms with decentralized rather than centralized R&D units. Thus, we predict:

> *Hypothesis 3: The post-divestiture increase in the originality of inventions is smaller for divesting firms with decentralized R&D units than for divesting firms with centralized R&D units, relative to equivalent non-divesting firms.*

> *Hypothesis 4: The post-divestiture increase in the proportion of inventions progressing into development is smaller for divesting firms with decentralized R&D units than for divesting firms with centralized R&D units, relative to equivalent non-divesting firms.*

METHODS

Research context

The study is set in the global pharmaceutical industry. As such, we describe innovation as the creation of new drugs that can be launched in the marketplace. Consistent with prior studies, we describe invention as the creation of new patents that have the potential to lead to new drugs (e.g., Fleming, 2001; Fleming & Sorenson, 2004). The progression of drug candidates through clinical trials is an indication of the progression of inventions into development (Chandy et al., 2006).

There are two reasons why the pharmaceutical industry provides a rich context for testing our hypotheses. First, the companies in this sector are large firms that are continually re-evaluating the composition of their businesses, and divestitures provide a way for them to refocus resources in their remaining businesses. For example, Merck & Co. CEO, Kenneth Frazier highlighted this as a benefit of divesting Merck's consumer products business:[1]

> *"The sale of our consumer care business is part of our efforts to ensure that assets within our portfolio align with our core strategy, have industry-leading potential and generate long-term shareholder value."*

Similarly, Pfizer has recently focused on its proprietary drugs business by divesting and merging its generics business (Upjohn) with Mylan. Said Pfizer CEO, Albert Bourla:[2]

> *"For Pfizer, this transaction represents our sharpened focus on innovative medicines and is a testament to our purpose – breakthroughs that change patients' lives. At the same time, we'll maintain the financial flexibility to advance our strong pipeline, invest for growth and continue to return capital to our shareholders."*

Further to this point, Karl-Ludwig Kley, Merck KGAaA's CEO in 2007, commented following the sale of its generics business:[3]

[1] https://www.fiercepharma.com/m-a/merck-announces-sale-of-consumer-care-business-to-bayer-ag-for-14-2-billion
[2] https://www.forbes.com/sites/stephenbrozak/2019/07/29/the-pfizer-mylan-deal-what-this-means-for-phama/#2f3c457311cd
[3] https://www.reuters.com/article/us-merck-mylan-idUSL1332538820070513

"This transaction will allow Merck to focus its resources on further growth within its pharmaceuticals and chemicals business sectors."

Second, the creation of patents and their conversion into final marketed drugs forms the lifeblood of large global pharmaceutical companies. This ensures that senior managers pay close attention to innovation. With only a limited period of exclusivity afforded by patent protection, pharmaceutical firms continuously seek to generate new drugs. Corporate strategies such as M&A and divestitures enable these firms to acquire or reallocate resources, and to access new knowledge, enabling them to create new inventions and develop them into final products.

Sample and data

The sample consists of 49 leading pharmaceutical firms over the period 1995 to 2015. Focusing on the larger pharmaceutical firms that are responsible for the majority of innovation in the industry is common within the strategic management literature (e.g., Anand, Oriani, & Vassolo, 2010; Gunther McGrath & Nerkar, 2004; Kapoor & Klueter, 2015). The sample is based on 2004-2006 annual prescription drug sales, as defined by the *Pharmaceutical Executive* magazine's Top 50 Pharmaceutical companies (e.g., Klueter, Monteiro, & Dunlap, 2017).[4] In this period, 64 unique firms appeared in the Top 50 in one or more years. The 15 firms that we excluded are either private firms or firms that did not provide sufficient information on their organizational structures in their public filings. These excluded firms were all in the lower half (26-50 ranking in terms of pharmaceutical sales) in one or more of the three years in the 2004-2006 period. Using the midpoint of the sample period (1995-2015) allows us to study firms that have at least 10 years of history within the sample time-frame. We dropped those firms in the sample that were acquired by other companies. Thus, by 2015, 33 out of the 49 sample firms remain. Compared to the universe

[4] The top 20 pharmaceutical firms by R&D spend represented 60 percent of industry R&D spend and the top 20 pharmaceutical firms by prescription sales represented 64 percent of industry sales in 2015 (EvaluatePharma, 2016).

of listed pharmaceutical firms from Compustat, our sample of 49 firms is significantly larger and more profitable on average.

We identify divestitures undertaken by the sample firms using SDC Platinum. Divestitures include both sales of businesses to other firms and spinoffs of businesses into new companies. We only consider deals of $500m or more in value to ensure that there is a significant impact on the sample firms from these divestitures. The firms in our sample undertook a total of 42 divestitures over the 1999-2012 period.[5] These divestitures were undertaken by 19 of the 49 sample firms.

We draw invention data from the European Patent Office Patstat database (e.g., Conti, Gambardella, & Mariani, 2013). This database provides good coverage across multiple patent-granting jurisdictions (Kang & Tarasconi, 2016).[6] To measure the progression of inventions into development, we draw upon clinical product development data obtained from the Pharmaprojects database (e.g., Chandy et al., 2006; Kapoor & Klueter, 2015). As we will describe in more detail, we hand-collected organization structure data from company 10-K, 20-F, DEF14A SEC filings, and annual reports. We obtain financial data from Compustat.

Empirical strategy

The empirical strategy we follow in this study is to compare the pre- versus post-divestiture changes in the innovation outcomes of firms that undertook divestitures (the "treated" firms) relative to those of comparable firms that did not undertake divestitures (the "control" firms). We also consider how these differences vary depending on whether the treated and control firms had

[5] Although the sample period runs from 1995 to 2015, we only consider divestitures that were undertaken between 1999 and 2012, in order to have a sufficient number of pre-divestiture observations for firms that divested in 1999 and a sufficient number of post-divestiture observations for firms that divested in 2012.

[6] Using patent data to measure firms' inventive output suffers from some limitations: not all inventions may get patented (e.g., Levin et al., 1987), patents may not always correspond to products (Hall et al., 2001), and patents may be filed for strategic rather than knowledge capture purposes (e.g., Spender & Grant, 1996). However, these limitations are mitigated in the pharmaceutical industry, in that firms patent a large proportion of their inventions and patents relate closely to final products (e.g., Dushnitsky & Shaver, 2009; Nerkar & Roberts, 2004).

centralized or decentralized R&D units. This empirical set-up calls for a triple differences-in-differences analysis (treated versus control firms, pre- versus post-divestiture, and centralized versus decentralized R&D), similar to the approach in Feldman (2016).

The treated firms in our sample are the 19 firms that undertook 42 divestitures during the 1999-2012 period. We used a propensity score matching model to generate a matched set of firms that did not undertake divestitures—the control firms. In this model, a probit regression first predicts the likelihood that a given firm in our sample undertakes a divestiture in *year n*, using the control variables described below as covariates to predict that probability. Results of this first-stage probit regression appear in Table 1.[7] From there, we identified the nearest neighbor to each treated firm in *year n*, as predicted by the propensity scores. We were able to match the treated firms that undertook 35 out of the 42 divestitures in *year n* to comparable control firms that did not undertake divestitures in that same year. Observations dropped out for either being not in the area of common support or because matching variables were not available.

Balance tests comparing the characteristics of the matched treated and control firms in *year n* appear in Table 2. This table shows that the covariates between the treated and control observations are quite similar in the matched sample, but not in the unmatched sample.

-----Tables 1 and 2 here-----

Having identified the matched set of treated and control firms, we built seven-year panels of firm-year observations around the year of the divestiture (*year n*). For the treated (divesting) firms, each panel consists of seven years: the three years prior to, the year of (*year n*), and the three years after each divestiture. Analogously, for the control (non-divesting) firms, each panel consists of seven years: the year in which it was matched to a firm that undertook a divestiture (*year n*), the

[7] From this analysis, it appears that the intensity of divestiture activity has declined over time and that firms that are more technologically diverse are more likely to divest.

three years before, and the three years after.[8] Any control observations that fell within three years of a divestiture by a control firm were dropped to ensure the control observations only included firms that had not divested during the relevant window. This led to a final sample of 365 observations, of which 237 were treated (i.e., firm-year observations in the seven-year period in which a given company undertook a divestiture) and 128 control observations (i.e., firm-year observations in the seven-year period in which a given company that did not undertake a divestiture was matched to a firm that did).

The construction of these firm-year panels pertaining to the treated and control firms in our sample enables us to conduct the pre- versus post-divestiture comparison. For the treated firms—those that undertook divestitures—this comparison is straightforward: the pre-divestiture years are the three years before those companies undertook divestitures and the year of each divestiture, while the post-divestiture years include the three years subsequent to the year of the divestiture. For the control firms—those that did not undertake divestitures—the comparable, "pre-divestiture" years are the three years before those companies were matched to the treated firms in our sample and the year in which those companies were matched to the treated firms (that is, *years n*, *n-1*, *n-2*, and *n-3*), and the "post-divestiture" years are the three years subsequent to that (*years n+1*, *n+2*, and *n+3*).

In the next subsection, we will more formally define the above-described variables measuring the treated versus control firms and the pre- versus post-divestiture years, and we will describe our measure of R&D organization design. To implement the triple differences-in-

[8] This approach allows a firm to appear as treated within the seven-year window in which it undertook a divestiture, but as a control in the seven-year windows in which it did not undertake divestitures. For example, Abbott Laboratories sold TAP Pharmaceuticals to Takeda in 2008, and then sold its non-U.S. businesses to Mylan in 2014. Thus, Abbott could appear as a control firm in our analysis between 1995 and 2005, as it undertook no divestitures during that time period, but Abbott could then appear as a treated firm starting in 2006 because it undertook divestitures after that time.

differences model, we will include the full set of interaction terms across all of these variables, which we will also describe in greater detail in the next subsection.

Variables

Dependent variables. We develop three separate dependent variables to test the hypotheses.

First, for the Baseline Hypothesis, we measure the quantity of inventions (*Quantity)* using the number of patent families filed annually by the firms in our sample. Patent family counts are used to avoid double counting patents filed in multiple jurisdictions. We used patents assigned in the European Community statistical classification of economic activities category (NACE2) 21 (manufacture of basic pharmaceutical products and pharmaceutical preparations). We define the year in which a patent family was created as the earliest filing date of a patent in that family. In regressions taking *Quantity* as the dependent variable, we use negative binomial regressions because this variable is a count variable.

Second, for Hypotheses 1 and 3, to measure the breadth of knowledge from which patents draw (Argyres & Silverman, 2004), reflecting patent originality (Hall et al., 2001), we used the International Patent Classification (IPC) 4-digit technical classifications of the citations made by a focal patent. We utilized measures of originality produced by the OECD (Squicciarini et al., 2013), which is the approach recommended by Hall et al. (2001). The larger the value, the more original is a patent, as it draws from a broader array of technologies. We assign the maximum originality of a patent in a given family as the originality for that family. We used these values to estimate an average originality per patent family in each firm-year (*Originality*). In regressions taking *Originality* as the dependent variable, we use fractional logit regressions because this variable is continuous and bounded between zero and one.

Third, for Hypotheses 2 and 4, to measure progression of inventions through the

development process, we examine the proportion of drug-candidates in Phase 1 clinical trials moving to Phase 2 in each firm-year (*Progress).*[9] We create this variable by counting the number of drug candidates in a firm's portfolio moving from Phase 1 to 2 in a year and dividing this by the number of drug candidates in Phase 1 in a firm's drug development portfolio. In regressions taking *Progress* as the dependent variable, we also use fractional logit regressions because this variable is continuous and bounded between zero and one.

Independent variables. To implement the triple differences-in-differences approach described above, we develop three key independent variables.

First, consistent with the earlier discussion, we define *Treat* as a binary variable taking the value one in each of the firm-year observations pertaining to the treated firms (i.e., those that undertook divestitures), and zero in each of the firm-year observations pertaining to the control firms in our sample (i.e., the matched companies that did not undertake divestitures).

Second, also in line with the earlier discussion, we define *After* is a binary variable taking the value one in the "post-divestiture" years pertaining to both the treated and control firms, and zero in the "pre-divestiture" years for those companies. Note that we define *After* as zero for the year of the divestiture but undertake a robustness check to see the impact of changing this to one.

Third, we define *R&D Decentralization* using top management team (TMT) data available from company 10-K/20-F/DEF 14A SEC filings (e.g., Albert, 2018; Girod & Whittington, 2015; Guadalupe, Li, & Wulf, 2014).[10] We developed a database of 15,129 executive and extended executive team roles for the sample of 49 firms over the 1995-2015 period, resulting in a total of

[9] An R&D manager in one of our sample firms indicated that the Phase 1 to Phase 2 transition is a key milestone for research managers: "Research managers are incentivized by the number of drugs that they can get into Phase 2 (Proof of Concept)." Due to non-disclosure agreements, we unfortunately cannot divulge the source of this quote.
[10] In interviews with R&D managers, they confirmed that the structure of the TMT provides an accurate reflection of their firms' high level structures, specifically in regard to how R&D is organized.

898 firm-years of data and an average of 16.8 executive and extended executive roles per firm-year (standard deviation = 11.1).[11] To represent the decentralization of R&D, we determined whether firms' R&D or Research (in the case of functionally separate R&D) was organized into a single or multiple units. For diversified firms that operate beyond pharmaceuticals, we focused on R&D units that pertain to pharmaceuticals, while R&D units dedicated to areas such as consumer products were excluded in order to control for the level of diversification. Using this approach, the variable *R&D Decentralization* takes the value one if there are multiple R&D or research groups reporting to separate heads within the TMT or to leads of business units, and zero if the firm has a single integrated pharmaceutical R&D or research group reporting to a single TMT lead. 12.3% of the firm-year observations in the sample have *R&D Decentralization* equal to one.

To implement the triple differences-in-differences analysis that we described earlier, we therefore include seven key independent variables in our regression models. First, we include *Treat*, *After*, and *R&D Decentralization.* Second, we include each of the three two-way interaction terms between these variables: *After*×*Treat*, *R&D Decentralization*×*Treat*, and *R&D Decentralization*×*After*. Third, we include the triple interaction term among all three variables: *R&D Decentralization*×*Treat*×*After*.

To the extent that the Baseline Hypothesis is supported, we expect *After*×*Treat* to have a negative coefficient when the dependent variable is *Quantity*. To the extent that Hypotheses 1 and 2 are supported, we expect to observe positive coefficients on *After*×*Treat* when the dependent variables are *Originality* and *Progress,* respectively. To the extent that Hypotheses 3 and 4 are supported, we expect to observe negative coefficients on *R&D Decentralization*×*Treat* ×*After*

[11] The coding of roles and various facets of organizational decentralization were undertaken in the dissertation research of one of the authors through careful review of the management roles in each organization. This coding was validated through review of organizational descriptions from companies' filings (e.g. CEOs' letters to shareholders).

when *Originality* and *Progress* are the dependent variables, respectively.

Control variables. We include four sets of control variables in our regression analyses. First, we include two additional structural variables to account for heterogeneity in the organization designs of the sample firms. Although *R&D Decentralization* is a binary variable, firms may have "hybrid" R&D organizations (e.g., Argyres & Silverman, 2004; Arora et al., 2014). To account for this, we include a control variable, *R&D Functional Differentiation*, which measures whether firms' R&D is integrated into one unit or has separate research and separate development units. This variable is akin to vertical dis-integration of R&D, as compared to the horizontal dis-integration that is captured by *R&D Decentralization*. *R&D Functional Differentiation* is used as a control variable because some aspects of R&D may be more centralized (e.g., research), while others may be more decentralized (e.g., development). This binary variable takes the value one if there are separate research and development heads reporting to the CEO, and zero if research and development are integrated.[12] 22 percent of the sample firm-years have functionally-differentiated R&D.

We also define *Corporate Decentralization* using the approach followed by Guadalupe et al. (2014), who categorized TMT members as general managers, administrative functional managers or product functional managers. The variable *Corporate Decentralization* is measured as the proportion of general manager roles in the TMT relative to the overall size of the TMT (excluding the CEO) (Albert, 2018). General manager roles relate to individuals who are responsible for the performance of a defined sub-section of the business, which may be a geographical or a product area. To account for firms operating in non-pharmaceutical domains,

[12] By way of interpretation, R&D Functional Differentiation takes the value one when decision rights are split between research and development and there are separate hierarchical reporting lines pertaining to each function. By contrast, R&D Functional Differentiation takes the value zero when a functionally-integrated R&D unit has decision rights over the complete R&D process and has a single associated hierarchical authority covering all R&D.

business unit leads in these areas are excluded. The higher the value of *Corporate Decentralization*, the more decentralized is that firm.[13]

Second, we include multiple firm-specific control variables in our regressions. We control for firm size (*Size)* using the natural log of each firm's annual sales. We include the annual spend on R&D by a firm as a proportion of annual revenues (*R&D Intensity*), as well as each firm's discounted patent stock (*Patent Stock*) of patent families filed by a focal firm (Arora et al., 2014). Since changes in executive leadership can shape both divestiture decisions and organization design, we control for CEO turnover using a binary variable (*CEO*) that takes the value one if a firm's CEO changes in any given year, and zero if not. Finally, we also control for a firm's operating performance using their return on assets (*Performance)*, and for its selling, general and administration expenses (SG&A) using the natural log of SG&A (*SG&A*).

Third, we also control for the degree of diversification of each firm, which can impact its divestiture decisions, organization design, and innovation outcomes. The variable *SBU* reflects the total number of business units within a given firm—the number of operating segments that report separate financial statements in annual reporting documents. The variable *Tech. Diversity* is a measure of the technological diversity of firms' R&D efforts, as calculated using a Herfindahl measure, whereby the sum of the squared proportions of patent families filed in a focal year that pertain to each therapeutic class (based on Pharmaprojects therapeutic classes) is subtracted from one. Higher values of *Tech. Diversity* reflect more technological diversity.

Fourth, in testing Hypotheses 2 and 4, we control for characteristics of firms' clinical

[13] Subsample analyses and firm fixed effect regressions of the number of general manager, administrative functional, and product functional roles (dependent variables) versus firm size (independent variable) exhibit no relationship, suggesting that *Corporate Decentralization* is not simply proxying for firm size. For example, AstraZeneca in 2005 had two general manager roles, two administrative functional roles, and four product functional roles, with a total of 65,300 employees. In contrast, CSL in 2008 had three general managers, four administrative functional roles, and one product functional role, with a total of 9,300 employees.

development portfolios that could influence the progression of drug-candidates into and through development. The variable *Portfolio Size* represents the number of drug-candidates under development from pre-clinical to Phase 3 in a firm's pipeline at the end of the focal year. *External* represents the proportion of externally sourced drug candidates within a firm's development pipeline. *NCE* represents the proportion of drug candidates with a firm's development pipeline that are New Chemical Entities.[14] *Bio* represents the proportion of drug-candidates that are biologics. Finally, *Novelty* takes a value between zero and two (Klueter, 2013). If the mechanism of action and origin of material in the relevant broad therapeutic domain are new to the firm, the value is set at two; if one of these is new, the value is set as one; and if neither of these are new, the value is set to zero. These values are averaged across a firm's complete portfolio in each firm-year.

Descriptive statistics appear in Table 3. In addition to the four sets of control variables described above, our specifications also include year, firm and business category fixed effects, and standard errors are clustered at the firm-level to account for intra-group correlation. The business category fixed effects consist of a set of dummies measuring whether firms have operating segments in categories other than pharmaceuticals (consumer goods, medical devices, animal medication, bulk chemicals, nutrition, and generic pharmaceuticals).

-----Table 3 here-----

RESULTS

Main analyses

We begin by testing the Baseline Hypothesis in Models 1-3 of Table 4. The negative coefficients on *After*×*Treat* ($p<0.01$) indicate that firms that undertake divestitures file fewer patents after these transactions than firms that do not divest. Economically, this differential amounts to divesting

[14] NCEs include no component that has been previously approved by the US Food and Drug Administration (FDA). NCE designation from the FDA provides firms with five years of marketing exclusivity.

firms filing 66 fewer patents after they divest (14 percent of the mean number of patents filed by the firms in our sample), relative to equivalent non-divesting firms. This result provides evidence in support of the Baseline Hypothesis.

-----Table 4 here-----

Regression results testing Hypotheses 1 and 3 appear in Models 1-3 of Table 5, where the dependent variable is *Originality*. Hypothesis 1 is supported in all three models, as shown by the positive coefficient on *After*×*Treat* ($p<0.05$). This indicates that the average originality of inventions produced by divesting firms increases by two percentage points more post-divestiture (2.5% of the mean originality of the patents filed by the firms in our sample) than it does for equivalent non-divesting firms. In Model 3, moreover, the negative coefficient on *R&D Decentralization*× *Treat*×*After* ($p=0.055$) provides evidence in support of Hypothesis 3 by showing that that the post-divestiture increase in the originality of inventions is three percentage points smaller for divesting firms with decentralized R&D units than for divesting firms with centralized R&D units, relative to equivalent non-divesting firms. Figure 1 illustrates this relationship graphically, showing that among firms with centralized R&D units, those that divest have greater increase in invention originality than those that do not divest, whereas the opposite is true among firms with decentralized R&D units.

-----Table 5 and Figure 1 here-----

Regression results testing Hypotheses 2 and 4 appear in Models 1-3 of Table 6, where the dependent variable is *Progress.* In Model 3, the positive coefficient on *After*×*Treat* ($p=0.065$) provides support for Hypothesis 2 by showing that the proportion of divesting firms' inventions that progress into development increases by five percentage points more post-divestiture (28 percent of mean value) than for equivalent non-divesting firms. Additionally, in Model 3, the

negative coefficient on *R&D Decentralization*×*Treat*×*After* (p=0.004) provides evidence in support of Hypothesis 4 by showing that the post-divestiture increase in the proportion of inventions progressing into development is 15 percentage points smaller for divesting firms with decentralized R&D units than for divesting firms with centralized R&D units, relative to equivalent non-divesting firms. Figure 2 illustrates this relationship graphically, showing that among firms with centralized R&D units, those that divest have a greater increase in the proportion of inventions progressing into development than firms that do not divest, whereas the opposite is true among firms with decentralized R&D units.

-----Table 6 and Figure 2 here-----

Robustness Checks

We conducted four robustness checks. First, as shown in Models 1-3 of Table 7, we used caliper (rather than nearest neighbor) matching (caliper = 0.005) in the propensity score matching model. Second, as shown in Models 4-6 in Table 7, we set the variable *After* to one (rather than zero) in the year of the divestiture. Third, as shown in Models 7-8 in Table 7, we tested alternative measures of *Originality* and *Progress*. As an alternative to *Originality*, we examine the average patent radicalness of patents filed by a firm (Squicciarini et al., 2013). As an alternative to *Progress*, we examine the number (rather than the proportion) of inventions progressing from Phase 1 to Phase 2 clinical trials using a negative binomial model. Fourth, as shown in Models 9-11 in Table 7, we tested an alternate measure for *R&D Decentralization*.[15] Results are consistent across these tests.

[15] This alternate representation of *R&D Decentralization* is linked to the *Corporate Decentralization* variable, under the logic that firms can have centralized R&D units, but if they are more decentralized at a corporate level, there may be a greater degree of decentralization of R&D activity within their centralized R&D unit. Thus, we create a trichotomous version of *R&D Decentralization* in the following way. First, for firms with centralized R&D units, those that had below-median levels of *Corporate Decentralization* were assigned a value of *R&D Decentralization* of zero. Second, for firms with centralized R&D units, those that had above-median levels of *Corporate Decentralization* were assigned a value of *R&D Decentralization* of one. Third, firms with multiple (decentralized) R&D units were assigned a value of *R&D Decentralization* of two. Thus, effectively, when *R&D Decentralization* is set to one, we are describing firms with hybrid R&D structures (e.g., Argyres & Silverman, 2004; Arora et al., 2014).

-----Table 7 here-----

DISCUSSION AND CONCLUSION

Summary of results

In this paper, we have analyzed how divestitures influence firms' innovation outcomes using a unique dataset in the context of the global pharmaceutical industry. There are three key findings. First, the number of inventions produced by divesting firms decreases by more post-divestiture than it does for equivalent non-divesting firms. Second, both the originality of inventions produced by divesting firms and the proportion of their inventions that progress into development increase by more post-divestiture than they do for equivalent non-divesting firms. Third, the innovation benefits of divestitures are smaller for divesting firms with decentralized rather than centralized R&D units, relative to equivalent non-divesting firms.

Contributions and directions for future research

This paper contributes to the strategy literature in several key ways. First, our study advances the knowledge-based view of the firm by highlighting how divestitures can influence both the stocks and flows of firms' knowledge (Grant, 1996). Although divestitures appear to reduce firms' knowledge stocks, these transactions also appear to facilitate the recombination of firms' remaining knowledge, suggesting that divestitures may help firms improve the flow of knowledge within their organizations. This implication is consistent with the work of Karim and Kaul (2015), who show how internal realignment of firms' business units can lead to novel knowledge recombination, thereby resulting in more impactful inventions. Additionally, though, our study illustrates that even when firms have a lower stock of knowledge than their competitors, they may be able to overcome that disadvantage by taking steps to recombine that knowledge in novel and distinct ways, and that divestitures can catalyze such knowledge reconfiguration. Large

organizations are often hamstrung by inertia stemming from codified routines and processes (e.g., Gilbert, 2005; March & Simon, 1958; Nelson & Winter, 1982), social and financial pressures that constrain decision-making (Cyert & March, 1963; Eisenhardt & Bourgeois, 1988), and implicit and explicit resistance from both internal and external stakeholders (Bigley & Wiersema, 2002; Christensen & Bower, 1996). As a result, it may be difficult for organizations to even start, much less execute, "soft" changes like the knowledge recombination that Karim and Kaul (2015) contemplate. Our study suggests that divestitures can spur exactly these kinds of changes, shedding light on one key antecedent to how firms may be able to leverage improved knowledge flows to offset lower knowledge stocks.

In addition to this contribution, our work introduces new insights to the literatures at the intersection of the three bodies of research on which we draw: corporate strategy, innovation, and organization design. In terms of the literature at the intersection of corporate strategy and innovation, much of this research has explored how expansionary corporate strategies like M&A (e.g., Ahuja & Katila, 2001; Puranam et al., 2009) and alliances (e.g., Mowery et al., 1996; Rothaermel & Deeds, 2004) may improve innovation outcomes. By comparison, our work explicitly introduces divestitures into this conversation, showing that divestitures can be as proactive and strategic as M&A and alliances, and indeed, can impart unique innovation benefits that firms would not otherwise be able to attain. The conceptual distinction that our work raises is that while expansionary strategies may help firms innovate better by enabling them to access to *external* technologies, resources, capabilities, and knowledge that they might not otherwise be able to develop internally, contractionary strategies like divestitures may help firms innovate better by promoting the *internal* reconfiguration of key inventive resources and human capital that they would not be able to achieve externally. This sheds light on the unique benefits of divestitures as

a mode of corporate strategy, and underscores the point that although divestitures are often viewed by managers and portrayed by the media as a sign of failure (Dranikoff, Koller, & Schneider, 2002), neither of these is necessarily true.

In terms of the literature at the intersection of corporate strategy and organization design, this study highlights the intricate relationship between the internal and external boundaries of the firm. The literatures on organization design and corporate strategy have largely remained separate from one another, with the former exploring internal boundary decisions such as the structure of R&D units (e.g., Argyres & Silverman, 2004), the relationship between the corporate center and international subsidiaries (e.g., Rugman & Verbeke, 2001) and the degree of divisionalization within firms (e.g., Argyres, 1996), and the latter considering the antecedents and consequences of external boundary decisions such as M&A, alliances, and divestitures (e.g., Feldman, 2013, 2016; Kale & Singh, 2009; Montgomery & Singh, 1987; Puranam, Singh, & Zollo, 2006). A few prior studies have examined the relationship between internal organization design and external firm boundaries, finding that firms that are more decentralized tend to undertake more and larger acquisitions (Arora et al., 2014) and to have richer communications with alliance partners (Badir, Büchel, & Tucci, 2009), while firms with centralized R&D are more likely to form strategic alliances (Zhang, Baden-Fuller, & Mangematin, 2007). While these studies have focused on how internal design choices can shape the *propensity* of firms undertake corporate strategies, our work instead illustrates how internal design elements *interact with* corporate strategies to influence firm outcomes. This distinction is important because it underscores the point that organization design choices are not only an antecedent of corporate strategy decisions, but rather that these two forms of decision-making are closely intertwined, and their linkage can have important implications for corporate outcomes like innovation.

In terms of the literature at the intersection of innovation and organization design, prior studies have focused on how organization design can shape the more creative, upstream ideation or invention stage of innovation (Argyres & Silverman, 2004; Arora et al., 2014; Karim & Kaul, 2015; Karim & Williams, 2012; Keum & See, 2017). Our study extends this body of research by exploring how organization design influences *downstream* innovation outcomes (in the form of the transition of inventions into development), in addition to the more standard upstream outcomes that prior research has considered. Focusing on the downstream stages of innovation is important because even when firms succeed at creating new inventions, they may still have difficulty converting these inventions into successful products. A familiar example is that of Xerox Palo Alto in the 1970s, which created many transformative inventions but failed to subsequently develop and commercialize them (Chesbrough & Rosenbloom, 2002). Thus, our work extends the literature on organization design and innovation by illustrating how certain organization design choices may help firms mitigate some of the challenges of moving beyond the initial creation of an invention.

Beyond these contributions, this study opens a number of interesting directions for future research. First, we have theorized in this study that two key drivers of the innovation benefits of divestitures are improved knowledge flows and resource reallocation, and we have inferred that these occur by measuring post-divestiture improvements in patent originality and progression into development. It would be interesting to be able to quantify these mechanisms more granularly, perhaps by gaining access to data on the movements of key inventive resources (e.g., scientists) within organizations that undertake divestitures. Second, we have focused in this study on the earlier "phases" of the innovation process—invention, and then the progression of inventions into development. As such, it would be interesting to explore whether the benefits of improved resource reallocation following divestitures trickle down to the commercialization of inventions (e.g.,

Garud, Tuertscher, & Van de Ven, 2013; Kapoor & Klueter, 2015), and potentially even to the financial performance of innovative firms in industries like pharmaceuticals, technology, and media. Third, we have explored the costs and benefits of a single mode of corporate strategy—divestitures—for innovation outcomes. However, the reality of corporate strategy is that it often unfolds inter-temporally (Feldman, 2020), with several acquisitions or divestitures undertaken sequentially (e.g., Hitt et al., 1996; Trichterborn et al., 2016), acquisitions followed by divestitures (Anand & Singh, 1997; Capron et al., 2001; Hayward & Shimizu, 2006; Hoskisson, Johnson, & Moesel, 1994), or even divestitures followed by acquisitions (Bennett & Feldman, 2017; Lang, Poulsen, & Stulz, 1995; Nanda & Narayanan, 1999). It would be interesting to explore the implications of such sequences of transactions for innovation outcomes, especially in light of our earlier point that divestitures may impart unique innovation benefits to companies relative to acquisitions. Finally, we have focused in this study on the design of firms' R&D units, rather than on their organization designs more generally. It would be interesting to explore how firms reorganize internally (beyond their R&D units) before undertaking divestitures, and what implications such reorganizations have for divestiture performance. This would provide a vital complement to research that has considered how design choices following M&A can shape the effectiveness of these corporate strategies (e.g., Puranam et al., 2009; Puranam et al., 2006).

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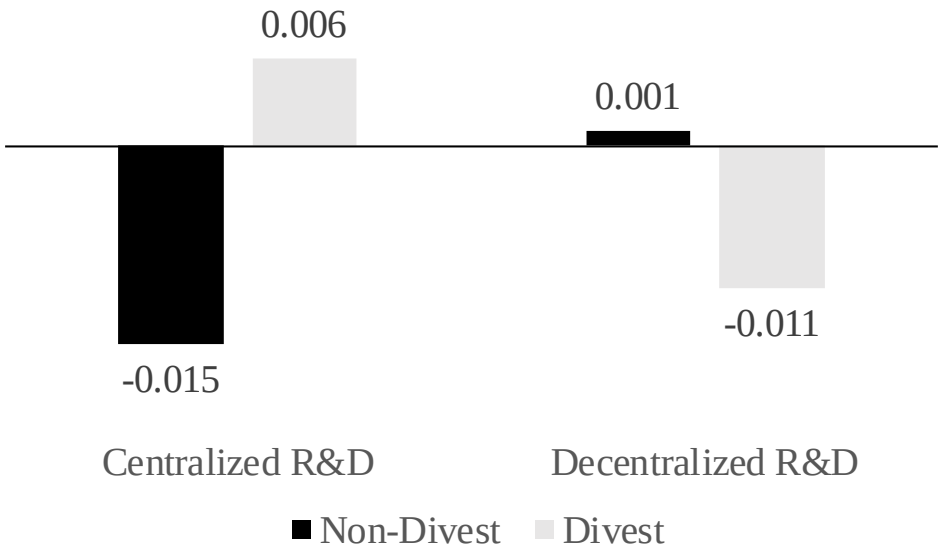
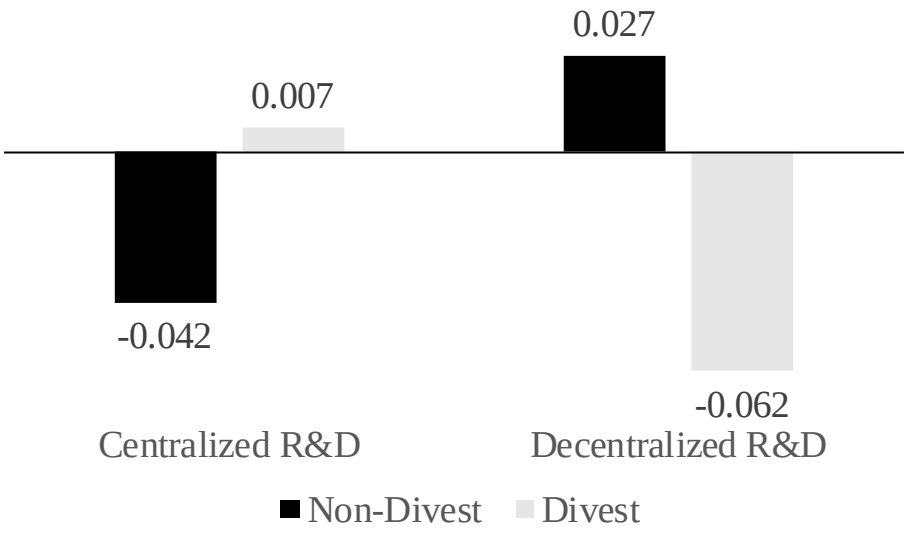
FIGURES AND TABLES

Figure 1: Relationship between divestitures and invention originality for divesting and non-divesting firms with centralized versus decentralized R&D (Hypothesis 3)



Height of bar represents change in originality following divestiture

Figure 2: Relationship between divestitures and proportion of inventions progressing to development for divesting and non-divesting firms with centralized versus decentralized R&D units (Hypothesis 4)



Height of bar represents change in the proportion of inventions progressing into development following divestiture

Table 1: First-stage probit regression analysis in propensity score matching model

DV=Treat	Model 1
R&D Decentralization	-0.185
	(0.555)
R&D Functional Differentiation	-0.082
	(0.734)
Corporate Decentralization	-0.264
	(0.565)
Size	0.320
	(0.373)
R&D Intensity	0.320
	(0.758)
Patent Stock	0.000
	(0.593)
CEO	-0.180
	(0.544)
Performance	-1.133
	(0.501)
SG&A	0.282
	(0.409)
SBU	-0.026
	(0.798)
Tech. Diversity	3.801
	(0.076)
Portfolio Size	-0.001
	(0.545)
External	-0.455
	(0.565)
NCE	-0.273
	(0.806)
Bio	-1.417
	(0.288)
Novelty	-0.280
	(0.777)
Year	-0.073
	(0.004)
N	749
Log Likelihood	-108.4

p-values in parentheses. Nearest neighbor matching

Table 2: Balance tests from propensity score matching model

	Unmatched Sample				Matched Sample			
Variable	**Treated**	**Control**	**t-statistic**	**p>|t|**	**Treated**	**Control**	**t-statistic**	**p>|t|**
R&D Decentralization	0.114	0.122	-0.130	0.894	0.114	0.143	-0.350	0.726
R&D Functional Differentiation	0.200	0.237	-0.500	0.618	0.200	0.229	-0.290	0.775
Corporate Decentralization	0.296	0.250	1.120	0.265	0.296	0.282	0.250	0.801
Size	10.041	8.580	5.810	0.000	10.041	10.142	-0.610	0.545
R&D Intensity	0.157	0.184	-0.690	0.492	0.157	0.135	1.400	0.165
Patent Stock	1455.286	600.236	7.180	0.000	1455.286	1601.644	-0.740	0.464
CEO	0.114	0.112	0.040	0.967	0.114	0.114	0.000	1.000
Performance	0.095	0.077	1.130	0.261	0.095	0.089	0.320	0.747
SG&A	9.212	7.763	6.230	0.000	9.212	9.237	-0.150	0.885
SBU	2.629	2.438	0.880	0.381	2.629	2.857	-0.900	0.370
Tech. Diversity	0.826	0.763	3.390	0.001	0.826	0.819	0.640	0.527
Portfolio Size	125.090	60.458	6.260	0.000	125.090	125.460	-0.020	0.983
External	0.453	0.523	-1.910	0.056	0.453	0.472	-0.630	0.531
NCE	0.611	0.502	2.810	0.005	0.611	0.637	-0.870	0.385
Bio	0.191	0.247	-1.610	0.108	0.191	0.177	0.650	0.515
Novelty	0.854	1.035	-4.350	0.000	0.854	0.837	0.530	0.596
Year	2005	2005	-0.360	0.720	2005	2005	-0.300	0.762

Table 3: Descriptive statistics

	MEAN	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.Quantity	456.222	267.763	1.00																		
2.Originality	0.844	0.051	0.10	1.00																	
3.Progress	0.191	0.147	-0.09	0.03	1.00																
4.R&D Decentralization	0.090	0.287	0.13	0.02	-0.04	1.00															
5.R&D Functional Differentiation	0.197	0.398	0.02	0.08	0.15	-0.16	1.00														
6.Corporate Decentralization	0.300	0.214	0.26	-0.02	0.02	0.12	-0.19	1.00													
7.Size	9.955	0.724	0.59	0.02	-0.14	0.19	0.03	0.18	1.00												
8.R&D Intensity	0.145	0.061	0.02	0.04	-0.02	-0.01	-0.15	0.00	-0.05	1.00											
9.Patent Stock	1387.706	822.986	0.90	0.14	-0.13	0.17	-0.04	0.21	0.70	0.12	1.00										
10.CEO	0.142	0.350	-0.04	-0.05	0.03	-0.07	0.01	-0.03	0.03	-0.09	-0.04	1.00									
11.Performance	0.100	0.068	0.25	0.12	-0.07	0.03	0.04	0.21	0.12	-0.10	0.20	-0.14	1.00								
12.SG&A	9.106	0.754	0.60	0.05	-0.15	0.16	-0.02	0.15	0.89	0.19	0.72	0.02	0.17	1.00							
13.SBU	2.616	1.092	-0.02	-0.14	0.01	-0.07	0.14	-0.06	0.13	-0.35	-0.07	0.06	-0.28	-0.04	1.00						
14.Tech Diversity	0.810	0.068	0.27	0.19	-0.01	0.02	-0.01	0.05	0.36	0.30	0.43	-0.02	-0.04	0.45	-0.19	1.00					
15.Portfolio Size	123.723	73.328	0.58	0.10	-0.07	0.23	-0.06	0.25	0.63	0.19	0.68	0.06	0.23	0.69	-0.11	0.43	1.00				
16.External	0.450	0.114	0.10	0.21	-0.02	0.04	-0.03	-0.12	0.09	0.11	0.15	-0.10	-0.04	0.20	-0.08	0.21	0.08	1.00			
17.NCE	0.611	0.120	0.02	0.04	0.01	0.07	0.09	0.11	0.11	-0.07	0.09	0.06	-0.20	0.01	0.13	0.25	0.11	-0.16	1.00		
18.Bio	0.192	0.097	0.02	0.11	-0.01	-0.05	-0.04	-0.10	0.08	0.22	0.02	-0.05	0.13	0.18	-0.27	0.08	0.07	0.11	-0.72	1.00	
19.Novelty	0.855	0.147	-0.55	-0.08	0.11	-0.16	-0.02	-0.23	-0.65	-0.23	-0.68	0.06	-0.28	-0.69	0.12	-0.47	-0.73	-0.14	-0.02	-0.25	1.00

Table 4: Regression analyses used to test Baseline Hypothesis

DV= Quantity	**Model 1**	**Model 2**	**Model 3**
After	0.146 (0.018)	0.156 (0.006)	0.158 (0.007)
Treat	0.109 (0.032)	0.110 (0.031)	0.111 (0.033)
R&D Decentralization	-0.047 (0.062)	0.002 (0.985)	0.011 (0.934)
(BLH) Treat x After	**-0.152** **(0.009)**	**-0.145** **(0.007)**	**-0.149** **(0.009)**
R&D Decentralization x Treat		-0.007 (0.958)	-0.019 (0.892)
R&D Decentralization x Post		-0.114 (0.002)	-0.140 (0.009)
R&D Decentralization x Post x Treat			0.034 (0.583)
Structural controls	Y	Y	Y
Firm-level controls	Y	Y	Y
Diversification controls	Y	Y	Y
Development Portfolio controls	N	N	N
Year Fixed effects	Y	Y	Y
Firm Fixed-effects	Y	Y	Y
Business Portfolio Fixed effects	Y	Y	Y
N R^2 Log Likelihood	368 0.227 -1988.9	368 0.228 -1986.4	368 0.228 -1986.3

p-values in parentheses
Negative Binomial Model
N is above 365 due to some control observations having higher weightings when they match to more than one treated observation
Errors clustered at firm-level

Table 5: Regression analyses used to test Hypotheses 1 and 3

DV=Originality	**Model 1**	**Model 2**	**Model 3**
After	-0.099 (0.105)	-0.096 (0.120)	-0.109 (0.097)
Treat	0.008 (0.671)	0.008 (0.657)	0.002 (0.922)
R&D Decentralization	-0.038 (0.479)	0.069 (0.529)	0.006 (0.941)
(H1) Treat x After	**0.134** **(0.045)**	**0.139** **(0.049)**	**0.159** **(0.042)**
R&D Decentralization x Treat		-0.096 (0.418)	-0.008 (0.933)
R&D Decentralization x Post		-0.066 (0.141)	0.117 (0.130)
(H3) R&D Decentralization x Post x Treat			**-0.246** **(0.055)**
Structural controls	Y	Y	Y
Firm-level controls	Y	Y	Y
Diversification controls	Y	Y	Y
Development Portfolio controls	N	N	N
Year Fixed effects	Y	Y	Y
Firm Fixed-effects	Y	Y	Y
Business Portfolio Fixed effects	Y	Y	Y
N	366	366	366
R^2	0.009	0.009	0.009
Log Likelihood	-156.7	-156.7	-156.7

p-values in parentheses
Fractional Logit Model
N is above 365 due to some control observations having higher weightings when they match to more than one treated observation
Errors clustered at firm-level

Table 6: Regression analyses used to test Hypotheses 2 and 4

DV=Originality	**Model 1**	**Model 2**	**Model 3**
After	-0.290 (0.124)	-0.262 (0.175)	-0.321 (0.110)
Treat	0.047 (0.639)	0.048 (0.634)	0.028 (0.782)
R&D Decentralization	0.040 (0.853)	-0.232 (0.602)	-0.543 (0.287)
(H2) Treat x After	**0.277** **(0.142)**	**0.278** **(0.140)**	**0.364** **(0.065)**
R&D Decentralization x Treat		0.406 (0.523)	0.807 (0.243)
R&D Decentralization x Post		-0.194 (0.523)	0.564 (0.008)
(H4) R&D Decentralization x Post x Treat			**-1.003** **(0.004)**
Structural controls	Y	Y	Y
Firm-level controls	Y	Y	Y
Diversification controls	Y	Y	Y
Development Portfolio controls	Y	Y	Y
Year Fixed effects	Y	Y	Y
Firm Fixed-effects	Y	Y	Y
Business Portfolio Fixed effects	Y	Y	Y
N	368	368	368
R^2	0.047	0.047	0.048
Log Likelihood	-171.5	-171.5	-171.4

p-values in parentheses
Fractional Logit Model
N is above 365 due to some control observations having higher weightings when they match to more than one treated observation
Errors clustered at firm-level

Table 7: Robustness checks

	Caliper match (radius = 0.005)			**After set at 1 for divestiture year**			**Alternative measures**		**R&D Decentralization on 3 point scale**		
Model	**Model 1 NB**	**Model 2 FL**	**Model 3 FL**	**Model 4 NB**	**Model 5 FL**	**Model 6 FL**	**Model 7 FL**	**Model 8 NB**	**Model 9 NB**	**Model 10 FL**	**Model 12 FL**
DV	***Quantity***	***Original-ity***	***Prog-ress***	***Quantity***	***Originality***	***Prog-ress***	***Radical***	***Num. Prog.***	***Quantity***	***Radical***	***Progress***
After	0.164	-0.112	-0.317	0.128	-0.082	-0.099	-0.060	-0.191	0.216	-0.061	-0.587
	(0.005)	(0.095)	(0.122)	(0.018)	(0.031)	(0.607)	(0.010)	(0.008)	(0.002)	(0.122)	(0.032)
Treat	0.130	0.003	0.071	0.122	-0.003	0.027	0.020	-0.060	0.127	0.051	-0.328
	(0.014)	(0.868)	(0.537)	(0.033)	(0.874)	(0.818)	(0.266)	(0.341)	(0.018)	(0.279)	(0.109)
R&D Decentralization	0.031	0.013	-0.463	-0.046	-0.010	-0.602	0.361	-0.267	0.036	0.024	-0.385
	(0.817)	(0.886)	(0.381)	(0.735)	(0.900)	(0.271)	(0.002)	(0.496)	(0.418)	(0.628)	(0.072)
Treat x After	**-0.146**	**0.160**	**0.333**	**-0.124**	**0.125**	**0.278**	**0.065**	**0.170**	**-0.179**	**0.083**	**0.677**
	(0.012)	**(0.040)**	**(0.105)**	**(0.041)**	**(0.021)**	**(0.220)**	**(0.026)**	**(0.122)**	**(0.016)**	**(0.022)**	**(0.033)**
R&D Decentralization x Treat	-0.040	-0.010	0.824	0.029	0.040	0.923	-0.284	0.186	-0.039	-0.020	0.523
	(0.779)	(0.918)	(0.242)	(0.830)	(0.632)	(0.240)	(0.044)	(0.679)	(0.392)	(0.711)	(0.076)
R&D Decentralization x Post	-0.148	0.122	0.514	-0.004	0.101	0.354	0.021	0.515	-0.120	0.011	0.499
	(0.003)	(0.129)	(0.016)	(0.941)	(0.035)	(0.084)	(0.519)	(0.000)	(0.037)	(0.747)	(0.025)
R&D Decentralization x Post x Treat	**0.019**	**-0.255**	**-1.070**	**-0.047**	**-0.260**	**-0.767**	**-0.085**	**-0.524**	**0.049**	**-0.048**	**-0.675**
	(0.785)	**(0.058)**	**(0.007)**	**(0.571)**	**(0.029)**	**(0.060)**	**(0.145)**	**(0.003)**	**(0.481)**	**(0.213)**	**(0.018)**
Structural controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm-level controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Diversification controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Development Portfolio controls	N	N	Y	N	N	Y	N	Y	N	N	Y
Year Fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm Fixed-effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Business Portfolio Fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	348	346	348	368	366	368	366	368	374	372	374
R^2	0.228	0.009	0.051	0.227	0.009	0.047	0.011	0.248	0.229	0.011	0.048
Log Likelihood	-1869.0	-148.4	-161.0	-1991.2	-156.7	-171.5	-236.2	-692.9	-2017.8	-240.1	-173.5

p-values in parentheses
NB – negative binomial, FL- fractional logit models
Errors clustered at firm-level