Letting Rivals Come Close or Warding Them Off?
The Effects of Substitution Threat on Imitation Deterrence

Francisco Polidoro Jr.
The University of Texas at Austin
McCombs School of Business
1 University Station B6300, Austin, TX 78712
e-mail: francisco.polidoro@mccombs.utexas.edu
phone: (512) 471-9187
fax: (512) 471-3937

Puay Khoon Toh
University of Minnesota
Carlson School of Management
321 Nineteenth Avenue South, RM 3-364, Minneapolis, MN 55455
e-mail: pktoh@umn.edu
phone: (612) 625-5941
fax: (612) 626 1316

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ABSTRACT

The Resource-based Theory postulates that firms must defend their resources against imitation to sustain competitive advantage. However, by deterring imitation, firms may induce rivals to create substitutes. This study shows that, contrary to received wisdom, firms are not uniformly inclined toward deterring resource imitation but, rather, this inclination reduces in response to substitution threat. By examining how firms manage the tradeoff between inimitability and non-substitutability, this study suggests that the scenario where firms have omnipotent resources that are both inimitable and non-substitutable may be unrealistic and that managing the tension between these two attributes is key to sustainable competitive advantage.

The Resource-based Theory (RBT) postulates that resources are essential in creating a sustainable competitive advantage (Alvarez & Barney, 2002; Barney, 1991; Barney, 1996; Dierickx & Cool, 1989; Grant, 1991; Peteraf, 1993; Wernerfelt, 1984). This theory views inimitability as an important resource attribute, without which a firm cannot sustain its competitive advantage, given that imitation erodes resource rarity and resource value (Jonsson & Regner, 2009; Lippman & Rumelt, 1982). In line with this insight, researchers have made considerable progress in understanding factors that help the firm deter imitation (e.g., McEvily & Chakravarthy, 2002; Reed & DeFillippi, 1990; Rivkin, 2000; Szulanski, 1996). However, while the literature has stressed the importance of inimitability, it seldom questions if deterring imitation is indeed always in the firm's best interest. In other words, knowing what may hold back a firm from deterring resource imitation remains an unresolved issue that is crucial for a more comprehensive understanding of RBT.

Interestingly, RBT itself identifies another key resource attribute – non-substitutability – that poses an inherent tension with inimitability. Even when rivals cannot perfectly imitate the firm's resource, they can often create alternative resources performing the same function, which also erode the sustainability of the firm's competitive advantage (Newbert, 2007; Peteraf & Bergen, 2003). Consequently, to uphold its resource value, the firm needs to somehow avoid resource substitution as well as deter resource imitation (McEvily, Das, & McCabe, 2000). In being deterrent toward rivals, however, the firm may ironically induce them to create substitute resources so as to avert the need to imitate the firm's resource (Lado, Boyd, Wright, & Kroll, 2006). This constitutes a tension between deterring imitation and avoiding substitution; and the firm's decision for imitation deterrence must account for these potential substitutes that rivals may create in return. This fundamental tension spurs the following research question: how does the threat of potential substitutes affect the firm's inclination to deter imitation in the first place?

We elucidate this theoretical tension in RBT within the context of innovations. Given that innovations are often vital knowledge-based resources constituting a firm's competitive advantage (Bates & Flynn, 1995; Grant, 1996; Rumelt, 1984), such that the firm has strong

incentives to protect their uniqueness (Lippmann & Rumelt, 1982), investigating situations where the firm may instead choose not to deter imitation of these innovations can be particularly insightful. When examining how potential substitutes influence the firm's deterrence inclination, we draw on evolutionary theory (Dosi, 1982; Nelson & Winter, 1982) and the literature on competitive dynamics (Ferrier, Smith, & Grimm, 1999; Young, Smith, & Grimm, 1996).

Evolutionary theory is useful for examining this tension in RBT because it characterizes the substitution threat that the firm faces as innovations in a product class evolve. Even when rivals cannot perfectly imitate the firm's innovation, they can often create alternatives with similar functionalities (Anderson & Tushman, 1990; Mitchell, 1989). These alternative innovations prompt competition for dominance and carry with them a threat of substitution: following the dominance of a particular type of innovation, the other innovations may become obsolete. For instance, Tushman & Anderson (1986) showed that the introduction of powdered coal and rotary kilns in the cement industry eventually rendered obsolete wood-fired vertical kilns. Similarly, Tripsas (1997) showed that the emergence of new typesetter technologies resulted in the substitution of pre-existing technologies in the typesetter industry.

Research on competitive dynamics, in turn, emphasizes that the firm's action toward its rivals, although beneficial to the firm in the short term, may instigate rivals to undertake actions that ultimately erode the firm's performance (Derfus, Maggitti, Grimm, & Smith, 2008). Accordingly, when making decisions that have the potential to affect rivals, the firm often takes into account the competitive dynamics that such decisions may engender. This insight underscores the tension that the firm faces when deciding to deter rivals from imitating its innovation, since such decision may indirectly spur rivals to create substitute innovations (Gallini, 1984; Lado et al., 2006; McEvily et al., 2000).

Given that substitution can inflict consequential damage to the firm, it is reasonable to expect that the firm, in its quest to sustain its competitive advantage, would not only seek to deter imitation but also to minimize substitution threat. Whereas the firm may have considerable discretion in deciding whether and when to deter rivals from imitating its resource, it cannot

decide what rivals will do instead. Rivals, unable to imitate the firm's resource, may attempt to find alternative resources that deliver comparable functionality and that threaten to substitute the firm's resource. We propose that the firm dynamically leverages the attribute over which it has more discretion, that is, inimitability, in response to substitution threat. We argue that the firm balances the tension between inimitability and non-substitutability, such that when substitution threat for a particular innovation increases, the firm will focus less on deterring imitation of that innovation. We also examine the focal innovation's characteristics that moderate this main effect, tilting the firm's balance closer toward or further away from deterring imitation. We argue that the influence of potential substitutes on imitation deterrence is attenuated when the focal innovation is valuable, and exacerbated when it is in early development stage or when it pioneers novel knowledge.

We focus empirically on pharmaceutical drugs to examine our propositions. When creating a new drug to achieve a particular therapeutic effect, firms can usually resort to different mechanisms of action, representing distinct knowledge bases on pharmacology and human physiology (Reuben & Wittcoff, 1989). For instance, protease inhibitors and fusion inhibitors are distinct mechanisms among anti-AIDS drugs. While protease inhibitors disrupt the proliferation of the virus by blocking its access to the protease enzyme, fusion inhibitors prevent the virus from fusing with the inside of a cell. Anti-AIDS drugs building on one of the mechanisms – protease inhibitors or fusion inhibitors – essentially represent potential substitutes of drugs building on the other mechanism. The firm sponsoring a new drug faces competition not only from imitative drugs that build on the same mechanism of action but also from substitute drugs that build on alternative mechanisms to achieve the same therapeutic effect (Danzon, 2000; Scriabine, 1999). Hence, this empirical setting enables the elucidation of how substitution threat inherent in the presence of alternative mechanisms of action in a therapeutic class reduces the propensity of the firm sponsoring a drug in that class to deter rivals from imitating that drug.

By examining how firms manage this central tension in RBT, our study highlights that, contrary to received wisdom, it may not always be in the firm's interest to deter resource

imitation. Firms manage inimitability and non-substitutability, not as independent resource attributes, but rather as interrelated ones. Moreover, our study answers the call for greater emphasis on how firms manage resources as a way to advance RBT (Priem & Butler, 2001; Sirmon, Hitt, & Ireland, 2007). In essence, through our propositions, we attempt to shift interpretations of RBT away from a static and somewhat simplistic scenario where omnipotent resources both generate high value and are sustainable, toward a more dynamic and realistic scenario where the firm needs to tradeoff between creating a more valuable competitive advantage with lower sustainability or a more sustainable competitive advantage that creates less value. We elaborate on these implications in the conclusion section.

THEORY AND HYPOTHESES

Resource inimitability is crucial for competitive advantage to be sustainable (Barney, 1991; Dierickx & Cool, 1989; Peteraf, 1993; Wernerfelt, 1984). When rivals imitate the firm's innovation, the innovation ceases to be rare and the firm is less able to capture value from it (Jonsson & Regner, 2009; Lippman & Rumelt, 1982). Accordingly, the firm has strong incentives to deter rivals from imitation. In this attempt to deter imitation, however, the firm also needs to consider that such attempt may induce rivals to create substitute innovations instead (Gallini, 1984; Lado et al., 2006; McEvily et al., 2000), and these substitute innovations also hinder the firm's ability to sustain its competitive advantage. In examining how the firm manages this tension between inimitability and non-substitutability, we draw on key elements of evolutionary theory and competitive dynamics.

Evolutionary theory draws attention to the technological changes that occur during the lifecycle of a product class (Dosi, 1982; Nelson & Winter, 1982). Sometimes a product class witnesses the emergence of innovations drawing on new alternative knowledge bases to achieve functionalities comparable to those of incumbent products (Mitchell, 1989; Tushman & Anderson, 1986). Following the emergence of these innovations, the product class undergoes a period of intense technological variation, as some firms explore these new knowledge and others refine existing technology so as to avoid obsolescence (Anderson & Tushman, 1990; Martin &

Mitchell, 1998). This period of technological effervescence subsides as social and organizational dynamics select a dominant technology (Suarez & Utterback, 1995; Tushman & Rosenkopf, 1992). Given the path-dependent nature of firms' knowledge accumulation, firms face enormous challenges when trying to build on a new knowledge base that has become dominant (Helfat, 1997; Tushman & Anderson, 1986). Hence, the firm sponsoring an innovation, besides attending to competition from imitative innovations that build on the same underlying knowledge, also needs to consider competition from substitute innovations. For instance, Mitchell (1989) showed that the firm creating a new electrodiagnostic medical device, besides facing competition from rivals creating similar devices building on the same underlying knowledge also contends with rivals' medical diagnostic devices that build on alternative knowledge bases, such as ultrasonic imaging and magnetic resonance.

Considering competition from imitative innovations alone, a simplistic interpretation of RBT would suggest that the firm's inclination is always to deter rivals from developing innovations based on the same knowledge, so as to defend its innovation's rarity and appropriate more value from its innovation. This inclination inextricably mirrors the firm's quest for uniqueness of its innovation. However, upon considering competition from substitute innovations as well, it is no longer straightforward that deterring imitation is uniformly in the firm's best interest. Such consideration is essential, given that the impact of substitute innovations can be consequential. While imitative innovations compel the firm to lose market share, substitute innovations are potentially more pernicious in that they may in some cases purge the firm from the market altogether (Tripsas, 1997; Tushman & Anderson, 1986).

The existence of potential substitutes creates challenges for the firm in asserting the technical superiority of its innovation. Substitute innovations typically differ in technical superiority along multiple functional dimensions (Adner & Zemsky, 2006; Christensen, 1997). For instance, when analyzing the evolution of cochlear implants, Garud & Rappa (1994) showed that some products provided greater efficacy, while others ensured greater safety. Similarly, Wade (1995) demonstrated that two types of microprocessors may be superior to each other

along different technical dimensions. With more competing innovations building on alternative knowledge bases within the product class, the firm's innovation has greater difficulties in outperforming these substitute innovations across all dimensions. Consequently, the firm's innovation is more vulnerable to substitution threat.

Other than accentuating these technical challenges, potential substitutes also intensify competition for institutional actors' support, which is crucial for the innovation's success. When competing innovations have greater merits than each other along different dimensions, it is difficult to figure out which innovation is superior, because of uncertainty over which dimension is more relevant in the first place (Nelson & Winter, 1982). In these situations, outside parties such as professional communities, regulatory agencies, governmental authorities, and consumer advocate groups play a major role in assessing innovations and determining which functional dimensions are relevant (Garud & Rappa, 1994; Tushman & Rosenkopf, 1992). With more potential substitutes championing different functional dimensions and more rivals pushing for these dimensions, it becomes increasingly harder for the firm to garner support from these institutional actors for its innovation, and accordingly, the firm faces greater substitution threat.

As we discussed above, prior studies building on evolutionary theory have shown that substitution can inflict consequential damages on the firm. Although the firm faces uncertainty about the magnitude of these damages, it is reasonable to expect that the firm, in its quest to sustain its competitive advantage, would not only seek to deter imitation but also to minimize substitution threat. In examining how the firm responds to escalating substitution threat before substitution occurs, we build on the literature on competitive dynamics. This literature emphasizes that, when undertaking a competitive action, the firm considers the rivals' responses that such action will elicit. The dominance of the firm may induce rivals to engage in strategic initiatives that challenge the status quo of the market process, which in turn can lead to erosion of the firm's dominance (Ferrier et al., 1999). For instance, the introduction of a new product by the firm, while adding to the firm's performance, may induce rivals to engage in competitive imitations that will subsequently limit the focal firm's advantage (Lee, Smith, Grimm, &

Schomburg, 2000). This highlights the broader principle that although a particular action may be initially advantageous to the firm, competitive dynamics following that action may ultimately worsen the firm's performance (Derfus et al., 2008). Accordingly, when making decisions that potentially affect rivals, the firm has to take into account the competitive dynamics that such decisions may engender.

These insights from evolutionary theory and competitive dynamics suggest that the firm can respond to potential substitution by readjusting its propensity to deter rivals from imitating its innovation[1]. Escalating threat from potential substitutes building on alternative knowledge bases tempers the firm's inclination toward imitation deterrence in two ways. First, by not aggressively deterring imitation, the firm decreases rivals' incentives to create substitute innovations. When the firm deters imitative innovations, it in effect pushes rivals toward alternatives (Gallini, 1984; Lado et al., 2006; McEvily et al., 2000). This results in rivals advancing the relevant technical dimensions of these alternative knowledge bases, thus making the firm's own innovation more vulnerable to subsequent substitution. Furthermore, in doing so, rivals typically also enhance institutional support for these substitute innovations. In other words, attempts to preserve inimitability may paradoxically aggravate substitution threat, which may ultimately erode the firm's ability to derive economic value from the innovation.

Second, by not aggressively deterring imitation, the firm encourages rivals to create similar innovations, which further helps the firm lower substitution threat. The presence of imitative innovations tends to gear the sponsoring firms toward further technological refinements and robust technical advances of the underlying knowledge base (Autio, Sapienza, & Almeida 2000), thus raising the bar for substitute innovations (Anderson & Tushman, 1990; Martin & Mitchell, 1998). Moreover, rivals committing to the same knowledge base become the firm's allies in pursuit of institutional support (Garud, Jain, & Kumaraswamy, 2002; Wade, 1995). Specifically, the presence of similar innovations increases the odds that outside parties will

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[1] Note that our propositions do not presume that the firm would uniformly choose to mitigate substitution threat over deterring imitation. Rather, they suggest that in balancing inimitability and non-substitutability, when substitution threat increases, the firm will reduce its inclination toward deterring imitation.

assess those imitative innovations more favorably than substitute innovations. Hence, by lowering its guard against imitation, the firm may indirectly reinforce its innovation and avoid aggravating substitution threat[2].

In sum, the degree to which the focal innovation is non-substitutable depends on the extent to which rivals abstain from building on alternative knowledge bases to create substitute innovations. As the number of potential substitutes within a product class increases, substitution threat escalates, which amplifies the firm's race for greater technical superiority and institutional support of its innovation. The firm, when deciding whether or not to deter imitation of its innovation, considers the following: letting rivals come close and create similar innovations can help strengthen the firm's position in this race and indirectly weaken the potential substitutes. Warding off rivals, in contrast, may encourage them to create and reinforce substitute innovations, in turn aggravating substitution threat. Accordingly, we argue that, holding constant other influences on the firm's propensity to deter imitation of a particular innovation, changes in substitution threat will affect how the firm balances the tradeoff between inimitability and non-substitutability of this innovation, such that an increase in substitution threat would tilt the firm toward mitigating substitution, away from imitation deterrence.

> *Hypothesis 1: The greater the threat from potential substitutes that the firm's innovation faces, the less likely the firm will deter imitation of its innovation.*

In establishing Hypothesis 1, a central feature in our arguments is that the firm balances the risk of having to share its advantage with rivals upon imitation and the potential loss of its advantage to substitutes. In the following sections, we further illustrate this central feature by examining specific characteristics of the focal innovation that moderate this balance, tilting it either toward deterring imitation or even further toward mitigating substitution. These additional arguments help us highlight that, although potential substitutes generally affect all innovations, the extent of such influence depends on granular aspects of the focal innovation.

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[2] These arguments resemble the notion of network externalities in industry standards (Conner, 1995). However, the benefits of attracting rivals in this case arise from enhancing technical performance and institutional support of the focal innovation, rather than locking-in different parties in the market that have adopted the innovation.

Innovation's Commercial Value

An innovation must be valuable for it to constitute a significant competitive advantage for the firm (Barney, 1991; Newbert, 2008). This value can arise or be eroded in various ways. The innovation that is already embodied in saleable products generates commercial value for the firm in terms of current profits. Rivals' imitative products directly erode such current profits. The firm's innovation that does not exhibit such commercial value currently can nonetheless potentially generate profits for the firm in the future, when the firm eventually identifies a feasible way to utilize it or to use its underlying principles through other innovations. A premature substitution would erode such future value completely.

As we discussed earlier, greater substitution threat tilts the firm's concern marginally away from the threat of imitative innovations. However, the immediate commercial value of the innovation moderates the extent of such firm's response to substitution threat, that is, the extent to which the firm reduces its propensity to deter imitation of the innovation upon observing substitution threat. When the focal innovation has become commercially valuable, the firm stands to lose more current profits to imitators. This holds back the extent that substitution threat will draw the firm's concern away from imitation deterrence. Moreover, when the innovation has already attained a commercially valuable position, its technical merits and institutional support have likely been established (Anderson & Tushman, 1990; Tushman & Rosenkopf, 1992), which implies that the innovation is likely less susceptible to substitution threat. Conversely, when the innovation has lower commercial value, the firm has less immediate profits to lose to potential imitators to begin with. Consequently, substitution threat will more easily draw the firm's focus away from deterring imitation. Moreover, the lower current commercial value of this innovation may indicate that the firm is still in the process of bolstering its technical aspects and obtaining institutional support for it (Garud et al., 2002; Wade, 1995), and hence the innovation is especially vulnerable to substitution threat.

Although, as Hypothesis 1 predicted, substitution threat generally reduces the firm's inclination to deter rivals' imitation of a particular innovation, the extent of such effect varies

according to the focal innovation's value. In striking a balance between inimitability and non-substitutability, the firm will tend to shift less vigorously away from deterring imitation and toward avoiding substitution when the innovation is commercially valuable.

> *Hypothesis 2: The greater the innovation's commercial value, the less that the threat from potential substitutes will reduce the firm's propensity to deter imitation of its innovation.*

Innovation's Development Stage

In this section, we examine how the effect of substitution threat on imitation deterrence varies across the innovation's stages of development. Usually, considerable periods of time elapse between the innovation's discovery, its development, and its eventual market introduction. At early stages, there tends to be uncertainties over the innovation's viability, the superiority of its technical attributes, and even its scope of applicability. These uncertainties gradually diminish as the firm further develops the innovation and introduces it into the market (McGrath, 1997).

We argue that the firm's increased focus on mitigating substitution threat is exacerbated when the firm's innovation is at earlier development stages. At early stages, the firm may lack information to fully assert the technical superiority of the innovation. This greater uncertainty typical of an incipient innovation stifles the ability of outside parties and customers to assess the innovation's potential technical merits. Because these technical merits are unproven, it is difficult for the firm to influence the assessment of the innovation and garner the support from outside parties (Anderson & Tushman, 1990; Nelson & Winter, 1982). Consequently, the innovation is especially susceptible to substitution at early stages, even if its technical attributes eventually turn out to be superior to rivals' substitute innovations. Moreover, while uncertainty about the focal innovation during its early stages may be more tolerable in the absence of a uniform performance yardstick (Agarwal, Sarkar, & Echambadi, 2002), potential substitutes carry with them a race to define uniform evaluation criteria that will be detrimental to the focal innovation whose attributes are still uncertain. Hence, at the earlier stages of the innovation development, the firm needs to attend more to the threat arising from substitute innovations.

> *Hypothesis 3: The earlier the innovation's development stage, the more that the threat*

from potential substitutes will reduce the firm's propensity to deter imitation of its innovation.

Innovation's Underlying Knowledge

We now turn to the novelty of the knowledge underlying the innovation as another contingency that accentuates the effect proposed in Hypothesis 1. As we discussed above, at the earlier development stages of the innovation there is greater uncertainty about its viability, technical superiority and scope of applicability, which exacerbates the challenges that the firm faces when trying to assert the innovation's merits. Uncertainty exists not only about the innovation itself but also about the knowledge base on which it builds. When the innovation pioneers a novel knowledge base, uncertainty is accentuated, because in this case there is not only imperfect predictability of the innovation's viability, nature and application, but also uncertainty in the soundness and reliability of scientific principles that form the underlying knowledge base (Dosi, 1982; Nelson & Winter, 1982). Using a particular knowledge base defines and constrains the set of elements, combinations, and cause-effect relationships that underlie the innovation (Cockburn, Henderson, & Stern, 2000; Fleming, 2001). When the firm pioneers a novel knowledge base (i.e., one that has not been utilized before within a product class), the associated elements, combinations and cause-effect relationships are typically yet to be fully understood, and accordingly, greater uncertainty remains surrounding the innovation building on it.

We argue that the effect of substitution threat on the firm's inclination to deter imitation, as we proposed in Hypothesis 1, is more salient when the firm's innovation pioneers novel knowledge, because the higher uncertainty associated with such an innovation makes it more vulnerable to substitution. As we discussed earlier, innovations building on alternative knowledge bases differ in technical superiority along multiple functional dimensions. The greater the number of knowledge bases already in place in the product class, the greater the number of functional dimensions against which the pioneering innovation is compared, which, coupled with higher uncertainty inherent in that technology, reduces its chances to prevail in the comparison with potential substitutes. When assessing an innovation, outside parties, such as professional

communities, regulatory agencies, and governmental authorities tend to tailor their evaluation routines to what they know about existing innovations (Dosi, 1982; Garud & Rappa, 1994). When an innovation builds on existing knowledge that these outside parties may already be familiar with, it is relatively easy for the sponsoring firm to garner the support of these outside parties. However, this is not the case for an innovation drawing on novel knowledge, given outside parties' unfamiliarity with the novel knowledge and inclination to assess the innovation based on what they know about substitute innovations. Hence, the novelty of the knowledge intensifies the substitution threat posed by innovations building on established knowledge bases.

Hypothesis 4: The more novel the innovation's underlying knowledge, the more that the threat from potential substitutes will reduce the firm's propensity to deter imitation of its innovation.

Figure 1 summarizes our hypotheses about the effects of substitution threat on imitation deterrence.

Insert Figure 1 about here

DATA AND METHODS

We use data on pharmaceutical drugs to test our propositions. As we mentioned earlier, an important characteristic of this setting is that, by identifying the drug's mechanism of action, we can observe the underlying knowledge base, given that different mechanisms reflect distinct knowledge on pharmacology and human physiology (Reuben & Wittcoff, 1989). For instance, to create a new cholesterol-reducing drug, firms can build on the mechanism of bile acid sequestrants or on that of statins, among others. Bile acid sequestrants prevent the recycling of bile acids in the intestine so the liver is forced to remove more cholesterol from the blood, whereas statins block the production of specific enzymes that the human body needs to produce cholesterol. Table 1 provides additional examples of mechanisms of action among cholesterol-reducing drugs.

Insert Table 1 about here

Another relevant feature of this empirical setting is that pharmaceutical firms face competition from both imitative drugs (i.e., drugs building on the same mechanism of action) and substitute drugs (i.e., drugs building on alternative mechanisms) within a therapeutic class. To block rivals' attempts to create imitative drugs, the firm sponsoring a new drug usually files for patents and subsequently resorts to patent infringement lawsuits to deter imitation (Levin, Klevorick, Nelson, & Winter, 1987). At the same time, the success of the new drug also relies on the validity of the underlying mechanism, which in turn depends on its recognition by several constituencies such as the scientific community, the U.S. Food and Drug Administration (FDA) and physicians (Scriabine, 1999; Travis, 2005).

This nature of competition from both imitative and substitute drugs constitutes an appropriate setting to examine the influence of substitution threat on the firm's tendency to deter imitation. As we mentioned above, bile-acid sequestrants and statins represent distinct mechanisms of action among cholesterol-reducing drugs. In the 1970s bile-acid sequestrants, including cholestyramine and colestipol, were available on the market but patients complained about nausea and abdominal discomfort. In 1984, the FDA approved the market introduction of Merck's lovastatin, which showed the potential to reduce cholesterol by 30% while presenting fewer side effects (Conaway, 2003; Scriabine, 1999). Within a few years, lovastatin became a best-selling drug and increasingly substituted pre-existing drugs used to lower cholesterol. This exemplifies the substitution threat inherent in drugs drawing on a new mechanism (in this case, statins), and illustrates the tension that a firm may face when deterring rivals from building imitative drugs that build on the same mechanism of action (in this case, bile-acid sequestrants).

To capture the firm's effort to deter rivals from imitating its innovation, we use data on patent litigations that the firm initiates. The firm's patents protect against infringements by rivals' technologies, products, or processes that are substantively similar to, or that are materially based on, the firm's patented technologies (Somaya 2003).[3] As patents only confer incomplete

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[3] Note that even if patent claims do not literally match the elements of a rival's infringing device or method, a court may still invoke the 'doctrine of equivalents' and deem the patented invention and rival's allegedly infringing device or method to be sufficiently equivalent in what they do and how they do it to warrant a finding of infringement.

protection (Dasgupta, 1988; Pepall, 1997), rivals may attempt to create innovations that build on the firm's patented innovations. Upon detecting infringement, the firm may initiate lawsuits to deter infringers by legally enforcing its rights to exclude them from particular areas of the technological space as defined in its patents (Cooter & Rubinfeld, 1989; Lanjouw & Schankerman, 2001). Besides deterring infringers, litigations also deter rivals who have not yet infringed on the firm's patents but who are observing these litigations (Lerner, 1995).

In the case of drug patents, litigation is a common means through which the firm protects its drug against rivals' efforts to create similar drugs. Even when the firm has patents protecting its drug, rivals can still attempt to create imitative drugs, often referred to as "me-too" or "follow-on" drugs (Danzon, 2000; DiMasi & Paquette, 2004; Mansfield, Schwartz, & Wagner, 1981). When the molecules of rivals' drugs operate with similar-enough principles as the firm's patented drug, they can still constitute infringements of the firm's patents and the firm may resort to litigation to deter the emergence of these drugs[4]. However, although litigations enable the firm to deter imitative drugs, they do not allow the firm to enforce over-arching exclusionary rights over the therapeutic function that its drug serves. Hence, patents do not protect the firm from substitute drugs.

Importantly, there is typically a long time lapse between the creation of a new drug and its market introduction (DiMasi, 2002; Dranove & Meltzer, 1994). Due to this time lapse, alternative means of deterrence, such as investments in excess production capacity, new brand introductions or fast move into the market (Dixit, 1980; Lieberman & Montgomery, 1988; Schmalensee, 1978), tend to be less applicable. In these situations where the firm needs to deter the emergence of imitative drugs while its own drug is still under development, patent litigations become the predominant means of deterrence (Danzon, 2000).

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[4] Following passage of the 1984 Hatch Waxman Act, rivals sponsoring a generic drug need only to demonstrate that the generic version is bioequivalent to the original branded drug and thus face considerably lower market entry costs (Morton, 1999). The firm may in some cases also resort to litigation to deter or delay the market entry of generic equivalents of the patented drug when the period of market exclusivity approaches expiration. As we discuss later, our analysis controls for this possibility.

We collected data on all new drugs that the FDA approved between 1980 and 2004 through a Freedom of Information Act (FOIA) request. We assigned a drug to its respective therapeutic class according to information that the FDA provided about the drug's therapeutic use. As Henderson & Cockburn (1994) noted, it is more meaningful to group pharmaceutical drugs in specific therapeutic classes, such as antihypertensives and antiarrhythmics, than in broad classes such as cardiovascular drugs. Moreover, by focusing on specific therapeutic classes we can examine the tension between the threat of substitution and the firm's inclination to deter imitation, since a drug represents a substitution threat to the focal drug if both target the same therapeutic effect.

The pharmacological databases *Micromedex*, *Mosby's Drug Consult*, and *Drug Facts and Comparisons* supplied information on drugs' mechanisms of action. We subjected the identification of mechanisms of action to validation by an external expert in pharmacology and medicinal chemistry. To identify patents protecting the drugs, we used the FDA's publication *Approved Drug Products with Therapeutic Equivalence Evaluation*, also known as the *Orange Book*. Pharmaceutical drugs are complex innovations and oftentimes firms use different patents to protect different components of a new drug. We identified all patents protecting all drugs in the sample. We then used the database of the U.S. Patent and Trademark Office (USPTO) to collect detailed information on these patents. Finally, we used the *LitAlert Database* to obtain data on patent litigation from text records of U.S. patent infringement lawsuits.

Prior studies relying on detailed information about pharmaceutical drugs have usually focused on a single therapeutic class (e.g., Afuah, 2002; Berndt, Pindyck, & Azoulay, 2003). To build a comprehensive sample, while ensuring reliability in the extensive data collection effort that our analysis entails, we limited the sample to all patents protecting drugs in the eighteen therapeutic classes listed in Table 2. These therapeutic classes account for approximately 50% (specifically, 317 out of 647) of all new chemical entities that the FDA approved between 1980 and 2004. The sample includes both well-established classes comprising various drugs, such as

antiulcerants, antihypertensives and cholesterol-reducing drugs, and classes that have emerged more recently, such as antiretrovirals, Alzheimer's disease and erectile dysfunction.

Insert Table 2 about here

The sample comprises 1,480 patents protecting 510 pharmaceutical drugs in the sample[5]. We collected data on litigation involving patents protecting drugs not included in the sample and found that the litigation propensity among these remaining patents is not statistically different from that among patents in the sample. Thus, we did not detect any evidence of selection bias arising from our sampling procedure. The sample contains considerable variation across firms: among the 108 firms in the sample, 21 sponsored 10 or more drugs each, while 42 sponsored only 1 drug each. Likewise, there is also substantial variation across therapeutic classes: some exhibit modest innovation activity (e.g., erectile dysfunction with 4 new drugs), while others have more than 50 drugs (e.g., antihypertensives and antineoplastics). Likewise, some classes (e.g., antifungals) do not comprise any innovation among the top-100 best-selling drugs, whereas other classes experience high concentration of top-selling drugs. For instance, antihypertensives accounted for 29 of the 100-best-selling drugs in 1995 (the midpoint in our analysis period).

Dependent Variable

To capture the propensity of the firm sponsoring an innovation to deter rivals from imitating that innovation, we used patent litigation records, which document instances where the firm sponsoring a drug sued another firm for infringement of a patent protecting that drug. For each patent in the sample, we created yearly observations following the year that the USPTO granted the patent to the firm. We set the dependent variable to one if the firm filed a lawsuit against another firm for infringement of the focal patent in a given year and to zero otherwise.

Independent Variables

Mechanisms of Action. To measure the threat of substitution within a product class, we counted the distinct mechanisms of action underlying drugs in the focal drug's therapeutic class

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[5] Out of the 510 pharmaceutical drugs in the sample, 317 were new chemical entities and 193 were drugs that the FDA classified as incremental modifications of these new chemical entities.

in a given year. Recall that our arguments relate to the substitution threat inherent in alternative knowledge bases that rivals can build on to create innovations with functionalities similar to those of the focal innovation (Dosi, 1982; Nelson & Winter, 1982). Our measure adequately captures potential substitutes because, as we discussed earlier, these mechanisms capture the key knowledge on pharmacology and human physiology underlying drugs, and different mechanisms spawn substitute innovations that compete for dominance in a therapeutic class. We counted the competing mechanisms, rather than drugs that rivals have already created building on these mechanisms, so as to capture substitution threat inherent in mechanisms that have yet to spawn many drugs[6]. We subsequently used an alternative measure of the average number of drugs across alternative mechanisms, and obtained fully robust results for all analyses.

Best-selling Drug. To identify commercially valuable innovations, we used data on the commercial success of new drugs. There is considerable variation across drugs in the extent to which they become best-selling products (Saftlas, 2007), and this variation has a direct impact on firms' profitability (DiMasi, 2002; Grabowski & Vernon, 1982). We created a dummy variable that was set to one if the *The Pharmacy Times*' annual listings indicated that the drug protected by the focal patent was one the top 100-best-selling drugs, and to zero otherwise. We obtained robust results when defining valuable drugs as those among the top-90 or top-110 best-selling drugs. A potential challenge here is that our measure may simply mirror the drug's development stage because a drug can only become commercially valuable after market introduction. In that case, the variable *Best-selling Drug* should have no influence on the main effect within the late development stage. To address this possibility, we subsequently restricted our sample to patents protecting drugs in the latest development stage (see variable below) and obtained fully robust results for *Best-selling Drug*.

Development Stage. To capture the key stages of the innovation's development, we identified three key events in the lifecycle of the drug that the focal patent protects: issuance of earliest patent protecting the drug, application for FDA approval, and FDA approval of that drug.

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[6] In a few cases, pharmacological databases discuss that the mechanism of action underlying the drug, although distinct from other mechanisms in the respective therapeutic class, is not fully understood.

These events progressively diminish uncertainty about the innovation (Couzin, 2005; Danzon, 2000; Scriabine, 1999). Upon discovery of the innovation, there is still uncertainty as to whether it will become a viable product. The application for FDA approval reveals that the innovation succeeded clinical trials but uncertainty remains about the likelihood that the FDA will approve the drug's market introduction. We coded the variable for development stage from 1 to 3, so that the lower the variable's value, the earlier the innovation is in its lifecycle.

New Mechanism. To capture the novelty of the innovation's underlying knowledge, we distinguished between innovations that pioneer novel knowledge and those that build on existing knowledge bases. As we discussed earlier, this distinction is relevant conceptually because the uncertainty associated with an innovation is significantly accentuated when the underlying knowledge is itself novel. To identify whether the innovation draws on novel knowledge, we traced whether the drug that the patent protects pioneered a new mechanism of action in the respective therapeutic class. To do so, we also gathered data on drugs introduced prior to 1980, as even if the drug appears to be the first one to draw on the respective mechanism within the period 1980–2004, it may have been preceded by drugs applying that mechanism prior to 1980. Beyond the data provided by the FDA, we searched for all other drugs listed in pharmacological databases and looked for their respective FDA approvals in the FDA's *Orange Book*. We set a dummy variable to one if the drug that the patent protects was the first one to draw on a new mechanism of action in its therapeutic class, and to zero otherwise.

Control Variables

We control for potential sources of heterogeneity across observations that may influence both litigation propensity and the number of competing mechanisms of action. One such source is the innovation's ease of imitation, since inimitability arguably induces competitors to build on other mechanisms of action and, accordingly, lowers the occurrences of patent infringements. We included the number of drugs building on the same mechanism as a proxy for ease of imitation, the logic being that inimitability of the focal patent should correspond with fewer

competing drugs building on the same mechanism. This variable also accounts for rarity of the innovation, in that the greater the number of similar drugs, the less rare the focal innovation.

In addition, the analysis contains a variety of patent-level controls. Innovations building on larger pools of prior inventions may be more difficult to imitate, due to the corresponding need to understand more knowledge components. Accordingly, we control for the focal patent's backward cites (i.e., the number of cites it makes to prior patents). To capture the patent's technological significance, which may drive its use (and infringements) by rivals, we control for the patent's forward cites (i.e., the number of cites it received until the year preceding the observation year), excluding cites made by the sponsoring firm. Consistent with prior work (Lanjouw & Schankerman, 2001), variables capturing both backward and forward cites are scaled (divided) by the number of claims in the patent. In subsequent robustness checks, we also tested for potential curvilinear effects of backward and forward cites by including their square terms (Lanjouw & Schankerman, 2001), and obtained robust results. Additionally, we included the patent's number of claims to account for the possible influence of patent scope. Similarly, we added the patent's cites to books and scientific papers to control for the possibility that the innovation is arguably more radical and impactful, and hence more frequently built on by rivals, when it builds on scientific knowledge. Further, to capture other characteristics that may render the patent more or less litigable, we included the number of previous litigations involving the patent and its square term for potential curvilinear effects. We also included the number of years elapsed since the USPTO granted the patent, and its squared term, to account for the influences on patent litigation that arise during the lifeline of the patent. For instance, as the patent approaches expiration and the entry of generic versions of the respective drug becomes an imminent threat, the firm may be inclined to engage in patent litigation to deter those imitative innovations. Further, the inclusion of this variable ensures that the measure for development stage appropriately captures the lifecycle phase of the drug that the focal patent protects and not the patent's age.

The analysis also includes controls at the level of the patent's technological class and mechanism of action. These controls capture rivals' activities in the neighborhood of the focal innovation, which likely increase with fewer alternative mechanisms, and which can prompt the firm to engage in litigation. To account for entries in the neighborhood of the focal innovation, we included the number of successful patent applications in the previous year within the focal patent's main USPTO technological class. Likewise, to control for entries in the mechanism of action underlying the focal innovation, we added the number of patents granted to rival firms in the previous year protecting drugs that build on the focal drug's mechanism of action. Models also control for the number of years elapsed since the last entry in the mechanism of action.

Additionally, the analysis contains firm-level variables that account for several firm-specific characteristics that may systematically influence propensity to litigate (Lerner, 1995; Waldfogel, 1998). We control for the number of litigation cases initiated by the firm in the previous five years to control for the firm's reputation for litigiousness, which may itself be a deterrent and reduce the firm's need to litigate subsequently (Lerner, 1995). As having more patents possibly increases the firm's propensity to litigate, we added the count of the patents granted to the firm in the past five years. Similarly, we control for the number of the firm's drugs that the FDA approved in the previous five years. The firm-level variables take into account mergers and acquisitions reported in the *Securities Data Company's* database, as well as *Lexis-Nexis* and historic information displayed on the companies' website, whenever available[7].

Further, our analysis controls for influences at the therapeutic-class level. To capture the commercial relevance of the therapeutic class, we added the number of drugs within the focal drug's therapeutic class that are among the top 100 best-selling drugs. We then added therapeutic class dummies to control for time-invariant heterogeneity across classes. Finally, we added year dummies to account for potential sources of heterogeneity stemming from factors that vary over time but are generally invariant across firms, such as economic conditions and changes in the regulatory environment.

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[7] For instance, if firm 1 acquired firm 2 in year t, then the count for firm 1's patents in the previous five years also considers firm 2's patents in those years. The same applies to counts of drugs and previous litigations.

Model Specification

We used logit regression with robust standard errors to analyze patent litigation propensity. The dependent variable – Patent Litigation$_{ijt}$ – denotes whether a firm (subscript i), owning the patent protecting a drug in a given therapeutic class (subscript j), sued another firm for patent infringement in a given year (subscript t). The logit specification models the logarithm of the odds of patent litigation, that is, $\log [\pi_{ijt}/(1-\pi_{ijt})]$, where π_{ijt} = Pr (Patent Litigation$_{ijt}$ = 1) and $(1-\pi_{ijt})$ = Pr (Patent Litigation$_{ijt}$ = 0). In the logit model, $\log [\pi_{ijt}/(1-\pi_{ijt})]$ = $X_{ijt-1}\beta + \varepsilon_{ijt}$, where X_{ijt-1} is a time-varying vector of lagged covariates, β is a vector of estimated coefficients, and ε_{ijt} is a vector of normally distributed error terms.

RESULTS

Table 3 reports descriptive statistics and correlations between the variables. Table 4 presents logistic estimates of influences on litigation propensity. Coefficients in logistic models reflect marginal changes in log odds ratio of the outcome (in this study, the incidence of patent litigation in a given year) with a unit change in each independent variable. To facilitate interpretation, we also report marginal effects on probability of litigation. Marginal effects are calculated at the mean of all independent variables. Model 1 contains the control variables only. Model 2 adds on the main effect of 'Mechanisms of Action'. Models 3 and 4 contain results of fixed-effect and random-effect logit models, respectively.

Insert Tables 3 & 4 about here

Hypothesis 1 predicted that with greater substitution threat, the firm sponsoring an innovation will have lower propensity to deter imitation. The coefficient on 'Mechanisms of Action' is significantly negative in model 2, with z-statistics of -8.92 and marginal effect of 2%, suggesting that the number of mechanisms in the therapeutic class reduces the probability that the firm will sue a rival for infringement of the focal patent protecting a drug in that class. Fixed- and random-effect logit regressions in models 3 and 4, respectively, show that this result remains significant when we account for potential influences of unobserved, time-invariant firm

heterogeneity. Moreover, likelihood ratio tests show that the inclusion of 'Mechanisms of Action' improves model fit in models 2-4 when compared with their respective base-model containing only control variables. The results support Hypothesis 1.

Hypotheses 2, 3 and 4 refer to contingency effects. Specifically, Hypothesis 2 predicted that the negative impact of substitution threat on deterrence propensity is attenuated when the innovation is commercially valuable, whereas Hypothesis 3 and 4 predicted that this negative impact is exacerbated at earlier development stages of the innovation and when the innovation pioneers novel knowledge, respectively. The traditional approach of using interaction terms for contingency variables is inappropriate here, due to the non-linearity of the models, especially taking into account that values of the main variable may vary systematically at different levels of the contingency variables (Penner-Hahn & Shaver, 2005). To circumvent this problem we used graphical analyses followed by split-sample econometric tests. We used the full logit model (model 2) to predict litigation propensity, which we then plotted against the main variable with a least-square fitted line, separately for the two levels of 'Best-selling Drug' in Figure 2. In line with Hypothesis 2, the slope of the fitted line is only negative when 'Best-selling Drug' is zero, suggesting that alternative mechanisms of action reduce litigation propensity especially when the protected drug is less valuable. Similarly, Figure 3 shows that the slope of the fitted line is most negative at the earliest development stage and Figure 4 reveals that the main variable reduces litigation propensity when the underlying innovation draws on novel knowledge, but not when it builds on existing knowledge. These findings are consistent with Hypotheses 3 and 4.

Insert Figures 2, 3 & 4 about here

To formally examine these contingency effects, we first split the sample by levels of the contingency variable, that is, 'Best-selling Drug' in Hypothesis 2, 'Development Stage' in Hypothesis 3, and 'New Mechanism' in Hypothesis 4. Next, we calculated marginal effects of the main variable, 'Mechanisms of Action', while holding all other variables at their mean levels, and computed their variances. We then used t-tests to compare marginal effects across models at

different levels of the contingency variable[8]. Note that it is appropriate to compare marginal effects rather than coefficients, since comparing coefficients across groups in non-linear estimations may be misleading if observations for each group lie in sufficiently different parts of the curve (for further details about this procedure, please refer to Penner-Hahn & Shaver, 2005: 130-177). Table 5 reports the results of the split-sample analysis. Results in models 1 and 2 reveal strong evidence that the effect of substitution threat on imitation deterrence is significantly less negative when the drug that the focal patent protects is a best-selling drug (t-statistic of -82.02). This strongly supports Hypothesis 2. Likewise, pair-wise t-test results in models 3-5 reveal that the marginal effect of substitution threat is significantly more negative in stage 1 (earliest) than stage 2 (t-statistic of 111.18), and similarly less positive in stage 2 than stage 3 (latest) (t-statistic of 19.5). These results support Hypothesis 3. Finally, results in models 6 and 7 confirm that the marginal effect of 'Mechanisms of Action' is significantly more negative when the drug draws on a new mechanism than when it builds on an existing mechanism (t-statistic of 134.46). This strongly supports Hypothesis 4.

Insert Table 5 about here

Turning back to the full-sample analysis in Table 3, we see that the main effect of 'Best-selling Drug' is significantly positive in all models. This is consistent with the expectation that the innovation's value tilts the firm's tradeoff between managing imitation and substitution threats toward greater propensity to deter imitation. Also, the main effect of 'New Mechanism' itself is significantly positive across all models, indicating that litigation propensity is higher when the focal innovation draws on novel knowledge.

Table 4 shows that several control variables significantly affect litigation propensity. Both the number of the patent's claims and the patent's cites to books and scientific papers increase the likelihood of infringement suits, suggesting that more far-reaching and radical

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[8] Variance of marginal effect is D'VD, where D is calculated by taking the first derivatives of the marginal effect by the coefficient estimates β, and V is the variance-covariance matrix of β. Calculations of t-statistics follow the standard formula of dividing the difference in marginal effects across the two groups by $[(var12/n1)+(var22/n2)]1/2$, where var is variance, n is sample size and subscript denotes group.

innovations attract imitation and, hence, litigation. Patents that have been litigated more in the past are more likely to be litigated, though this inclination increases at decreasing rates. The emergence of new drugs building on the same mechanism of action makes litigation more likely. The time elapsed since the creation of the innovation has a non-monotonic effect on the firm's likelihood of suing another firm for patent litigation. Also, the longer the time since the last rival's entry into the focal mechanism, the less likely the patent will experience litigation. Finally, firms that have a greater number of patents or products are more likely to sue rivals for patent infringement.

Sensitivity Analysis

We made several additional attempts to enhance the accuracy and robustness of our key findings. To avoid a bias in selecting only successful drugs, we had originally requested the FDA to provide data on all new drug applications submitted between 1980 and 2004, including those that failed to receive FDA approval. However, the FDA informed us that the agency "does not release data on all NDAs submitted, as requested (…) but only on those submitted and approved" (FDA, 2004; emphasis in original). When the FDA does not approve a new drug, it issues a non-approval letter to the sponsoring firm. Firms have both legal and reputational incentives to disclose that news (Skinner, 1994). Following prior studies, we searched *Lexis-Nexis* for news on the voluntary announcement of non-approval letters (Bosch & Lee, 1994; Sharma & Lacey, 2004), and identified over eighty such events. However, among these cases there were only nine new molecular entities, and the remaining cases referred to incremental modifications of existing drugs. This evidence suggests that the FDA typically approves the vast majority of new molecular entities. Hence, we are reasonably confident that the missing data for failed drug applications are few and hence should not have significantly biased our findings.

Although we use patent litigation to capture the firm's deterrence of similar innovations in the therapeutic class, a potential concern is that firms may use patent litigation to sue rivals for using its innovation toward applications in another therapeutic class (Mehta, 2008: 80-82). To address this concern, we searched the pharmacological databases and identified six drugs in our

study that had FDA-approval for use in more than one application. We dropped all patents protecting these six drugs from our sample, and found that all our findings remained fully robust.

Our sample had included patents that were not associated with any infringement suit throughout the analysis period, so as to avoid selection bias. As Table 3 shows, only 4% of patent-year observations in the sample were subjected to litigation. A potential concern is that the incidence of zeros in the dependent variable may relate to some unobserved patent characteristics that render these patents unlikely to be litigated. To address this concern, we re-ran all analyses in Tables 4 and 5[9] on only patents that experienced litigation at some point throughout the sample range. Results remained fully robust.

A related concern is that the incidence of zeroes in the dependent variable may suggest that in some instances patent litigation is an ineffective means of deterrence. Although our analysis controls for various attributes of the focal patent that may reflect the effectiveness of litigation, we went further to address this potential concern. We removed instances where litigation may be ineffective, by dropping the top 25% of observations in the sample with the highest number of entries in the mechanism of action (that is, highest potential for infringement), and where litigation did not occur. For further robustness, we also separately dropped the top 20% and 10% of observations with the highest entries in the mechanism of action and no litigation. Findings from analyses using these reduced samples remained fully robust.

Another potential concern is that consolidation of firms during the sample period may have affected our findings. Although it is plausible that consolidation waves systematically draw the firm's attention away from litigation, there is no *a priori* reason to suspect that they systematically affect the competing mechanisms of action that the firm's innovation faces. Moreover, year dummies should have captured these time-specific endogenous factors. Nevertheless, we addressed the potential concern that, in periods of frequent consolidations, the way a firm adjusts its litigation propensity in response to substitution threat may be dampened or heightened. We re-ran all analyses in Table 4 dropping all observations occurring in the nineties,

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[9] Due to the sample size reduction that this robustness test entails, we are unable to run the fixed-effect model.

when many mergers and acquisitions occurred (and also when use of contract research organizations increased rapidly) in the pharmaceutical industry. The finding that substitution threat reduces litigation propensity remained fully robust.

Finally, we examined the possibility that therapeutic-class-specific factors may drive our findings. While class dummies capture factors that affect both mechanisms of action and litigation propensity, they do not account for how the main effect may vary in different classes. Notwithstanding absence of concrete evidence for such factors, we conducted additional analysis. We re-ran models in Table 4 dropping all observations relating to the nine classes whose dummies in the full logistic model were significant and which thus reflect significant differences in litigation propensity. Results were fully robust, providing some assurance that this hypothetical concern is not significant in our analysis.

DISCUSSION AND CONCLUSION

In this paper, our central proposition is that, contrary to received wisdom, firms are not always uniformly inclined toward deterring imitation but, rather, reduce such inclination in response to substitution threat. In support of this proposition, we find that the more pharmacological mechanisms of action there are within a therapeutic class, on which rivals can build to create substitute drugs, the lower the propensity of the firm to deter imitation of its focal drug via patent litigation. Furthermore, we examine characteristics of the focal innovation that moderate the influence of potential substitutes, tilting the firm's balance toward either deterring imitation or mitigating substitution. Findings reveal that the negative influence of alternative mechanisms of action on firm's propensity to engage in patent litigation is attenuated when the drug is commercially valuable. Results also show that this negative impact is exacerbated when the drug is still under clinical trials, but gradually weakens as the drug advances toward commercialization. Similarly, this negative effect is greater when the drug pioneers a new mechanism of action than when the drug builds on a pre-existing mechanism. Together, these propositions elucidate how firms manage the tension between maintaining inimitability and enhancing non-substitutability of their resources.

Limitations

A potential limitation of this study is the generalizability of the findings. We chose the drugs context because it allows us to distinguish between substitute and imitative drugs. Moreover, imitation deterrence is highly relevant in this setting, as the drug development process spans many years, such that rivals have ample opportunities to create imitative drugs between discovery of the new drug and market launch. The corresponding shortcoming may be that our propositions are less applicable to settings where there are no potential substitutes, or where imitation deterrence is ineffective. However, as the various examples we provided throughout the text suggest, substitution threat is indeed very common. Also, by focusing on a setting where firms have strong incentives to deter imitation, our test of the mitigating effects of substitution threat on imitation deterrence is in fact a conservative one. In settings where firms are less inclined toward deterring imitation to start with, substitution threat would be even more salient, and we would expect the effect we propose to be even stronger.

Another potential limitation of this study is the focus on patent litigation as a proxy for the firm's attempt to deter imitation of its focal innovation. Patent litigation is not the only deterrence mechanism and in some cases might be ineffective in deterring rivals. In the setting we chose, however, patent litigation is particularly relevant, as pharmaceutical firms have strong incentives to resort to patents to protect their drugs. Moreover, the long time lapse between discovery and market launch suggests that the sponsoring firm has greater need to deter imitation during this period but may lack other deterrence tools such as excess production capacity or new brand introductions. Furthermore, our analysis included various important controls and additional test for patent effectiveness described earlier in the 'Sensitivity Analysis' section.

Implications for Management Practice

From a managerial perspective, research's emphasis on inimitability has led to the focus on what the firm may do to deter imitation, such as designing complexity in its organization and product systems, or using intellectual property rights instruments. This may have been mistaken as a message for managers to uniformly go forth with imitation deterrence. Yet, extant literature

does not fully convey what may be at stake when the firm deters imitation. On the topic of substitution, while much has been discussed about the disruptive effects of technological substitution and the need to avoid substitution, little guidance has thus far been given on the actions that managers may adopt to mitigate substitution threat.

This paper highlights the practical compromise that managers need to make between deterring imitation and pre-empting substitution. Specifically, prior to deterring rivals' imitation, managers need to consider how these rivals may respond to the firm's deterrence efforts, and whether rivals may go on to develop substitutes that may be devastating to the firm subsequently. When faced with potentially threatening substitutes, managers may consider, somewhat counter-intuitively, allowing imitation so as to gather sufficient mass to fend off these substitutes. We stress again that our call is not that managers should always compromise inimitability to defend against substitutions, but rather that managers should realize the need to balance between both resource attributes. Future examination of how different levels of imitation deterrence in the presence of potential substitutes affect both the magnitude and longevity of competitive advantage can provide important prescriptive insights into this managerial problem.

Theoretical Contributions

This study contributes to RBT in two important ways. First, while RBT scholars and evolutionary theorists have extensively discussed the nature, typology, and *ex post* effects of substitution, few have thus far examined how the firm, in anticipation of these *ex post* effects, *ex ante* attempts to mitigate substitution threat. Yet, given the well-known consequences of substitution, it is reasonable to expect the firm to *ex ant*e behave strategically in mitigating this substitution threat. Examining what firms can do to avoid resource substitution has the potential to lead to a more comprehensive understanding of how firms can sustain resource value. As this study shows, an important way in which the firm responds to potential substitution is by readjusting its propensity to deter imitation.

Second, by drawing on insights from evolutionary theory and competitive dynamics, this study highlights the dynamic nature of resource attributes. The degree to which a resource is

non-substitutable varies as competition evolves. Most importantly, although the firm cannot directly control resource non-substitutability, the firm can dynamically leverage resource inimitability by adjusting its inclination to deter imitation in response to substitution threat. Emphasizing these dynamic considerations, in turn, has the potential to expand RBT (Newbert, 2007; Priem & Butler, 2001). A static interpretation of the link between resource attributes and sustainable competitive advantage may lead to the somewhat simplistic view that firms can attain omnipotent resources that are both inimitable and non-substitutable. Yet, considering the competition that unfolds as rivals seek to emulate the focal firm's advantage helps us realize that, in reality, these two resource attributes are interdependent, and that the firm balances between sustaining either attribute. Without recognizing how the firm manages this interdependence, we may have underestimated the true difficulties that the firm faces in trying to create resources that are both inimitable and non-substitutable.

Future Research

The central propositions in this paper, besides advancing RBT, may relate to and inform future research on other literature streams where a similar tension may be present. For instance, the strategic groups literature emphasizes competition among firms operating in the same group, given that mobility barriers mitigate the incidence of competition across groups (Caves & Porter, 1977; Cool & Schendel, 1987). Although mobility barriers restrict group membership, changing technologies may eventually erode group boundaries. Moreover, while a firm may want to deter rivals from pursuing similar strategies, it needs to take into account that rivals may instead pursue an alternative strategy that eventually becomes a dominant substitute in the industry. Closer examinations of whether this central tension also exists in strategic groups, and whether the underpinnings of the tension are similar, may prove fruitful toward furthering understanding of the dilemma that firms may face between inimitability and non-substitutability.

Similarly, this study can also inform research on competitive dynamics. Some scholars have shown that the similarity between the markets where firms operate influences the incidence of competitive dynamics (e.g., Baum & Korn, 1999; Gimeno & Woo, 1996). When a firm

operates in the same markets as a rival, it needs to take into account that multimarket contact enhances the scope for retaliation – the rival can respond to the firm's competitive actions in a given market with retaliatory attacks in any of the markets where they both operate. The prospect of cross-market retaliation deters firms from engaging in rivalrous actions. There is the possibility, though, that multimarket contact, somewhat paradoxically, compels firms to engage in subtle competitive actions to avoid retaliatory attacks. Future research can investigate whether multimarket interactions, by raising the challenges involved in direct competitive actions, increase firms' propensities to engage in devious actions such as the introduction of disruptive technologies that, although less observable by rivals and, hence, less likely to elicit an immediate competitive response, have the potential to more pervasively alter the competitive landscape.

Further, by highlighting firms' need to balance the tension between resource inimitability and resource non-substitutability, this study suggests promising avenues for future work on how firms manage resource attributes. For instance, future research can expand our understanding of this central tension by examining how substitution threat may affect firms differently depending on the availability of other deterrence mechanisms and on the efficacy of these mechanisms. Specifically, future studies can investigate how license agreements and patent litigation outcomes influence the strategies that firms implement to balance the tradeoff between inimitability and non-substitutability. Additionally, future studies can investigate alternative ways in which firms can mitigate their vulnerability to substitution, such as securing preferential access to relevant complementary resources or attaining high levels of resource interdependence.

Most importantly, this study indicates intriguing questions for future work on the value creation process of firm resources. As we mentioned earlier, the state where a firm has omnipotent resources that are at the same time inimitable and non-substitutable may be difficult to achieve. A more realistic path toward value creation is that where the firm possesses less imitable resources but faces higher substitution threats, such that it has a shorter time to appropriate a greater proportion of value created in each period. Alternatively, the firm may

sustain value creation through more imitable resources that face lower substitution threat, which awards the firm a longer time to capture a smaller portion of value created in each period.

Future investigation of the alternative paths delineated above can lead to promising extensions of RBT as a theory of sustainable of competitive advantage. Although firms in technology-intensive industries typically face a constant threat of disruptions as newer innovations building on different technologies rapidly emerge (D'Aveni, 1994; Eisenhardt, 1989), some firms seem to be able to sustain competitive advantage in these turbulent environments. While most existing explanations point to complementary or fungible assets that these firms have (Teece, 1986), our central proposition suggests that perhaps competitive advantage persists not because the firms are better able to transition through change, but rather because they allow rivals to come close and build similar resources, in a way that resists the type of change that would otherwise cause their obsolescence. Alternatively, while prior research has emphasized the capabilities that firms must have to dynamically respond to rapidly changing environments (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997), it is possible that some firms sustain competitive advantage in turbulent environments by letting rivals come close and appropriating less, but enough, value from the current advantage while transitioning to a new resource combination that will provide the next competitive advantage.

In conclusion, this study examines how firms manage the tension inherent in the pursuit of inimitable and non-substitutable resources and shows that firms, contrary to received wisdom, exhibit reduced propensities to deter imitation when facing substitution threat. An important way in which RBT can expand our understanding of why some firms are better than others in attaining and sustaining competitive advantage is through an increased focus on the tradeoff that firms face between creating a more valuable competitive advantage with lower sustainability and a more sustainable advantage that creates less value. We hope that the possibilities we delineated above, which are but suggestions at this point, indicate fecund opportunities for future research.

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FIGURE 1
Influences of Substitution Threat on Imitation Deterrence
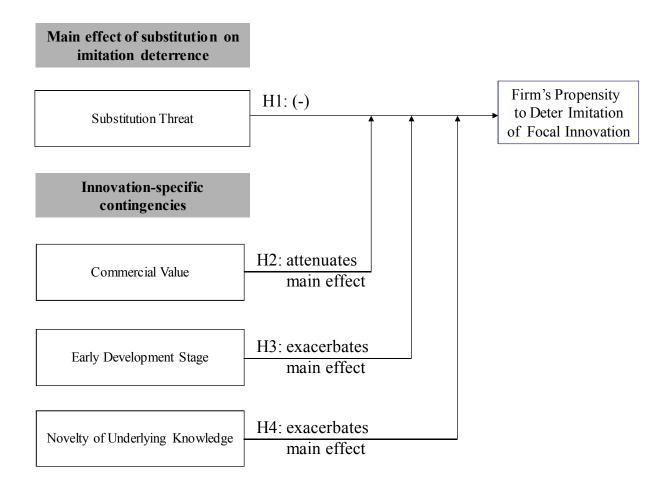
FIGURE 2
Effects of Mechanisms of Action on Patent Litigation Contingent on Commercial Value
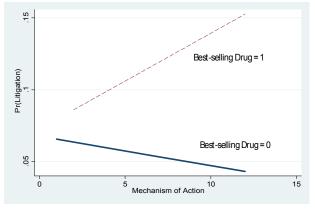
FIGURE 3
Effects of Mechanisms of Action on Patent Litigation Contingent on Development Stage
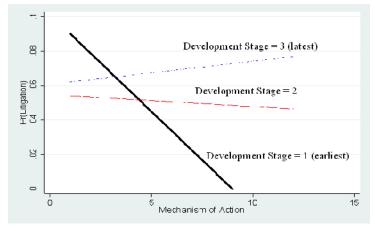
FIGURE 4
Effects of Mechanisms of Action on Patent Litigation Contingent on New Mechanism
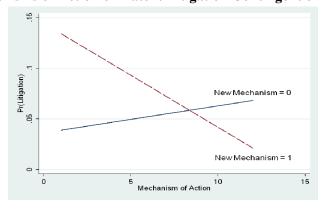
Table 1
Mechanisms of Action among Cholesterol-reducing drugs

Mechanism of action	Representative drugs
Nicotinic acid Nicotinic acid exerts cholesterol-reducing effects by promoting a decrease in esterification of hepatic triglycerides, inhibition of lipolysis in adipose tissue and an increase in lipoprotein lipase.	Niacin
Bile acid sequestrants Bile acid sequestrants bind bile acids in the intestine forming large masses which cannot be reabsorbed, thereby forcing the liver to convert more cholesterol into bile acids, which lowers the level of cholesterol.	Cholestyramine Colestipol
Fibrates Fibrates lower blood triglyceride levels by reducing the liver's production of triglyceride-carrying particles that circulates in the blood and by speeding up the removal of triglycerides from the blood.	Clofibrate Gemfibrozil Fenofibrate
Probucol Probucol lowers cholesterol by inhibiting the oxidation of cholesterol in low density lipoproteins.	Probucol
Statins Statins inhibit an enzyme in the liver that is involved in the production of cholesterol, thereby decreasing cholesterol synthesis.	Lovastatin Pravastatin Simvastatin Fluvastatin Atorvastatin
Ezetimibe Ezetimibe lowers cholesterol by reducing the absorption of cholesterol from the intestine.	Ezetimibe

TABLE 2
List of Therapeutic Classes Included in the Study

Alzheimer's Disease
Ansiolitics
Antiarrhythmic Agents
Antiarthritis Drugs
Antibiotics
Anticoagulants
Antidepressants
Antidiabetic Agents
Antiemetics
Antifungals
Antihyptertensives
Antineoplastics
Antriretrovirals
Antiulcerants
Cholesterol-reducing Drugs
Bronchodilators
Erectile Dysfunction
Glaucoma

TABLE 3
Descriptive Statistics and Correlation Matrix

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9
1 Patent Litigation	0.04	0.20									
2 Mechanisms of Action	7.05	3.08	-0.01								
3 Best-selling Drug	0.08	0.27	0.07	0.04							
4 Development Stage	2.38	0.88	0.07	0.16	0.22						
5 New Mechanism	0.20	0.40	0.06	-0.08	0.07	0.02					
6 Number of Drugs Building on Same Mechanism	4.85	3.90	-0.08	0.21	-0.09	-0.05	-0.49				
7 Backward Cites	0.81	1.90	-0.02	0.09	-0.02	0.02	0.02	0.03			
8 Forward Cites	1.73	3.77	0.03	0.05	0.05	0.11	0.03	-0.02	0.39		
9 Claims	16.11	15.55	0.04	-0.06	-0.03	-0.02	0.01	-0.12	-0.24	-0.18	
10 Cites to Science	4.76	11.35	0.02	-0.15	0.02	-0.05	0.08	-0.05	0.20	0.01	0.08
11 Previous Litigations	0.23	1.07	0.24	-0.04	0.03	0.12	0.09	-0.12	-0.04	0.09	0.03
12 Previous Litigations Squared	1.20	7.49	0.16	-0.04	0.02	0.08	0.09	-0.09	-0.04	0.06	0.02
13 Time Elapsed	9.73	7.31	0.05	0.13	0.10	0.43	-0.03	0.05	-0.07	0.27	-0.03
14 Time Elapsed Squared	148.12	238.90	0.02	0.12	0.09	0.37	-0.04	0.05	-0.06	0.25	-0.03
15 Entries in Technological Class	7.13	1.35	-0.01	-0.13	-0.01	-0.15	0.04	-0.07	-0.09	-0.14	0.03
16 Entries in Mechanism of Action	1.44	3.22	0.04	-0.27	-0.05	-0.15	0.05	-0.05	-0.06	-0.03	0.00
17 Time Since Last Rival's Entry	1.72	3.22	-0.05	0.07	0.02	0.19	0.07	0.02	-0.01	-0.01	-0.09
18 Firm's Previous Litigations	15.32	24.88	0.11	-0.03	0.12	0.21	0.03	-0.07	-0.04	0.08	0.00
19 Firm's Patents	560.40	543.41	0.12	0.17	0.16	0.21	-0.04	-0.07	-0.03	0.08	-0.01
20 Firm's Drugs	4.68	3.45	0.10	-0.07	0.14	0.19	0.07	-0.09	-0.05	0.01	-0.04
21 Therapeutic Class Best-selling Drugs	8.82	12.71	0.03	0.10	0.09	0.20	-0.15	0.18	0.02	0.04	0.06

Variable	10	11	12	13	14	15	16	17	18	19	20
11 Previous Litigations	0.03										
12 Previous Litigations Squared	0.03	0.94									
13 Time Elapsed	-0.22	0.16	0.12								
14 Time Elapsed Squared	-0.19	0.13	0.09	0.95							
15 Entries in Technological Class	0.05	0.00	0.00	-0.19	-0.22						
16 Entries in Mechanism of Action	0.10	0.03	0.03	-0.21	-0.17	0.13					
17 Time Since Last Rival's Entry	-0.07	-0.02	-0.03	0.33	0.34	-0.12	-0.28				
18 Firm's Previous Litigations	0.03	0.19	0.16	0.16	0.17	-0.31	-0.05	-0.02			
19 Firm's Patents	0.01	0.11	0.08	0.11	0.10	-0.08	-0.02	-0.08	0.47		
20 Firm's Drugs	0.00	0.09	0.07	0.09	0.07	0.08	0.01	-0.06	0.37	0.42	
21 Therapeutic Class Best-selling Drugs	-0.09	0.04	0.01	0.25	0.24	0.02	-0.16	0.00	0.03	0.10	0.06

TABLE 4
Estimates of Influences on Patent Litigation Propensity

	Logit		Fixed-Effect Logit	Random-Effect Logit
	Model 1	Model 2	Model 3	Model 4
Mechanisms of Action (H1: <0)		-0.93 •••	-0.98 •••	-1.00 •••
		(-8.92)	(-8.88)	(-9.13)
		[-0.0204]	[-0.0029]	[-0.0018]
Best-selling Drug	0.24 •	0.23 •	0.23 •	0.24 •
	(1.82)	(1.69)	(1.69)	(1.77)
	[0.0064]	[0.0055]	[0.0007]	[0.0005]
Development Stage	-0.01	0.001	-0.01	-0.003
	(0.21)	(0.01)	(0.19)	(0.04)
	[-0.0003]	[0.0001]	[-0.0001]	[-0.0001]
New Mechanism	0.28 •••	0.28 •••	0.33 ••	0.32 ••
	(2.64)	(2.58)	(2.12)	(2.13)
	[0.0073]	[0.0066]	[0.0010]	[0.0006]
Number of Drugs Building on Same Mechanism	-0.04 •	-0.02	-0.03	-0.03
	(-1.78)	(-0.88)	(-1.05)	(-1.13)
	[-0.0009]	[-0.0004]	[-0.0001]	[-0.0001]
Backward Cites	-0.03	-0.02	-0.02	-0.02
	(-0.52)	(-0.43)	(-0.62)	(-0.63)
	[-0.0006]	[-0.0004]	[-0.0001]	[-0.0001]
Forward Cites	0.01	0.01	0.01	0.01
	(1.26)	(1.17)	(1.21)	(1.25)
	[0.0003]	[0.0002]	[0.0001]	[0.0001]
Claims	0.01 •••	0.01 •••	0.01 •••	0.01 •••
	(3.75)	(4.34)	(5.18)	(4.92)
	[0.0002]	[0.0003]	[0.0001]	[0.0001]
Cites to Science	0.01 ••	0.01 •	0.01 •••	0.01 ••
	(2.02)	(1.90)	(2.72)	(2.33)
	[0.0002]	[0.0002]	[0.0001]	[0.0001]
Previous Litigations	1.27 •••	1.15 •••	1.14 •••	1.16 •••
	(15.5)	(14.8)	(14.9)	(15.1)
	[0.0307]	[0.0254]	[0.0033]	[0.0021]
Previous Litigations Squared	-0.14 •••	-0.12 •••	-0.12 •••	-0.13 •••
	(-10.8)	(-10.1)	(-10.8)	(-11.0)
	[-0.0034]	[-0.0027]	[-0.0004]	[-0.0002]
Time Elapsed	0.31 •••	0.34 •••	0.32 •••	0.33 •••
	(11.0)	(11.5)	(9.57)	(9.74)
	[0.0074]	[0.0074]	[0.0009]	[0.0006]
Time Elapsed Squared	-0.01 •••	-0.02 •••	-0.01 •••	-0.01 •••
	(-11.9)	(-12.6)	(-9.76)	(-9.92)
	[-0.0003]	[-0.0003]	[-0.0001]	[-0.0001]
Entries in Technological Class	-0.04	-0.03	-0.01	-0.02
	(-0.91)	(-0.59)	(-0.17)	(-0.31)
	[-0.0010]	[-0.0006]	[-0.0001]	[-0.0001]
Entries in Mechanism of Action	0.09 •••	0.07 •••	0.06 •••	0.07 •••
	(6.03)	(4.95)	(3.30)	(3.40)
	[0.0022]	[0.0016]	[0.0002]	[0.0001]
Time Since Last Rival's Entry	-0.12 •••	-0.13 •••	-0.12 •••	-0.11 •••
	(-4.59)	(-4.78)	(-4.04)	(-4.00)
	[-0.0020]	[-0.0029]	[-0.0003]	[-0.0002]
Firm's Previous Litigations	-0.001	-0.001	-0.02 •••	-0.01 •••
	(-0.24)	(-0.53)	(-4.44)	(-3.76)
	[-0.0001]	[-0.0001]	[-0.0001]	[-0.0001]
Firm's Patents	0.0003 •••	0.0003 •••	0.001 •••	0.001 •••
	(3.32)	(3.43)	(5.58)	(5.27)
	[0.0001]	[0.0001]	[0.0001]	[0.0001]
Firm's Drugs	0.06 •••	0.07 •••	0.09 •••	0.10 •••
	(4.26)	(4.45)	(3.52)	(3.87)
	[0.0015]	[0.0014]	[0.0003]	[0.0002]
Therapeutic Class Best-selling Drugs	0.002	-0.02 •••	-0.03 •••	-0.03 •••
	(0.27)	(-2.60)	(-3.26)	(-3.17)
	[0.0001]	[-0.0005]	[-0.0001]	[-0.0001]
Constant	-3.95 •••	0.63		0.53
	(-10.0)	(0.98)		(0.69)
Therapeutic Class Dummies	included	included	included	included
Year Dummies	included	included	included	included
Number of Observations	12306	12306	11164	13562
Model Loglikelihood	-2150.85	-2106.98	-1894.64	-2046.15
Change in Loglikelihood [*]		43.87	41.72	43.84
Chi-square Statistics	1309.48	1375.11	1382.39	886.02

[*] Relative to base model without Mechanisms of Action
Robust z statistics in parentheses. Two-tailed test for all variables.
Marginal effects in square brackets. Marginal effects are calculated at the mean of independent variables.
••• p<0.01, •• p<0.05, • p<0.1

TABLE 5
Split-Sample Estimates of Influences on Patent Litigation Propensity

	Best-selling Drug		Development Stage			New Mechanism	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Best-selling Drug = 0	Best-selling Drug = 1	Development Stage = 1	Development Stage = 2	Development Stage = 3	New Mechanism = 0	New Mechanism = 1
Mechanisms of Action	-1.03 •••	0.81 ••	-0.63 •••	0.11	0.08 •••	0.05 •	-0.09 •
	(-8.97)	(2.02)	(-5.47)	(1.07)	(2.93)	(1.65)	(-1.87)
	[-0.0182]	[0.0515]	[-0.0040]	[0.0020]	[0.0030]	[0.0011]	[-0.0038]
T-tests of difference in marginal effects across models[1]	-82.02		111.18	19.5		134.46	
Number of Drugs Building on Same Mechanism [(*)]	-0.05 ••	0.10					
	(-2.50)	(1.32)					
	[-0.0009]	[0.0062]					
Backward Cites	-0.01	-0.17	-0.13	-0.36	-0.03	-0.07	0.05
	(-0.24)	(-0.96)	(-1.48)	(-1.20)	(-0.64)	(-1.07)	(1.01)
	[-0.0002]	[-0.0107]	[-0.0008]	[-0.0063]	[-0.0011]	[-0.0016]	[0.0018]
Forward Cites	0.02 •	0.03 •	0.10 •••	0.07 •	0.01	0.04 ••	-0.05 ••
	(1.86)	(1.80)	(3.29)	(1.77)	(0.96)	(2.53)	(-2.33)
	[0.0003]	[0.0021]	[0.0007]	[0.0012]	[0.0004]	[0.0009]	[-0.0018]
Claims	0.01 •••	0.02 ••	0.002	0.02 •	0.01 •••	0.01 •••	-0.002
	(3.86)	(2.55)	(0.38)	(1.76)	(2.91)	(3.67)	(-0.53)
	[0.0002]	[0.0013]	[0.0001]	[0.0003]	[0.0003]	[0.0002]	[-0.0001]
Cites to Science	0.01 ••	-0.02	0.01 •••	-0.04	0.01 ••	0.01	0.01 ••
	(2.03)	(-1.55)	(2.65)	(-0.77)	(2.49)	(1.08)	(2.00)
	[0.0001]	[-0.0013]	[0.0001]	[-0.0006]	[0.0005]	[0.0002]	[0.0005]
Previous Litigations	1.11 •••	1.14 •••	3.55 •••	2.09 •••	1.25 •••	1.16 •••	1.78 •••
	(13.0)	(5.56)	(6.58)	(4.76)	(14.2)	(9.72)	(12.3)
	[0.0197]	[0.0728]	[0.0226]	[0.0368]	[0.0467]	[0.0255]	[0.0706]
Previous Litigations Squared	-0.12 •••	-0.12 •••	-0.53 •••	-0.21 •••	-0.14 •••	-0.14 •••	-0.21 •••
	(-8.95)	(-3.21)	(-6.30)	(-3.33)	(-9.53)	(-6.50)	(-9.27)
	[-0.0021]	[-0.0078]	[-0.0034]	[-0.0038]	[-0.0052]	[-0.0030]	[-0.0083]
Time Elapsed	0.36 •••	0.32 •••	0.0253	0.38 ••	0.28 •••	0.33 •••	0.30 •••
	(11.2)	(3.85)	(0.25)	(2.32)	(8.12)	(9.54)	(6.55)
	[0.0063]	[0.0203]	[0.0002]	[0.0067]	[0.0103]	[0.0072]	[0.0117]
Time Elapsed Squared	-0.02 •••	-0.02 •••	0.0108	-0.02 ••	-0.01 •••	-0.02 •••	-0.01 •••
	(-12.1)	(-4.50)	(1.64)	(-2.06)	(-9.43)	(-10.5)	(-5.85)
	[-0.0003]	[-0.0010]	[0.0001]	[-0.0003]	[-0.0005]	[-0.0004]	[-0.0004]
Entries in Technological Class	-0.0250	-0.30 •••	-0.10	-0.14	0.01	-0.10 •••	0.11 •
	(-0.44)	(-2.75)	(-0.65)	(-1.41)	(0.32)	(-2.77)	(1.67)
	[-0.0004]	[-0.0191]	[-0.0006]	[-0.0024]	[0.0005]	[-0.0023]	[0.0042]
Entries in Mechanism of Action	0.07 •••	0.12 •	-0.12 •••	-0.13 •	0.06 •••	0.04 ••	0.02
	(4.78)	(1.84)	(-3.14)	(-1.92)	(4.55)	(2.11)	(1.29)
	[0.0013]	[0.0075]	[-0.0007]	[-0.0023]	[0.0021]	[0.0008]	[0.0007]
Time Since Last Rival's Entry	-0.13 •••	-0.16 ••	-0.72 ••	0.10	-0.06 •••	-0.28 •••	-0.04
	(-4.39)	(-2.25)	(-1.97)	(1.16)	(-2.95)	(-6.20)	(-1.46)
	[-0.0023]	[-0.0101]	[-0.0046]	[0.0018]	[-0.0024]	[-0.0061]	[-0.0017]
Firm's Previous Litigations	-0.0005	-0.001	0.02 ••	0.02 •••	-0.002	0.01 •••	-0.01 •••
	(-0.20)	(-0.13)	(2.06)	(3.42)	(-1.23)	(5.39)	(-3.17)
	[-0.0001]	[-0.0001]	[0.0001]	[0.0003]	[-0.0001]	[0.0002]	[-0.0004]
Firm's Patents	0.0004 •••	-0.0004	0.0008 •••	0.0006 ••	0.0003 •••	0.0004 •••	0.0004 ••
	(3.65)	(-1.12)	(3.69)	(1.97)	(3.11)	(4.68)	(2.13)
	[0.0001]	[-0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
Firm's Drugs	0.07 •••	0.03	-0.17 •••	0.13 •••	0.08 •••	0.05 •••	0.06 ••
	(4.09)	(0.64)	(-3.68)	(2.70)	(5.26)	(3.54)	(2.09)
	[0.0012]	[0.0018]	[0.0011]	[0.0023]	[0.0030]	[0.0012]	[0.0025]
Therapeutic Class Best-selling Drugs	-0.02 •	-0.09 •••	0.0238	0.03 •••	0.002	0.02 •••	-0.01 •
	(-1.74)	(-3.46)	(1.63)	(2.69)	(0.67)	(5.96)	(-1.82)
	[-0.0003]	[-0.0057]	[0.0002]	[0.0005]	[0.0001]	[0.0005]	[-0.0004]
Constant	1.12	-9.38 ••	-0.63	-6.37 •••	-5.77 •••	-5.24 •••	-5.27 •••
	(1.61)	(-2.09)	(-0.48)	(-4.71)	(-13.0)	(-11.8)	(-7.22)
Therapeutic Class Dummies	included	included	not included [(*)]	not included [(*)]	not included [(*)]	not included [(*)]	not included [(*)]
Year Dummies	included	included	not included [(*)]	not included [(*)]	not included [(*)]	not included [(*)]	not included [(*)]
Number of Observations	11177	973	3455	1241	8866	10181	3381
Model Loglikelihood	-1758.34	-288.87	-246.2	-175.52	-1760.59	-1587.25	-690.44
Chi-square Statistics	1156.73	136.77	266.98	115.71	706.26	582.36	449.59

[1] Note that t-tests here compare the marginal effects, not coefficients, of 'Mechanisms of Action' across pairs of subsamples.
(*) Variables dropped due to reduced sample size.
Robust z statistics in parentheses. Two-tailed test for all variables.
Marginal effects in square brackets. Marginal effects are calculated at the mean of independent variables.
••• p<0.01, •• p<0.05, • p<0.1

Francisco Polidoro Jr. (francisco.polidoro@mccombs.utexas.edu) is an assistant professor at the McCombs School of Business at the University of Texas at Austin. He received his Ph.D. from the University of Michigan. His research focuses on interactions between firms and outside parties, such as alliance partners, rivals, regulatory agencies and the scientific community, and on how those interactions affect technological innovations and technological change.

Puay Khoon Toh (pktoh@umn.edu) is an assistant professor at the Carlson School of Management, University of Minnesota. He received his Ph.D. in strategic management from the Ross School of Business, University of Michigan. His research interests include technology management, competitive dynamics, R&D organization, and firm resource accumulation.