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SHIELDING INNOVATIVE PRODUCTS FROM IMITAITON: PATENT FENCING, DOMINANCE, AND FIRM PERFORMANCE IN PHARMACEUTICALS

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Abstract

This paper investigates how patenting fencing, i.e. using multiple patents for product protection, reduces imitation and enhances firm performance, building on both resource-based (isolating mechanisms) as well as signaling theory. For creative imitation, i.e. introducing drugs within the same pharmaceutical class, fencing increases performance, while imitation does not have a negative performance effect, and fencing does not reduce such imitation, confirming signaling effects. Although fencing extends market exclusivity and postpones generic imitation, there is no effect of such imitation on performance. For both creative and generic imitation, firm dominance reduces performance effects of fencing, indicating that signaling by fencing plays less a role for dominant firms. The results further indicate that marketing original products negatively affects firm performance of dominant firms, questioning conventional wisdom in pharmaceuticals.

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Abstract

This paper investigates how patenting fencing, i.e. using multiple patents for product protection, reduces imitation and enhances firm performance, building on both resource-based (isolating mechanisms) as well as signaling theory. For creative imitation, i.e. introducing drugs within the same pharmaceutical class, fencing increases performance, while imitation does not have a negative performance effect, and fencing does not reduce such imitation, confirming signaling effects. Although fencing extends market exclusivity and postpones generic imitation, there is no effect of such imitation on performance. For both creative and generic imitation, firm dominance reduces performance effects of fencing, indicating that signaling by fencing plays less a role for dominant firms. The results further indicate that marketing original products negatively affects firm performance of dominant firms, questioning conventional wisdom in pharmaceuticals.

Keywords: Value appropriation, patent management, intellectual property, Tobin's Q, resource-based view

INTRODUCTION

> "[…] products where there is a technology play or there is some opportunity in terms of intellectual property with which you can fence your product, or products where relatively you have competition enough maybe two others or three others. Those would be the products which would hold pricing."
> GV Prassad, CEO of Dr. Reddy's Laboratories Limited, in Q1 FY06 Results Earnings Call, July 26, 2005

The resource-based view of the firm (e.g. Penrose, 1959; Wernerfelt, 1984) sees patents as a cornerstone to maintain both a sustainable competitive advantage and firm performance as they aim at preventing imitation (Rumelt, 1984; Somaya, 2003). Nevertheless, patent protection frequently is imperfect, and competitors imitate the knowledge which shall be protected (Mansfield, Schwartz, & Wagner, 1981). In this line, Somaya noted that

> "While the average patent may be a weak and porous instrument, carefully crafted patents and combinations of patents may become more effective tools for firm strategy." (Somaya, 2012, p. 1089)

In fact, Granstrand (1999) outlined a number of strategies firms employ to hinder competition through filing multiple patents. Among them, patent fencing has received considerable attention in the literature so far (Cohen, Nelson, & Walsh, 2000; Sternitzke, 2013; Ziedonis, 2004). Could it be that, while single patents hardly deter imitation, multiple of them effectively do so? For instance, Bresnahan (1985) describes how Xerox successfully shielded its products from imitation by using a large patent portfolio, while Bright (1949) outlined that Thomas Edison acquired important patents around his basic one on the electric light-bulb to reduce competition in the market. However, apart from these single cases, the literature on IP strategies is sparse, and little is known if fencing strategies actually reduce imitation and help improve firm performance.

Building on the basic framework from the RBV that isolating mechanisms shield firms from imitation, and by doing so, enhance firm performance, I investigate how far patent fencing

instead of filing single patents fulfills the function as an isolating mechanism here. More recent research indicated that, under some circumstances, patenting fulfils signaling functions to overcome frictions in capital markets as well (Haeussler, Harhoff, & Mueller, 2014; Hsu & Ziedonis, 2013). As signaling patent quantity is easier than signaling patent quality (Long, 2002), fencing might not only serve as an effective value appropriation function, but also for signaling such appropriation. Thus, the study introduces firm dominance as a moderator in the patent fencing → imitation → firm performance relationship, taking into account the position that a company holds in the market, while assuming that non-dominant firms have to overcome frictions by using patent fencing for signaling effective appropriation, while dominant firms are less affected this way.

The analysis takes place in the pharmaceutical and biotech industry, a discrete product industry with an average level of patent fencing, above-average use of patents for imitation protection and signaling purposes (Cohen et al., 2000), where patents protect millions of dollars in revenues. It builds on patents listed in the so-called Orange Book, a directory from the US Food and Drug Administration (FDA), which summarizes those patents being relevant for pharmaceutical product imitation protection and study how far they deter creative imitation, i.e. introductions of products in the same drug class, pure imitation (i.e. entry of generics) and their effect on firm performance. The findings demonstrate that signaling effects are in place. Surprisingly, the basic assumptions of the resource-based view are only partially supported, while only limited evidence is found that fencing actually enhances firm performance by reducing imitation. My results further outline that dominant pharmaceutical company's show a lower performance when they market more original products.

The findings not only contribute to the sparse literature on IP strategies, they also complement prior work on the RBV that, in quite a few areas, still primarily grounds on logic and intuition instead on empirics (Newbert, 2008; Yeoh & Roth, 1999). In particular, the pivotal relationship between isolating mechanisms, imitation/substitution, and performance has not been investigated yet, while this work presents the first empirical approach. As well, the findings also contribute to the literature on signaling and patents (Long, 2002), expanding the prior work on startups (Haeussler et al., 2014; Hsu & Ziedonis, 2013) to publicly listed corporations.

THEORY

The Resource-based View (RBV) of the firm (Penrose, 1959; Wernerfelt, 1984) assumes that resource-capability combinations of a firm are valuable and rare, which is the basis for a competitive advantage that ultimately helps increasing firm performance (e.g. Newbert, 2008). However, only a sustainable competitive advantage allows achieving long-term performance gains (Barney, 1991). Sustainability emerges from barriers to imitation and/or substitution that assure long-term rents (Lavie, 2006; Peteraf, 1993), while these barriers come from isolating mechanisms, for which (Rumelt, 1984) provides an excellent overview. Among them, causal ambiguity (McEvily & Chakravarthy, 2002; Reed & DeFillippi, 1990), path dependencies (Barney, 1991; King & Zeithaml, 2001), and patent rights (Mahoney & Pandian, 1992; Peteraf, 1993; Rumelt, 1984; Somaya, 2003) have received the greatest attention to date. Isolating mechanisms are also known as appropriation mechanisms (Arundel, 2001; Cohen et al., 2000; Levin, Klevorick, Nelson, & Winter, 1987).

Hence, the RBV suggests a framework in which isolating mechanisms lead to less imitation/ substitution and, by doing so, ultimately improve sustainable firm performance. While these relationships are grounded in logic, there is surprisingly little empirical research backing

that logic (Ethiraj & Zhu, 2008; Newbert, 2007), and only parts of this relationship have been studied so far. Moreover, considering the inimitability – performance linkage, the few studies available have not directly tested what happens if imitation occurs, albeit finding a negative effect here. Hatch and Dyer (2004), for instance, measured imitability as hiring staff from competitors to improve manufacturing processes. King and Zeithaml (2001) computed inimitability by causal ambiguity of the firms' critical competencies, while DeCarolis and Deeds (1999) measured imitation by citations to firm patents. None of these instruments clearly presented events in which imitation, in fact, took place, and how such imitation influenced firm performance.

Albeit the prior resource-based literature has failed to clearly demonstrate that imitation reduces performance, it is unchallenged that imitation occurs (Mansfield et al., 1981). Building on the logic of the RBV, I therefore propose:

H1: Imitation of a firm's products reduces its performance.

Patents do not exclude imitation, but increase imitation costs and time, especially in pharmaceuticals (Mansfield et al., 1981). Hence, patenting still negatively impacts imitation. But imitation protection is not the only reason for patenting, albeit the most important one (Blind, Edler, Frietsch, & Schmoch, 2006). There are others, such as blocking competitors, obtaining licensing revenues, reputation enhancement, etc. (Blind et al., 2006; Cohen, Goto, Nagata, Nelson, & Walsh, 2002; Cohen et al., 2000). Among them, imitation protection and blocking are closely related (Cohen et al., 2000; Sternitzke, 2013). In both cases, the patentee does not want to allow its competitors to evade its technology space (already covered with products or not) to in the end, avoid eventual imitation or substitution.

According to the literature, there are several forms of blocking by filing multiple patents (Granstrand, 1999). Fencing, i.e. filing multiple patents that describe different technological

solutions for similar functional outcomes, has received the most attention in literature so far (see e.g. Reitzig, 2004; Sampat & Ziedonis, 2004), and I will subsequently further analyze this strategy. As Bresnahan (1985) describes for the XEROX case, patent fencing can, in fact, keep competitors at bay successfully. Given that isolating or appropriation mechanisms reduce imitation, and patent fencing should be more effective in doing so than single patent filings, I propose the following:

H2: Patent fencing reduces imitation.

This also means that, given the isolating mechanism → imitation reduction→ performance relationship from the RBV that patent fencing takes a place in here as well, leading to the following hypothesis:

H3: Imitation mediates the relationship between patent fencing and firm performance.

Omitting imitation as a mediator in the patent fencing – performance relationship would certainly lead to a positive effect of patent fencing on firm performance, given that fencing reduces imitation, which increases performance. Some studies have found a positive effect between patent counts on the firm level and firm performance (Ernst, 2001; Hall, Jaffe, & Trajtenberg, 2005; Schoenecker & Swanson, 2002), without taking imitation into account. Therefore, I propose:

H4a: Patent fencing has, <u>not</u> controlling for imitation, a positive effect on firm performance.

So far, the proposed mechanisms build on the notion that patenting, in fact, is effective in achieving imitation protection. However, firm performance not solely depends on factual situations, but on expectations about the future of the company, as far as capital market-based performance measures are considered. Among the various functions patents fulfil, reputation building is one that has received little attention in research so far (Blind et al., 2006). Only two

studies on patent motives touch reputation enhancement (Cohen et al., 2000) or signaling to capital markets (Sheehan, Martinez, & Guellec, 2004). Both found different levels or prevalence across industries, with an above-average level in pharmaceuticals. In this line, Hsu and Ziedonis (2013) combine the resource-based perspective that regards patents as isolating mechanisms in product markets with the literature stream of signaling (Spence, 1973) in factor markets, following the tradition of Ndofor and Levitas (2004), Deephouse (2000) and Roberts and Dowling (2002) who linked these literature streams before. In their view, both the isolating and signaling functions work independently:

> "Importantly, patents could serve a meaningful role as signaling devices even if they fail to deter imitation in the product market, and vice versa." (Hsu & Ziedonis, 2013, p. 765)

Long (2002) even goes further, challenging the isolating role of patents while arguing that

> "under some circumstances, the informational function of patents may be more valuable to the rights holder than the substance of the rights." (Long, 2002, p. 625)

Prior, scholars argued that patenting can be seen as positive signals of underlying firm characteristics such as the quality of a firms' technology, productivity, etc. (Haeussler et al., 2014; Stuart, Hoang, & Hybels, 1999; Wagner & Cockburn, 2010). Lin, Chen, and Wu (2006) propose that patents signal future cash flows, which impacts stock valuation and thus, firm value. However, investors at the stock market possess little experience in analyzing patents (Rivette & Kline, 2000), and it is unlikely that they assess how far the specific patents are, in fact, effective mechanisms for preventing imitation. Long (2002) further argues that

> "since the number of patents a firm has received is a measurable attribute of a portfolio whereas the quality of individual patents is not, firms have the incentive to cover the same subject matter in a portfolio with more rather than fewer patents." (Long, 2002, p. 678).

This means that investors may tend to simply count the numbers, and firms may tend to employ patent fencing for signaling purposes as well to positively influence stock market

valuation and, by doing so, firm performance. Apart from that, companies seem to utilize patent fencing to get noticed by competitors as well (Peters, Thiel, & Tucci, 2013). Therefore, patent fencing seems to possess a signaling function that should also impact firm performance regardless how well the patents serve as isolating mechanism. I propose:

H4b: Patent fencing has, controlling for imitation, a positive effect on firm performance.

There is a consensus in the literature that particularly startup companies build on patent signaling as they encounter market frictions (Haeussler et al., 2014; Hsu & Ziedonis, 2013; Long, 2002; Wagner & Cockburn, 2010), which is indirectly confirmed by the Carnegie Mellon Survey that finds reputation enhancement by patents to be a motive particularly for small firms (Cohen et al., 2000). Apart from startups, also publicly listed firms should use patents for signaling to capital markets, but to a lower extend as in the case of startups where an investment is much less fungible (and reversible) (Long, 2002). Startup investors are looking for companies that have the potential of huge value increases in order to justify investments under high levels of uncertainty. Both having proven that the market actually pays for the company's products and that the growing company is on the way to a strong market position reduce uncertainty significantly and, thus, increase firm value (Gompers & Lerner, 2004). Hence, it should finally be the acceptance of the companies' products in the market and, thus, its market position, that determine the degree to which a firm employs signaling efforts. Asymmetric information and uncertainty are distinct characteristics (Gompers & Lerner, 2004). While uncertainty gets smaller when a firm shows market success by, in the best case, occupying a dominant market position (where the management obviously has done a fine job), there always remains a certain level of asymmetric information between management and outside investors. This level of asymmetric information is smaller for publicly listed firms, which have to comply with certain reporting standards according

to the stock markets where their shares are listed, and startup companies that do not report to the public. But still among publicly listed firms, there are huge differences – ranging from e.g. former startup companies with a small pipeline that went public a couple of years ago to large incumbents with market-proven research programs, dozens of products and a strong position on the market. Nevertheless, both asymmetric information and uncertainty are somewhat intertwined, as companies signal information to outside investors in order to reduce levels of uncertainty about the company. Given that patent fencing fulfils a signaling function, that market proof reduces the need for signaling, and that there is a wide spectrum of dominance among publicly listed firms, I propose:

H5: Dominance negatively moderates the relationship between patent fencing and firm performance.

Dominance may not only reduce the need to use patents as signals, it may also help overcome disadvantages of imitation for a number of reasons. First, dominant firms possess a better knowledge base (Sorescu, Chandy, & Prabhu, 2003), which is relevant for securing future product development options. Second, they have likely built a larger market-based asset base, including stronger brands, a larger customer base, and more market-based alliances as well as superior distribution channels (Sorescu et al., 2003). Third, they have lower financing costs (Aldrich & Auster, 1986). Fourth, dominance also positively impacts firm profitability (Szymanski, Bharadwaj, & Varadarajan, 1993), leading to more funds available for future projects. Altogether, these characteristics may help dominant firms even in the light of imitation, as their asset base allows them either to in-license new products or to acquire smaller companies for refilling their product pipeline once imitation occurs. Therefore, I argue that dominance plays a moderating role in the patent fencing – performance relationship:

H6: Dominance reduces the effect of imitation on firm performance.

The relationship of the hypotheses is outlined in Figure 1, where I predict a positive impact of patent fencing on firm value, negatively moderated by firm dominance. Patent fencing reduces imitation, which itself reduces firm performance, implying that imitation takes a moderating role. Again, dominance is expected to moderate the effect of imitation on firm performance.

[insert Figure 1 about here]

PATENTING, PATENT FENCING, AND IMITATION IN PHARMACEUTICALS

Cohen et al. (2000) provide an overview of fencing activities in different industries and found this number to be high in discrete and particularly chemistry-related industries. Here, imitation protection and blocking is above industry average as well. The lowest share of fencing patents, according to their definition, can be found in typical complex product industries, where patents are primarily filed to be able to participate in cross-licensing (Grindley & Teece, 1997), and for which Cohen et al. (2000) show that imitation protection and blocking is below industry average. Therefore, in order to study patent fencing and its impact on imitation protection, this paper concentrates on the pharmaceutical industry with its average rate of patent fencing and above-average rates in imitation protection. Here, patenting and signaling play an important role (Arundel & Kabla, 1998; Cohen et al., 2000; Mansfield, 1986).

In order to understand the patenting processes and strategies in pharmaceuticals, one has to recall how innovation and imitation in this industry takes place (see e.g. Sternitzke, 2013). In brief, R&D intensive firms search for novel molecules to cure specific diseases. If the design of a newly developed molecule is hardly related to any other molecule known before and if it involves a novel molecular mechanism of action to treat some diseases, then the product – once marketed

– opens up a new class of drugs. But often times, new molecules are slight derivatives of already existing ones, building on the same molecular backbone, differentiated by chemical subgroups, as Goodman and Gilman (1994, 2006, 2011) illustrate, leading to, on average, 4.1 drugs per class (DiMasi & Faden, 2011; DiMasi & Paquette, 2004).

Once a company discovers a new molecule, it usually patents its substance, creating a relatively broad patent that prevents any substance use. Once firms realize that the substance is indeed suitable to treat humans, having passed toxicity and efficacy tests, and it has shown the wished effects in human beings, they start searching for novel applications of these drugs (Chong & Sullivan Jr, 2007). Further improvements of the product take place, dosing and formulations are optimized, etc., protected by secondary patents (Burdon & Sloper, 2003; Kapczynski, Park, & Sampat, 2012). This activity is also known as drug lifecycle management or evergreening. However, not all of the secondary patents will actually become effective in protecting products (Amin & Kesselheim, 2012). In fact, many of them both aim at preventing imitation and blocking competitors at the same time (Sternitzke, 2013). In a broader context, this activity can be described as fencing. However, the boundaries are blurry when it comes to clearly assign these patent filings to specific products, as they are broadly address various further developments (Sternitzke, 2013), which could, as well, end up in mirroring technological trajectories (Achilladelis, 1993; Achilladelis & Antonakis, 2001).

There is a regulatory framework to tackle this issue and which helps to clearly assign the more relevant patents to products: In the United States, product protection by patents is regulated under the Drug Price Competition and Patent Term Restoration Act (the Hatch-Waxman Act). This legal framework defines processes among generic and original drug makers on patent terms and drug approval, giving companies who market new drugs certain exclusivity periods to

recuperate high product development investments, while it, at the same time, facilitating generic entry. Original drug makers can list their relevant patents in the so-called FDA Orange Book, a directory of all approved substances under exclusivity status, and they are incentivized to do so. Hence, these Orange Book patents are what matters for preventing imitation in pharmaceuticals.

Recently, Orange Book patents received some attention for assessing their impact on generic drug makers. Kapczynski et al. (2012) could show that characteristics from lifecycle management activities such as formulation, substance and use patents are widespread in Orange Book-listed patents. They are also legal substitutes according to the discussion in Sternitzke (2013). Listed secondary patents are challenged more frequently by generic manufacturers, rising doubts about their quality (Hemphill & Sampat, 2012). Nevertheless, secondary Orange Book patents prolong exclusivity periods by about seven years (Kapczynski et al., 2012). The impact of these patents on non-generic competition, so far, remains unexplored. However, Kapczynski et al. (2012) also show that about two thirds of all drugs contain Orange Book patents with chemical compound claims. These claims are often relatively broad, as some yet unpublished research by the author demonstrated. Discussions with a patent professional revealed that the goal of the patentees here is to broadly block competitors and prevent them from introducing similar products in the same class.

While the paragraphs above have described how drug development and fencing occur in pharmaceuticals, it is time to look at imitation here, for which Luo, Sun, and Wang (2011) and Lee and Zhou (2012) provide a general framework. They define three kinds: pure imitation, i.e. the direct replication of some other firms' products; creative imitation, which involves novel aspects such as slight design modifications; and novel innovations, which involve entirely new designs that may at least partially be influenced by prior ones. This framework applies as well to

the pharmaceutical industry: Newly developed drug molecules represent novel innovations. When, however, the new molecular design is similar to an existing one and the drug represents a follow-on product inside an already established drug class, creative imitation happens. Finally, after patent expiry, generic manufacturers enter the field, marketing exact copies of the original molecules, which equals pure imitation (see also Ethiraj & Zhu, 2008). The latter two forms are subsequently tested.

DATA AND METHODOLOGY

Sample selection and data sources

The sample consists of an unbalanced panel of companies from the United States doing business in the years 2003-2010 within the Standard Industrial Classification (SIC) codes 2833-2836 and 3851, had to be listed on an American stock exchange for at least two years, had to have products under exclusivity status by the US Food and Drug Administration (FDA) during this period and in at least one year. In total, 102 firms fulfilled these criteria, leading up to 481 firm year observations.

Data on SIC codes were obtained from the Securities and Exchange Commission (SEC) website. Financial information was obtained from Thomson Datastream. Drug data, including information on patents per drug, were obtained from the FDA Orange Book editions for the observation period. I built on 10-k filings to assess top-selling drugs per company and year as well as identify corporate subsidiaries, for which I merged the names with the parent company for the drug data from the Orange Book.

The drugs under Orange Book exclusivity were assigned to classes. For the primary class (baseline model), each drug was assigned to one class only, building on the work of DiMasi and Faden (2011) who provided a subset of my sample as a starting point. From there, I used some

recent editions of Goodman and Gilman's The Pharmacological Basis for Therapeutics, a standard work in pharmacology for several decades, which has been used to classify drugs before (Cockburn & Henderson, 1994; Kissin & Bradley, 2012). The book employs a classification of drugs building both on the chemical structure and molecular mechanisms of action (Kissin & Bradley, 2012). This book does not mention all FDA approved drugs. Thus, further sources were consulted: The PubChem and Drugbank (Wishart et al., 2008) databases, the anatomic-therapeutic-chemical classification (ATC) from the WHO Collaboration Centre for Drug Statistics Methodology, PubMed, and websites such as drugs.com. Finally, every drug could be classified.

For robustness checks, I employed two further classifications, which, however, were only available for a subset of drugs, certainly the most relevant ones. One of these alternative class definitions is based on the *ATC codes* provided in Drugbank, truncated after four of five levels. In addition, in its national drug code register, the FDA uses *established pharmacological classes*, which I also took into account. There are some overlaps between these classes, and for the two alternative 'classes', some drugs may belong to more than one class.

Dependent variable

Firm performance as a dependent variable was operationalized by Tobin's Q (Tobin, 1969), i.e. the ratio of a firm's market value and the current replacement value of its tangible assets. This market-based measure has frequently been used in strategic management research (see e.g. Wernerfelt & Montgomery, 1988), but also in studies relying on patent data (Hall et al., 2005). I chose the widely-employed approach from Chung and Pruitt (1994) who use a simplified formula where the data is easy to obtain from corporate balance sheets. This simplified Q is based on the sum of the market value of a company's common stock, the liquidation value of its preferred

stock, the book value of its liabilities minus the book value of its current assets in the nominator, and, in the denominator, its total assets.

Independent variables

When firms are imitated, usually their products or services are imitated, not the firm as a whole. Hence, for measuring imitation and its impact on firm performance, analyses on the product level are useful which are subsequently aggregated on the firm level (as firm level data generally stems from aggregation). Therefore, as will subsequently be explained in more depth, I measure fencing (and partially imitation) on the product level, building averages for firm level aggregation, while other variables such as the number of original products and the number of product exclusivity expirations is expressed as counts per firm year. The reason for taking these direct measures on the product level as indicators is straight forward: Investors, who ultimately assess firm value and, thus, my firm performance measure, directly look at events such as new product introductions, imitation events, and exclusivity expirations. Hence, I also directly took these measures into account.

Creative imitation. I measured creative imitation by the amount of competitive entries of new original products into classes in which the companies already hold products under exclusivity, increasing the amount of available products therein, following Ethiraj and Zhu (2008). Original products are, in contrast to generics, major sources of revenues, with a large impact on company valuation (Sorescu et al., 2003). I used measures based on both brands and chemical substances to define the number of products within a class. I expect the brand measure to deliver more realistic results, as a company may market different products based on the same chemical substance, while brand differentiation is rooted in different dosing or indications which lead to new patent fencing efforts on the product level.

My main analysis refers to the primary classification (molecular similarity), with robustness checks for the two alternative measures that cover only subsets of the dataset: Some of the classes from the primary classification refer to metal oxides or salts as well as simple carbon chains where either imitation of the chemical form may not be possible or hardly innovative, while other classes comprise orphan drugs, where, due to the low market potential, entry of follow-on drugs is rare (DiMasi & Paquette, 2004). A robustness check excludes these classes, adjusting the database for computing patent fencing as well. A further robustness check measured creative imitation by entry of New Molecular Entities (NMEs) only, which may have a more disruptive impact than entries of incremental innovations.

In order to also account for the situation that a company may be active in several classes, but receives competitive entry only in e.g. one class, I computed two alternative forms of imitation as a robustness check: First, the amount of entries over all classes; second, the share of classes where at least one entry occurred.

Pure imitation. As pure imitation refers to generic entry, I used the duration of the exclusivity period from the FDA Orange Book as measure of imitation protection. Such exclusivity is usually a composition of one or more types of new drug product exclusivity (e.g. for new chemical entities or new indications). These exclusivities are in most cases much shorter than patent exclusivity, which prolongs overall exclusivity. I computed three different measures for the duration of exclusivity: (i) A forward-oriented measure, counting the days of exclusivity that still remain (baseline measure). (ii) A backward-oriented approach, counting the days from drug approval to the calendar year end of the observation period. This measure may be imprecise, as past duration may have depended on patents that have already expired at the observation point. (iii) I compute a composite measure as the sum of (i) and (ii). As exclusivity is tied to sub-

categories of the approval number, the maximum period was taken per approval number, and averages per firm year were computed across all approval numbers.

Patent fencing. I measured patent fencing by the average number of patents per drug, company and year as obtained from the FDA Orange Book, cross-validating it with a former patent professional from a pharmaceutical company who confirmed that it measures those fencing patents that are the most relevant ones with respect to preventing imitation.

As patent fencing is a measure based on FDA approval numbers, I computed the average number of patents per brand in case of more than one approval number per brand. For robustness checks, I computed the variable based on chemical substances instead of brands, the maximum number of patents per brand, based on the approval number with most patents, and lagged values, taking into account the fencing setup one year before. Additionally, it was accounted for the effect that in some classes, fencing may have been easier than in others, computing a relative value of fencing per company and year for benchmarking fencing of an individual drug against the class – year average, and then computing averages per company and year.

Dominance. For calculating this market-based variable, I build on established measures for dominance, taking the number of employees as a proxy in the baseline model and employing sales as a robustness check (Sorescu et al., 2003; Yeoh & Roth, 1999), Within an industry, the latter is somewhat proportional to overall market share (Szymanski et al., 1993).

Controls

I employed a range of controls in order to capture effects which are expected to have an impact on Tobin's Q, both product-related measures and financially-related ones. Fixed effects and time-dummies were also used, as Kapczynski et al. (2012) could show that firms tend to increase the amount of Orange Book patents per drug class over time.

Exclusivity expirations. I counted the number of drugs which lost exclusivity in the corresponding calendar year, leading to a potential entry of generics, which usually goes hand in hand with a significant reduction in revenues for the firm marketing the original product (Caves, Whinston, Hurwitz, Pakes, & Temin, 1991). Alternatively, I used the number of expiring top-selling products, being accountable for more than ten percent of revenues in the prior year. Top-sellers were identified by matching Orange Book drug names with those from 10-k filings.

Dummy for biopharmaceutical firms. I used a dummy for companies which described themselves as biopharmaceutical companies in their 10-k filings.

Share of generic products. This variable measures the degree to which a company is marketing generics. It was computed as the share of different brands (alternatively, chemical substances) marketed by a firm that were not patent protected. As the descriptive results will show, many companies market both generic and original products.

Original products. I computed the absolute number of original products (brands and chemical substances, respectively). Such a measure serves as a baseline for a scenario that every product is solely protected by a single patent (representing a conservative view on a discrete product industry).

New Molecular Entities. I calculated the share of NMEs, based on original products (brands, with a robustness check for chemicals). Marketing NMEs point towards strong competencies in innovative product development. Upon introduction, NMEs are also responsible for higher firm value increases than drugs based on already established substances (Sorescu et al., 2003), and they are associated with more Orange Book-listed patents (Hemphill & Sampat, 2011).

Clinical trials: In order to control for the future potential of the company, I considered its product pipeline by looking at the clinical trials (phase 1-3) for which the company and its subsidiaries are listed as a sponsor or collaborator in the database clinicaltrials.gov during the observation year and the two preceding years. As the database is somewhat incomplete regarding industry-sponsored clinical trials prior to 2005, a robustness check was conducted with phase 2 and 3 data for the years 2007-2010.

Product portfolio diversification: To take product portfolio diversification into account and, thus, dependence on different product classes, I computed 1 minus the Herfindahl Index for the amount of brands as well as different chemical substances.

R&D intensity. To account for the underlying R&D activities, I controlled for R&D intensity in the observation year, following Yeoh and Roth (1999) and running robustness checks with lagged values for t-1 to t-3 as well.

Selling intensity. Many scholars have noted that actively promoting a drug in pharmaceuticals is a critical success factor. A company's sales force is the main driving force here (Yeoh & Roth, 1999). I therefore controlled for selling intensity as has been done in prior work (e.g. Ferrier, 2001).

Leverage. Accounting for leverage has also been a control for Tobin's q in the past (Hill & Hansen, 1991; Miller, 2006) and is therefore included, computed as the ratio of total debt to total assets.

Firm age. The sample also includes younger firms, mainly active in biotech, which may be confronted with much higher market expectations about their future than incumbent firms, leading to a higher market valuation. Therefore, I control for firm age.

All variables apart from diversification, pure imitation, computed shares, and dummies were skewed and thus logged (ln(variable+1)).

Model

I used Stata 12 with the XTREG function to estimate primarily fixed-effect models with cluster-robust standard errors. For measuring mediating effects, I followed the procedures from Baron and Kenny (1986), Newbert (2008), and Souitaris and Maestro (2010), building on four sub-models A-D: For sub-model A, I regressed the mediator (imitation) on the independent variable (patent fencing). For sub-model B, I regressed the dependent variable (firm performance) on the mediator (imitation). For sub-model C, I regressed the dependent variable (firm performance) on the independent variable (patent fencing), excluding the mediator (imitation). Finally, I regressed the depending variable (firm performance) on both the independent variable (patent fencing) and the mediator (imitation), obtaining sub-model D, whereas the effect of the independent variable (patent fencing) must be smaller in sub-model D than in sub-model C in order to show the mediation. With respect to pure imitation (i.e. the duration of patent protection that prevents generic entry), the model in Figure 1 changes in the way that patent fencing should increase the exclusivity period, which, in turn, should increase firm performance. Subsequently, the models presented are denoted with (a) (e.g. model Ia) when testing for creative imitation, while (b) (such as Ib) measures pure imitation. The extent to which signaling occurs according to H4a/b is tested comparing sub-models C and D. Fencing still has a positive effect on firm performance when controlling for imitation, then signaling should be in place.

RESULTS

Descriptive statistics

The descriptive statistics are shown for the subsequently-mentioned baseline model IIa-D. The average Tobin's q is about 3, implying that the market value is three times as high as the replacement value of the firms' assets. The average company encounters about 2.5 creative imitation events from competitors per year, the average length of the exclusivity period still remaining that shields generic entry is about 8.6 years, while a firm protects its products with about 4 patents and has about 5 patent-protected original products, of which one third is a NME. About one third of all products have lost exclusivity already. On average, a company has been involved in about 46 clinical trials during the past three years, and it employs about 9,850 people.

[insert Table 1 about here]

Multivariate statistics

Overall, as Table 2 reveals, I find only partial support for the hypotheses. Before I discuss overall findings, I will report the details first. In models I and II represent baseline models with product-related data based on brands. Model I shows the relationship without interaction terms, model II adds the latter (see Tables 3 and 4). To assess how far a fixed- or random-effects model is appropriate, I performed a Hausman test on the baseline model II-D and found the fixed-effect model to be appropriate. This model was also tested for mulicollinearity using variance inflation factors (VIF), finding no unexpected effects.

For creative imitation, I do not find a significant effect of fencing on creative imitation (based on entry into the primary classes) in model Ia-A. In model Ia-B, the effect of creative imitation on firm performance is positive and (marginally) significant. In model Ia-C, the relationship between fencing and firm performance is highly significant and negative. The

situation does not change in model Ia-D, where the magnitude of the fencing coefficient is very similar. This also means that adding imitation when going from submodel C to D does not change the effect of fencing as could be expected for having two separate effects: signaling and shielding imitation. So far, these results are somewhat counterintuitive and contradict the hypotheses. Adding interaction terms of dominance in models IIa, in submodel IIa-B the independent variables are insignificant. The relationship between both fencing as well as dominance and firm performance becomes positive and (marginally) significant in models IIa-C/D, whereas only the interaction between dominance and fencing shows a significant (and negative) effect on firm performance, while no significance is found for the other term. The coefficient for fencing in model D is only marginally smaller than in case of model C. Excluding orphan drugs and drugs based on inorganic substances/simple organic structures, the significance level decrease for the independent variables, so that only the interaction term of dominance and fencing remains (marginally) significant and negative.

Testing pure imitation, in model Ib/IIb – A, I find a highly significant and positive effect of fencing on imitation (measured in years of imitation protection), as was postulated. In all submodels, the effect of imitation on performance is not significant. Models Ib – C and D show a highly significant and negative effect of fencing on performance, while dominance is not significant here. In model IIb, where interaction terms are added, model IIb - C shows a positive and marginally significant effect of fencing on performance. The significance diminishes when adding the imitation variable. Thus, it is possible to distinguish signaling and imitation protection here. In models IIb – C/D, the interaction term of fencing and dominance is significant and negative, as was the case already for creative imitation, while the coefficient for fencing is a bit smaller in submodel D than C.

[insert Tables 2-4 about here]

Next, I split the sample into dominant and non-dominant firms, where dominance is larger or smaller than the mean, rerunning models A-D for each creative and pure imitation (see Table 5). I can confirm the moderating effect of dominance for the relationship between fencing and performance, but not for imitation and performance, as both the significance levels and the magnitude of the effect are smaller for non-dominant than dominant firms. Furthermore, splitting the sample as such reveals that creative imitation has a (marginally) significant and positive performance effect for dominant firms, which is surprising, while it is not significant for non-dominant ones. Postponed pure imitation has only a significantly positive effect on performance for dominant firms.

[insert Table 5 about here]

With respect to my hypotheses, H1 shows mixed results. Postponing generic imitation enhances firm performance only for dominant firms. Surprisingly, there is a marginally significant and positive effect of creative imitation on performance for dominant firms, while, again, no significant effect for non-dominant ones can be detected. Fencing reduces imitation (H2) only by postponing generic entry, both for dominant and non-dominant firms. No mediation effect of imitation in the fencing → imitation → performance relationship was detected, which means H3 is rejected. H4a proposed a positive effect of fencing on performance, *without* controlling for imitation. For the full dataset, this effect is supported. Controlling for dominance by spilling the sample in comparison to controlling for it by a variable, however, shows that the relationship becomes significant and negative. This means H4a is only partially supported. H4b, which proposed a significant positive effect of fencing on performance while *controlling for imitation* can only be confirmed for the full dataset and creative imitation. Overall, signaling

effects appear to be in place, and they appear to be much stronger than isolating effects. H5, which proposed a moderating role of dominance in the fencing → performance relationship is supported, while the moderating role of dominance in the imitation → performance relationship is not (see Table 2).

Looking at the control variables in Tables 3-4 (full dataset), in most models that have creative imitation as a dependent variable, the amount of original products has a significant and positive effect on creative imitation (the more products are available, the higher the likelihood of imitation). The share of generics in most models has a significant and negative effect on firm performance. Surprisingly, this is also the case for the amount of original products as well as the product pipeline and R&D intensity, while sales intensity has a marginally significant and positive effect. Firm age, in contrast, has a significant and positive performance effect. Most of the other controls remain insignificant throughout the presented models as well as the various robustness checks.

Splitting the sample into dominant and non-dominant firms reveals some clarifications: First, the share of generics only has negative performance implications for non-dominant firms, while the amount of original products only negatively influences performance for dominant firms. The effects of the product pipeline as well as sales and R&D intensities diminish when splitting the sample.

Robustness checks

The wide array of robustness checks included running full models with the alternative variables mentioned in the variables sections. The results are replicated in most robustness check measures, with variances in significance levels. When using alternative variables and outlier corrected data, it is worth mentioning that for pure imitation measured by backward duration and composite

duration variables, not only the imitation variable in model D shows the expected results, but the interaction term of dominance and imitation as well, while the interaction of dominance and fencing becomes insignificant.

As the panel is unbalanced, a selection problem cannot be ruled out, i.e. that the error term of the models is related to an unobserved variable that influences which firms to include into the model. To address this issue, I employ a maximum likelihood random effects model in STATA. Rerunning models IIa/b, I find basically the same results as reported previously. In model IIb – D, however, fencing and dominance show (marginally) significant and positive effects as well.

In case of measuring creative imitation by product entry (count data) as a dependent variable, i.e. in sub-models a-A, negative binomial fixed-effect estimation was alternatively used, but the fencing → creative imitation link remains insignificant. Finally, I employed the Sobel-Godman test for checking the mediating effect of imitation of models Ia/b-D, but cannot find the proposed effect.

DISCUSSION

The models show that fencing only prolongs market exclusivity when shielding original products against early generic entry, but it does not deter creative imitation, i.e. the introduction of follow-on drugs within the same drug class. This is surprising in the light of Lichtenberg and Philipson (2002) who argued that competition arising from creative imitation has a huge negative impact on revenues. Controlling for the moderating role of firm dominance, there is also no effect of imitation on performance, which is, at least for extending market exclusivity to shield the products against generics, somewhat surprising. There seem to govern distinct effects for dominant and non-dominant firms regarding both types of imitation, as dominant firms benefit from both creative imitation (showing a marginally significant effect) and shielding generic entry,

while non-dominant firms do not. The positive effect of creative imitation might imply that competitors as well introduce new molecules inside a class which allow further business opportunities for the companies who have entered the class earlier. Such opportunities may arise from a larger joint marketing effort of the competitors towards physicians, facilitating market and demand development (similar as Van de Ven (2005) observed for information technology), or opportunities that allow a product portfolio expansion by patenting competitors' products for new indications as observed in Sternitzke (2013). Dominant firms may be better able to use these opportunities than non-dominant firms. These findings complement the prior work of Lee and Zhou (2012) or De Carolis (2003) that studied the effects of own imitative strategies or imitation on firm performance.

Overall, signaling effects can be confirmed, while, as proposed, dominant firms benefit less from signaling through patent fencing, while this effect, without interactions with dominance in place, is even negative. This finding goes beyond the findings from Stuart et al. (1999) who showed that patents have only limited explanatory power for IPO valuations of biotech startups when other signaling effects are considered. Remarkably, the market does not see that dominance helps firms better overcome negative effects from imitation. In this line, the findings also imply that there is no mediating role of imitation, as postulated in the RBV, for the fencing – performance relationship here, implying that isolating mechanisms hardly influence firm performance directly or indirectly. So, overall, the effect of signaling seems to have more impact than the originally sought imitation protection. Hence, my research complements the prior one on the duality of signaling and value appropriation (e.g. Hsu & Ziedonis, 2013) by expanding this work from startups to publicly listed firms. My findings also demonstrate that there are significant differences in value appropriation between 'simple' patent filings (for which I

controlled for by the number of products under exclusivity) and advanced patenting strategies such as fencing.

Prior work on the resource-based view is extremely sparse regarding substitution effects (Newbert, 2007). As creative innovation, i.e. introducing novel, but structurally similar drugs within a class can be regarded as substitution (Berndt, Pindyck, & Azoulay, 2003), this paper also adds to this literature stream. It also complements the prior sparse work on the RBV on the isolating mechanism – imitation – performance relationship as it is, to my knowledge, the first work that directly addresses this relationship. The results further contribute to the portfolio theory of patent rights (see e.g. Parchomovsky & Wagner, 2005) as it is not solely simple patent counts that have an impact on firm value, but also the structure of this portfolio and the interdependencies between patents. In fact, the value of individual patents seems to depend not only on complementary assets but on complementary patents as well. Consequently, current approaches to valuing individual patents may be incomplete.

Could it be that endogeneity masked the patent strategy – performance relationship in this case, as better performing firms could pursue more sophisticated patenting strategies? While this cannot entirely be excluded, it seems unlikely for a number of reasons. First, it takes more than ten years between patenting and impact on firm performance (Sternitzke, 2010). Second, while patenting is, without doubt, expensive and may cost ten thousands of dollars per patent for the United States alone, these costs are particularly small in comparison to overall drug development costs, which are in the order of several hundred million dollars (DiMasi, Hansen, & Grabowski, 2003). Therefore, it appears unlikely that even past performance had a significant effect on the patent strategy chosen. Third, patent fencing as a strategy is known in the industry. It is nothing

only very potent firms are aware of. Taken together, reverse causality seems to be less a problem in this study.

MANAGERIAL IMPLICATIONS

Managers of dominant companies need to worry less about creative imitation, while they benefit from long-running product exclusivities. Patent fencing, which causes such exclusivities, however, reduces firm performance. Here, managers seem to be in a position to trade cash flow against stock performance, which is somewhat contradictory. Overall, signaling by patents does not seem to pay off here. But can firms, in fact, omit mentioning the patents protecting their products? Given capital market regulations that all information must be disclosed which might impact company performance, this seems to be rather unlikely.

A surprising finding in this study is that the market does not value the amount of original products on the market for dominant firms. This contradicts common practice in the industry, where gaps in the product pipeline are frequently closed by acquisitions:

> "Having a steady stream of new products and relatively strong patent protections is imperative. If the R&D department has a gap in its output, the executive team better buy something new and promising […]"
> BloombergBusinessweek (2014b) about Pfizer, Inc.

The acquisitions of Pfizer are only one example here, completing three mayor M&A within nine years (Warner-Lambert in 2000 for $87bn, Pharmacia in 2003 for $60bn, Wyeth in 2009 for $68bn), and in 2014 approaching AstraZeneca for $100bn). Recent reports indicate that pharmaceutical firms have found other ways than M&A to offset sales decreases due to expiring drug patents. They raise prices significantly BloombergBusinessweek (2014a).

CONCLUSIONS AND LIMITATIONS

Generally, this study provided evidence of substantial patent fencing activities for companies in pharmaceuticals and biotechnology. While a positive effect of fencing on postponing generic

imitation can be confirmed, generic imitation negatively impacts firm performance only for dominant firms, which, at the same time, benefit from creative imitation. In the light of creative imitation, fencing clearly shows signaling effects on performance, while dominant firms benefit less from fencing than non-dominant ones, implying that those firms which are already very well established in the market do not need to make use of patents for signaling competency. At the same time, dominance does not help firms overcome negative effects from imitation. Overall, these findings confirm that patent fencing plays both a role as isolating mechanism and signaling element, while the results, at the same time, show that imitation does not serve as a mediator in the fencing – performance relationship.

There are some limitations of my study which may open up avenues for future research. First of all, I relied on the FDA Orange Book to identify products assigned to the firms in the sample. When studying 10-k filings I realized that some firms had in-licensed products which sometimes were responsible for significant revenues. The same applies to so-called biologics (often, but not exclusively manufactured by biopharmaceutical firms for which I control with a dummy) as well as vaccines. Both types of drugs are not listed in the Orange Book. Second, patent fences relating to a drug may also involve patents not contained in the Orange Book as process patents may not be listed therein. Third, the study exclusively dealt with only one form of patenting strategies. There are, however, more that may be investigated. Fourth, my study entirely focused on biotechnology and pharmaceuticals. This approach calls for additional examination in other industries and countries outside the US. Finally, the finding that dominant firms are negatively affected by marketing multiple original products calls for a deeper examination.

REFERENCES

Achilladelis, B. 1993. The Dynamics of Technological Innovation: The Sector of Antibacterial Medicines. ***Research Policy***, 22(4): 279-303.

Achilladelis, B. & Antonakis, N. 2001. The dynamics of technological innovation: the case of the pharmaceutical industry. ***Research Policy***, 30(4): 535-588.
Aldrich, H. & Auster, E. R. 1986. Even dwarfs started small: Liabilities of age and size and their strategic implications. In B. M. Staw & L. L. Cummings (Eds.), Vol. 8: 165-198: JAI Press, Inc.
Amin, T. & Kesselheim, A. S. 2012. Secondary patenting of branded pharmaceuticals: a case study of how patents on two HIV drugs could be extended for decades. ***Health Affairs***, 31(10): 2286-2294.
Arundel, A. & Kabla, I. 1998. What percentage of innovations are patented?: Empirical estimates for European firms. ***Research Policy***, 27(2): 127-141.
Arundel, A. 2001. The relative effectiveness of patents and secrecy for appropriation. ***Research Policy***, 30(4): 611-624.
Barney, J. B. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17(1): 99-120.
Baron, R. M. & Kenny, D. A. 1986. The moderator-mediator variable distinction in social psychological research: Conceptual strategic, and statistical considerations. ***Journal of Personality and Social Psychology***, 51(6): 1173-1182.
Berndt, E. R., Pindyck, R. S., & Azoulay, P. 2003. Consumption externalities and diffusion in pharmaceutical markets: antiulcer drugs. ***The Journal of Industrial Economics***, 51(2): 243-270.
Blind, K., Edler, J., Frietsch, R., & Schmoch, U. 2006. Motives to patent: Empirical evidence from Germany. ***Research Policy***, 35(5): 655-672.
BloombergBusinessweek. 2014a. Big Pharma's Favorite Prescription: Higher Prices. ***BloombergBusinessweek***.
BloombergBusinessweek. 2014b. Pfizer Needs Something New for Its Profit Pain. ***BloombergBusinessweek***.
Bresnahan, T. F. 1985. Post-entry competition in the plain paper copier market. ***The American Economic Review***, 75(2): 15-19.
Bright, A. A. 1949. ***The electric-lamp industry***. New York: Macmillan.
Burdon, M. & Sloper, K. 2003. The art of using secondary patents to improve protection. ***Journal of Medical Marketing***, 3(3): 226-238.
Caves, R. E., Whinston, M. D., Hurwitz, M. A., Pakes, A., & Temin, P. 1991. Patent expiration, entry, and competition in the US pharmaceutical industry. ***Brookings papers on economic activity. Microeconomics***, 1991: 1-66.
Chong, C. R. & Sullivan Jr, D. J. 2007. New uses for old drugs. ***Nature***, 448(9 August): 645-646.
Chung, K. H. & Pruitt, S. W. 1994. A simple approximation of Tobin's q. ***Financial Management***, 23(3): 70-74.
Cockburn, I. & Henderson, R. 1994. Racing to invest? The dynamics of competition in ethical drug discovery. ***Journal of Economics & Management Strategy***, 3(3): 481-519.
Cohen, W. M., Nelson, R. R., & Walsh, J. 2000. Protecting Their Intellectual Assets: Appropriability Conditions and Why US Manufacturing Firms Patent (or Not). ***NBER working paper***.
Cohen, W. M., Goto, A., Nagata, A., Nelson, R. R., & Walsh, J. P. 2002. R&D spillovers, patents and the incentives to innovate in Japan and the United States. ***Research Policy***, 31(8-9): 1349-1367.
De Carolis, D. M. 2003. Competencies and Imitability in the Pharmaceutical Industry: An Analysis of Their Relationship with Firm Performance. ***Journal of Management***, 29(1): 27-50.

DeCarolis, D. M. & Deeds, D. L. 1999. The Impact of Stocks and Flows of Organizational Knowledge on Firm Performance: An Empirical Investigation of the Biotechnology Industry. ***Strategic Management Journal***, 20(10): 953-968.
Deephouse, D. L. 2000. Media reputation as a strategic resource: An integration of mass communication and resource-based theories. ***Journal of Management***, 26(6): 1091-1112.
DiMasi, J. A., Hansen, R. W., & Grabowski, H. G. 2003. The price of innovation: new estimates of drug development costs. ***Journal of Health Economics***, 22(2): 151-185.
DiMasi, J. A. & Paquette, C. 2004. The economics of follow-on drug research and development: trends in entry rates and the timing of development. ***Pharmacoeconomics***, 22(2): 1-14.
DiMasi, J. A. & Faden, L. B. 2011. Competitiveness in follow-on drug R&D: a race or imitation? ***Nature Reviews Drug Reviews***, 10(1): 23-27.
Ernst, H. 2001. Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level. ***Research Policy***, 30(1): 143-158.
Ethiraj, S. K. & Zhu, D. H. 2008. Performance effects of imitative entry. ***Strategic Management Journal***, 29(8): 797-817.
Ferrier, W. J. 2001. Navigating the competitive landscape: The drivers and consequences of competitive aggressiveness. ***Academy of Management Journal***, 44(4): 858-877.
Gompers, P. A. & Lerner, J. 2004. ***The venture capital cycle***. Cambridge, MA: MIT press.
Goodman & Gilman. 1994, 2006, 2011. ***Goodman and Gilman's The pharmacological basis of therapeutics*** (8, 11, 12 ed.). New York: McGraw Hill.
Granstrand, O. 1999. ***The economics and management of intellectual property***. Cheltenham: Edgar Elgar.
Grindley, P. C. & Teece, D. J. 1997. Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics. ***California Management Review***, 39(2): 8-41.
Haeussler, C., Harhoff, D., & Mueller, E. 2014. How patenting informs VC investors – The case of biotechnology. ***Research Policy***, 43(8): 1286-1298.
Hall, B. H., Jaffe, A., & Trajtenberg, M. 2005. Market value and patent citations. ***RAND Journal of Economics***, 36(1): 16-38.
Hatch, N. W. & Dyer, J. H. 2004. Human capital and learning as a source of sustainable competitive advantage. ***Strategic Management Journal***, 25(12): 1155-1178.
Heckman, J. J. 1979. Sample selection bias as a specification error. ***Econometrica***: 153-161.
Hemphill, C. S. & Sampat, B. N. 2011. When Do Generics Challenge Drug Patents? ***Journal of Empirical Legal Studies***, 8(4): 613-649.
Hemphill, C. S. & Sampat, B. N. 2012. Evergreening, patent challenges, and effective market life in pharmaceuticals. ***Journal of health economics***, 31(2): 327-339.
Hill, C. W. L. & Hansen, G. S. 1991. A longitudinal study of the cause and consequences of changes in diversification in the US pharmaceutical industry 1977-1986. ***Strategic Management Journal***, 12(3): 187-199.
Hsu, D. H. & Ziedonis, R. H. 2013. Resources as dual sources of advantage: Implications for valuing entrepreneurial-firm patents. ***Strategic Management Journal***, 34(7): 761-781.
Kapczynski, A., Park, C., & Sampat, B. 2012. Polymorphs and prodrugs and salts (oh my!): an empirical analysis of "secondary" pharmaceutical patents. ***PloS one***, 7(12): e49470.
King, A. W. & Zeithaml, C. P. 2001. Competencies and firm performance: examining the causal ambiguity paradox. ***Strategic Management Journal***, 22(1): 75-99.
Kissin, I. & Bradley, E. 2012. Top journals selectivity index and me-too drugs. ***Scientometrics***, 91(1): 131 - 142.

Lavie, D. 2006. The competitive advantage of interconnected firms: An extension of the resource-based view. ***Academy of Management Review***, 31(3): 638-658.
Lee, R. P. & Zhou, K. Z. 2012. Is product imitation good for firm performance? An examination of product imitation types and contingency factors. ***Journal of International Marketing***, 20(3): 1-16.
Levin, R. C., Klevorick, A. K., Nelson, R. R., & Winter, S. G. 1987. Appropriating the returns from industrial research and development. ***Brookings Papers on Economic Activity***, 3: 783-831.
Lichtenberg, F. R. & Philipson, T. J. 2002. The Dual Effects of Intellectual Property Regulations: Within-and Between-Patent Competition in the US Pharmaceuticals Industry. ***Journal of Law and Economics***, 45(S2): 643-672.
Lin, B.-W., Chen, C.-J., & Wu, H.-L. 2006. Patent portfolio diversity, technology strategy, and firm value. ***IEEE Transactions on Engineering Management***, 53(1): 17-26.
Long, C. 2002. Patent signals. ***The University of Chicago Law Review***, 69(2): 625-679.
Luo, Y., Sun, J., & Wang, S. L. 2011. Emerging economy copycats: capability, environment, and strategy. ***Academy of Management Perspectives***, 25(2): 37-56.
Mahoney, J. T. & Pandian, J. R. 1992. The resource-based view within the conversation of strategic management. ***Strategic Management Journal***, 13(5): 363-380.
Mansfield, E., Schwartz, M., & Wagner, S. 1981. Imitation costs and patents: an empirical study. ***Economic Journal***, 91(364): 907-918.
Mansfield, E. 1986. Patents and innovation: an empirical study. ***Management Science***, 32(2): 173-181.
McEvily, S. K. & Chakravarthy, B. 2002. The persistence of knowledge-based advantage: an empirical test for product performance and technological knowledge. ***Strategic Management Journal***, 23(4): 285-306.
Miller, D. J. 2006. Technological diversity, related diversification, and firm performance. ***Strategic Management Journal***, 27(7): 601-619.
Ndofor, H. A. & Levitas, E. 2004. Signaling the strategic value of knowledge. ***Journal of Management***, 30(5): 685-702.
Newbert, S. L. 2007. Empirical research on the resource-based view of the firm: an assessment and suggestions for future research. ***Strategic Management Journal***, 28(2): 121-146.
Newbert, S. L. 2008. Value, rareness, competitive advantage, and performance: a conceptual-level empirical investigation of the resource-based view of the firm. ***Strategic Management Journal***, 29(7): 745-768.
Parchomovsky, G. & Wagner, R. P. 2005. Patent Portfolios. ***University of Pennsylvania Law Review***, 154(1): 1-78.
Penrose, E. T. 1959. ***The theory of the growth of the firm*** (1 ed.). Oxford: Blackwell.
Peteraf, M. A. 1993. The cornerstones of competitive advantage: a resource-based view. ***Strategic Management Journal***, 14(3): 179-192.
Peters, T., Thiel, J., & Tucci, C. 2013. Protecting growth options in dynamic markets: The role of strategic disclosure in integrated intellectual property strategies. ***California Management Review***, 55(4): 121-142.
Puhani, P. 2000. The Heckman correction for sample selection and its critique. ***Journal of Economic Surveys***, 14(1): 53-68.
Reed, R. & DeFillippi, R. J. 1990. Causal ambiguity, barriers to imitation, and sustainable competitive advantage. ***Academy of Management Review***, 15(1): 88-102.
Reitzig, M. 2004. The private value of "thickets" and "fences": towards an updated picture of the use of patents across industries. ***Economics of Innovation and New Technology***, 13(5): 457-476.

Rivette, K. G. & Kline, D. 2000. Discovering New Value in Intellectual Property. ***Harvard Business Review***, 78(1): 54-67.
Roberts, P. W. & Dowling, G. R. 2002. Corporate reputation and sustained superior financial performance. ***Strategic Management Journal***, 23(12): 1077-1093.
Rumelt, R. P. 1984. Towards a strategic theory of the firm. In R. B. Lamb (Ed.): 556-570. Englewood Cliffs, NJ: Prentice Hall.
Sampat, B. N. & Ziedonis, A. A. 2004. Patent citations and the economic value of patents. In H. F. Moed & W. Glänzel & U. Schmoch (Eds.): 277-298. Boston: Kluwer.
Schoenecker, T. & Swanson, L. 2002. Indicators of Firm Technological Capability: Validity and Performance Implications. ***IEEE Transactions on Engineering Management***, 49(1): 36-44.
Sheehan, J., Martinez, C., & Guellec, D. 2004. Patents, Innovation and Economic Performance. ***OECD Conference Proceedings, Chapter 4***: 89-110.
Somaya, D. 2003. Strategic determinants of decisions not to settle patent litigation. ***Strategic Management Journal***, 24(1): 17-38.
Somaya, D. 2012. Patent Strategy and Management An Integrative Review and Research Agenda. ***Journal of Management***, 38(4): 1084-1114.
Sorescu, A. B., Chandy, R. K., & Prabhu, J. C. 2003. Sources and Financial Consequences of Radical Innovation: Insights from Pharmaceuticals. ***Journal of Marketing***, 67(4): 82-102.
Souitaris, V. & Maestro, B. M. M. 2010. Polychronicity in top management teams: the impact on strategic decision processes and performance of new technology ventures. ***Strategic Management Journal***, 31(6): 652-678.
Spence, M. 1973. Job market signaling. ***Quarterly Journal of Economics***, 87(3): 355-374.
Sternitzke, C. 2010. Knowledge sources, patent protection, and commercialization of pharmaceutical innovations. ***Research Policy***, 39(6): 810-821.
Sternitzke, C. 2013. An exploratory analysis of patent fencing in pharmaceuticals: The case of PDE5 inhibitors. ***Research Policy***, 42(2): 542-551.
Stuart, T. E., Hoang, H., & Hybels, R. C. 1999. Interorganizational Endorsements and the Performance of Entrepreneurial Ventures. ***Administrative Science Quarterly***, 44(2): 315-318.
Szymanski, D. M., Bharadwaj, S. G., & Varadarajan, P. R. 1993. An analysis of the market share-profitability relationship. ***The Journal of Marketing***: 1-18.
Tobin, J. 1969. A general equilibrium approach to monetary theory. ***Journal of Money, Credit and Banking***, 1(1): 15-29.
Van de Ven, A. H. 2005. Running in Packs to Develop Knowledge-Intensive Technologies. ***MIS Quarterly***, 29(2): 365-377.
Wagner, S. & Cockburn, I. 2010. Patents and the survival of Internet-related IPOs. ***Research Policy***, 39(2): 214-228.
Wernerfelt, B. 1984. A resource-based view of the firm. ***Strategic Management Journal***, 5(2): 171-180.
Wernerfelt, B. & Montgomery, C. A. 1988. Tobin's q and the importance of focus in firm performance. ***American Economic Review***, 78(1): 246-250.
Wishart, D. S., Knox, C., Guo, A. C., Cheng, D., Shrivastava, S., Tzur, D., Gautam, B., & Hassanali, M. 2008. DrugBank: a knowledgebase for drugs, drug actions and drug targets. ***Nucleic Acids Research***, 36(Jan): D901-906.
Yeoh, P.-L. & Roth, K. 1999. An Empirical Analysis of Sustained Advantage in the US Pharmaceutical Industry: Impact of Firm Resources and Capabilities. ***Strategic Management Journal***, 20(7): 637-654.

Ziedonis, R. H. 2004. Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms. ***Management Science***, 50(6): 804-820.

FIGURE 1

Model and Hypotheses

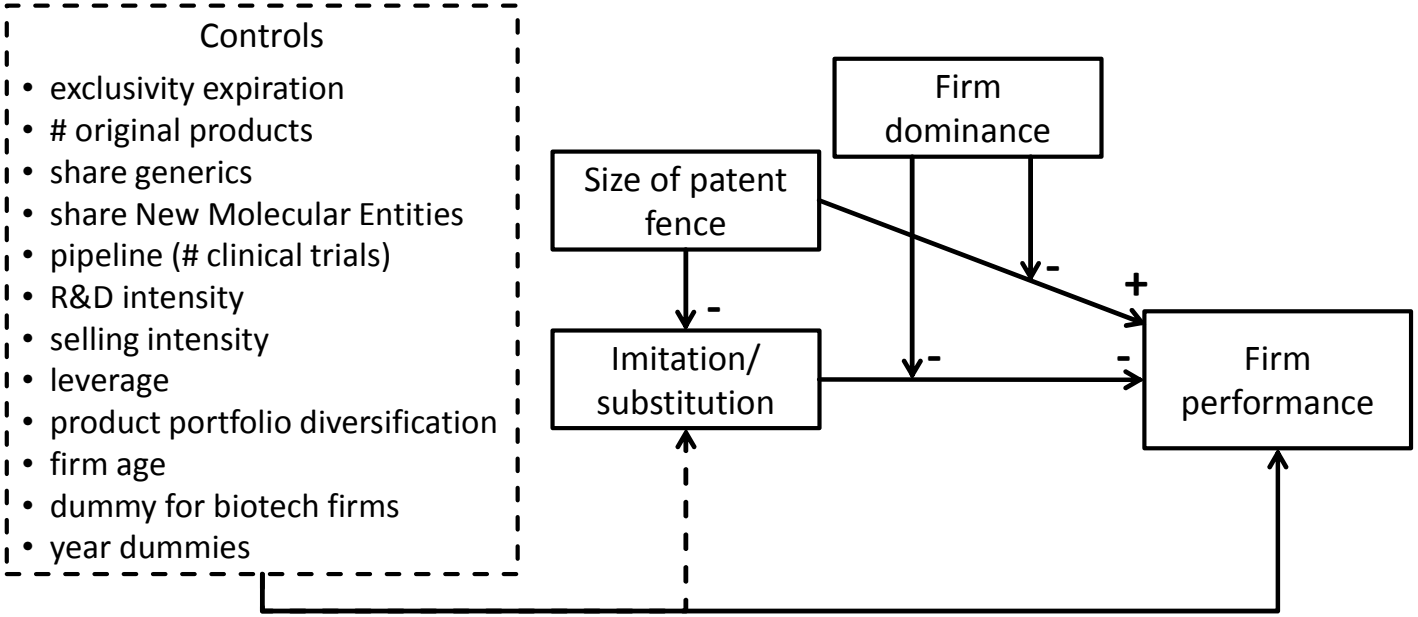

TABLE 1

Descriptive statistics for the data points included into the baseline model (IIa-D, value for pure imitation from model IIb-D).

		unlogged	
	Variable	Mean	Std. Dev.
(1)	Tobin's q	2.86	4.42
(2)	creative imitation [entries]	2.37	4.61
(3)	pure imitation [years]	8.66	3.63
(4)	fencing	3.83	2.59
(5)	dominance	9,847.38	24,300.17
(6)	exclusivity expirations	0.24	0.75
(7)	share generics	0.34	0.39
(8)	#original products	5.36	9.77
(9)	share NMEs	0.33	0.39
(10)	product portfolio diversification	0.36	0.36
(11)	pipeline (clinical trials)	46.28	122.66
(12)	R&D intensity	2.93	32.89
(13)	selling intensity	5.36	56.00
(14)	leverage	0.25	0.31
(15)	firm age	31.77	33.05
(16)	biotech dummy	0.42	0.49

TABLE 2

Overview about the results. Sample split into dominant and non-dominant firms

Hypo-theses	Independent variable	Dependent variable	Predicted effect	Creative imitation findings		Pure imitation findings	
				Overall	Sample split	Overall	Sample split
H1	Imitation	Firm performance	negative	×	opposite effect df	×	✓ df only
H2	Fencing	Imitation	negative	×	×	✓	✓
H3	Fencing → imitation →	Firm performance	mediation	×	×	×	×
H4a	Fencing without imitation control	Firm performance	positive	✓	× df + ndf	✓	× df + ndf
H4b	Fencing with imitation control	Firm performance	positive	✓ signa-ling in place	× df + ndf signaling in place	×	× df + ndf signaling in place
H5	Dominance × fencing	Firm performance	negative	✓	✓	✓	✓
H6	Dominance × imitation	Firm performance	negative	×	×	×	×

× - not confirmed; ✓- confirmed; df – dominant firms; ndf – non-dominant firms

TABLE 3

Creative imitation: Heteroskedasticity-consistent and clustered standard errors in brackets. +≤0.1 *≤0.05 ** p≤0.01 *** p≤0.001; § Model II-A equals Model I-A

analysis based on creative imitation of brands							
	Model Ia, similar molecule class, brand level, imitation as entry				Model IIa§		
Variable	A	B	C	D	B	C	D
Tobin's q	-	depvar	depvar	depvar	depvar	depvar	depvar
imitation	depvar	0.077+	-	0.076+	0.126	-	0.147
		(0.043)		(0.042)	(0.173)		(0.170)
fencing	-0.023	-	-0.246***	-0.245**	-	1.102+	1.053+
	(0.101)		(0.091)	(0.088)		(0.563)	(0.553)
dominance	-	-0.055	-0.062	-0.059	-0.052	0.301+	0.297+
		(0.073)	(0.076)	(0.075)	(0.075)	(0.166)	(0.164)
fencing × dominance	-	-	-	-	-	-0.225*	-0.217*
						(0.088)	(0.087)
imitation × dominance	-	-	-	-	-0.007	-	-0.011
					(0.020)		(0.020)
exclusivity expirations	-0.052	-0.096*	-0.093*	-0.089+	-0.094+	-0.068	-0.061
	(0.084)	(0.046)	(0.049)	(0.047)	(0.048)	(0.045)	(0.045)
share generics	0.113	-0.417**	-0.420**	-0.431**	-0.416*	-0.449**	-0.456**
	(0.133)	(0.159)	(0.158)	(0.158)	(0.160)	(0.152)	(0.153)
#original products	0.574*	-0.330*	-0.283+	-0.327*	-0.318+	-0.279+	-0.297+
	(0.222)	(0.157)	(0.156)	(0.157)	(0.165)	(0.144)	(0.152)
share NMEs	0.051	0.008	0.012	0.009	0.015	0.064	0.073
	(0.238)	(0.190)	(0.194)	(0.187)	(0.198)	(0.212)	(0.213)
product portfolio	0.060	0.071	0.094	0.088	0.058	0.060	0.036
diversification	(0.241)	(0.190)	(0.182)	(0.182)	(0.204)	(0.178)	(0.191)
Pipeline (clinical trials)	0.038	-0.088*	-0.084*	-0.087*	-0.087*	-0.083*	-0.085*
	(0.028)	(0.038)	(0.036)	(0.037)	(0.038)	(0.036)	(0.036)
R&D intensity	-0.482*	-0.081	-0.109	-0.067	-0.071	-0.231	-0.173
	(0.241)	(0.231)	(0.222)	(0.228)	(0.241)	(0.225)	(0.237)
selling intensity	0.445*	0.085	0.105	0.065	0.076	0.229	0.176
	(0.225)	(0.195)	(0.188)	(0.191)	(0.201)	(0.202)	(0.206)
leverage	-0.228	0.273	0.254	0.273	0.280	0.204	0.233
	(0.147)	(0.186)	(0.184)	(0.187)	(0.187)	(0.191)	(0.194)
firm age	0.019	1.322***	1.354**	1.354**	1.315***	1.330***	1.319***
	(0.262)	(0.347)	(0.365)	(0.371)	(0.342)	(0.341)	(0.340)
biotech dummy	-0.056	-0.303	-0.321	-0.316	-0.301	-0.349	-0.341
	(0.137)	(0.375)	(0.397)	(0.394)	(0.372)	(0.374)	(0.368)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-0.230	-1.570	-1.286	-1.282	-1.580	-3.434*	-3.370*
	(0.732)	(1.088)	(1.198)	(1.211)	(1.088)	(1.537)	(1.527)
F-value	4.81	6.24	6.83	6.65	6.16	7.07	6.61
Adj. R^2 (within)	0.165	0.323	0.327	0.334	0.324	0.352	0.358
N	481	471	471	471	471	471	471

TABLE 4:
Pure imitation: Heteroskedasticity-consistent and clustered standard errors in brackets.

analysis based on forward duration imitation protection and brands

	Model Ib				Model IIb§		
Variable	A	B	C	D	B	C	D
Tobin's q	-	depvar	depvar	depvar	depvar	depvar	depvar
imitation	depvar	0.003	-	0.017	0.014	-	-0.010
		(0.014)		(0.013)	(0.044)		(0.042)
fencing	6.130***	-	-0.243**	-0.471***	-	1.101^{+}	0.874
	(1.018)		(0.091)	(0.14)		(0.565)	(0.642)
dominance	-	-0.100	-0.064	-0.121	-0.085	0.298^{+}	0.200
		(0.082)	(0.077)	(0.081)	(0.109)	(0.165)	(0.159)
fencing × dominance	-	-	-	-	-	-0.224*	-0.218*
						(0.088)	(0.096)
imitation × dominance	-	-	-	-	-0.002	-	0.004
					(0.006)		(0.005)
exclusivity expirations	-0.051	-0.068	-0.089*	-0.051	-0.070	-0.063	-0.026
	(0.245)	(0.045)	(0.050)	(0.045)	(0.045)	(0.046)	(0.041)
share generics	0.269	-0.323*	-0.374**	-0.326*	-0.314*	-0.401**	-0.382**
	(0.896)	(0.142)	(0.139)	(0.136)	(0.141)	(0.135)	(0.145)
#original products	-0.155	-0.222	-0.262^{+}	-0.210	-0.220	-0.257^{+}	-0.201
	(1.637)	(0.145)	(0.155)	(0.130)	(0.144)	(0.142)	(0.126)
share NMEs	-1.577	0.225	-0.001	0.241	0.228	0.050	0.267
	(2.283)	(0.16)	(0.193)	(0.152)	(0.162)	(0.213)	(0.176)
product portfolio	0.807	0.037	0.081	0.032	0.033	0.047	0.009
diversification	(1.514)	(0.184)	(0.183)	(0.171)	(0.185)	(0.178)	(0.169)
Pipeline (clinical trials)	0.110	-0.078*	-0.084*	-0.075*	-0.078*	-0.082*	-0.075*
	(0.199)	(0.037)	(0.036)	(0.036)	(0.037)	(0.035)	(0.035)
R&D intensity	0.756	-0.271	-0.113	-0.285	-0.282	-0.235	-0.411
	(1.671)	(0.256)	(0.224)	(0.263)	(0.264)	(0.227)	(0.257)
selling intensity	-0.426	0.260	0.110	0.258	0.269	0.234	0.388^{+}
	(1.507)	(0.220)	(0.189)	(0.224)	(0.223)	(0.203)	(0.233)
leverage	1.417	0.303	0.248	0.276	0.311^{+}	0.198	0.210
	(1.255)	(0.191)	(0.183)	(0.189)	(0.187)	(0.19)	(0.192)
firm age	-3.548^{+}	1.014***	1.392***	1.069***	1.019***	1.370***	1.033***
	(2.001)	(0.269)	(0.376)	(0.271)	(0.271)	(0.351)	(0.251)
biotech dummy	0.338	-0.738*	-0.318	-0.835**	-0.743*	-0.346	-0.840***
	(1.268)	(0.306)	(0.395)	(0.279)	(0.303)	(0.373)	(0.239)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	11.243	-0.447	-1.419	0.090	-0.556	-3.569*	-1.797
	(6.780)	(0.856)	(1.222)	(0.863)	(0.974)	(1.564)	(1.316)
F-value	3.43	5.6	6.65	6.85	5.38	6.89	6.66
Adj. R^2 (within)	0.271	0.357	0.326	0.386	0.358	0.351	0.409
N	454	444	471	444	444	471	444

+≤0.1 *≤0.05 ** p≤0.01 *** p≤0.001

TABLE 5

Sample split into firms with dominance ≤ mean and >mean. To provide a one glance overview, only significant relationships are reported, omitting numeric values of coefficients and standard errors.

	dominance > mean								dominance ≤ mean							
	creative imitation				pure imitation				creative imitation				pure imitation			
Variable | models	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Tobin's q		depvar	depvar	depvar		depvar	depvar	depvar		depvar	depvar	depvar		depvar	depvar	depvar
imitation	depvar	0.074^{+}	-	0.073^{+}	depvar	0.016	-	0.034*	depvar	0.061	-	0.064	depvar	0.001	-	0.011
		(0.040)		(0.039)		(0.015)		(0.015)		(0.077)		(0.076)		(0.016)		(0.014)
fencing	-0.050	-	-0.888***	-0.885***	5.252***	-	-0.888***	-1.074***	0.054	-	-0.186^{+}	-0.190^{+}	5.918***	-	-0.186^{+}	-0.308^{+}
	(0.645)		(0.239)	(0.232)	(1.386)		(0.239)	(0.260)	(0.083)		(0.093)	(0.108)	(1.100)		(0.109)	(0.165)
exclusivity	-0.015	-0.046	-0.031	-0.030	-0.126	-0.046	-0.031	-0.026	-0.211	-0.197	-0.186	-0.173	0.410	-0.112	-0.186	-0.067
expirations	(0.081)	(0.039)	(0.038)	(0.037)	(0.209)	(0.040)	(0.038)	(0.036)	(0.217)	(0.166)	(0.176)	(0.177)	(1.784)	(0.199)	(0.176)	(0.213)
share generics	0.069	-0.170	-0.193	-0.198	1.700	-0.189	-0.193	-0.251^{+}	0.092	-0.524*	-0.531*	-0.538*	-0.574	-0.562*	-0.531*	-0.565*
	(0.169)	(0.128)	(0.124)	(0.122)	(1.026)	(0.136)	(0.124)	(0.128)	(0.177)	(0.214)	(0.215)	(0.214)	(1.394)	(0.234)	(0.215)	(0.233)
#original	0.781*	-0.384*	-0.348*	-0.405*	0.597	-0.333^{+}	-0.348*	-0.368*	0.298	-0.253	-0.232	-0.249	0.344	-0.180	-0.232	-0.197
products	(0.341)	(0.188)	(0.156)	(0.160)	(1.605)	(0.181)	(0.156)	(0.157)	(0.274)	(0.232)	(0.239)	(0.234)	(2.612)	(0.237)	(0.239)	(0.239)
share NMEs	1.142^{+}	0.255	0.240	0.157	1.860	0.315	0.240	0.171	-0.211	0.052	0.019	0.034	-2.006	0.389	0.019	0.367^{+}
	(0.577)	(0.307)	(0.258)	(0.257)	(2.307)	(0.318)	(0.258)	(0.256)	(0.202)	(0.268)	(0.264)	(0.260)	(2.293)	(0.237)	(0.264)	(0.219)
product portfolio	0.358	0.101	-0.110	-0.136	-3.997*	0.214	-0.110	0.022	0.234	-0.033	0.014	-0.003	2.644	-0.076	0.014	-0.062
diversification	(0.389)	(0.218)	(0.239)	(0.225)	(1.705)	(0.273)	(0.239)	(0.261)	(0.246)	(0.244)	(0.233)	(0.237)	(2.268)	(0.283)	(0.233)	(0.272)
Pipeline (clinical	0.081^{+}	-0.052	-0.039	-0.045	0.166	-0.050	-0.039	-0.046	-0.042	-0.083	-0.089	-0.086	0.043	-0.068	-0.089	-0.070
trials)	(0.044)	(0.040)	(0.041)	(0.041)	(0.147)	(0.041)	(0.041)	(0.040)	(0.055)	(0.080)	(0.079)	(0.079)	(0.384)	(0.077)	(0.079)	(0.078)
R&D intensity	-2.056	-0.182	-0.561	-0.411	-15.608	-0.064	-0.561	-0.034	-0.520^{+}	0.012	0.003	0.036	2.023	-0.084	0.003	-0.081
	(1.832)	(1.618)	(1.404)	(1.381)	(9.309)	(1.551)	(1.404)	(1.288)	(0.265)	(0.215)	(0.207)	(0.214)	(1.861)	(0.244)	(0.207)	(0.259)
selling intensity	1.058	0.775	0.853	0.775	11.962^{+}	0.661	0.853	0.444	0.475^{+}	0.022	0.028	-0.004	-1.573	0.101	0.028	0.089
	(1.396)	(1.537)	(1.364)	(1.320)	(6.649)	(1.531)	(1.364)	(1.286)	(0.247)	(0.182)	(0.180)	(0.181)	(1.686)	(0.205)	(0.180)	(0.220)
leverage	0.216	-0.197	-0.149	-0.165	1.752	-0.214	-0.149	-0.210	-0.421*	0.364	0.340	0.366	0.025	0.397	0.340	0.390
	(0.495)	(0.375)	(0.344)	(0.337)	(2.225)	(0.388)	(0.344)	(0.331)	(0.189)	(0.263)	(0.260)	(0.266)	(1.285)	(0.268)	(0.260)	(0.268)
firm age	-0.312	0.838***	0.970***	0.993***	-1.458	0.820***	0.970***	1.018***	0.300	2.410**	2.508**	2.488**	-11.369***	1.532	2.508**	1.645^{+}
	(0.377)	(0.166)	(0.168)	(0.160)	(1.445)	(0.182)	(0.168)	(0.191)	(0.562)	(0.760)	(0.811)	(0.813)	(3.312)	(0.950)	(0.811)	(0.950)
biotech dummy*	NA	NA	NA	NA	NA	NA	NA	NA	-0.011	-0.281	-0.285	-0.284	-0.027	-0.654*	-0.285	-0.702*
									(0.185)	(0.284)	(0.296)	(0.292)	(1.541)	(0.304)	(0.296)	(0.286)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
intercept	0.049	-0.710	0.326	0.322	3.227	-0.855	0.326	-0.238	-0.932	-5.132*	-5.132*	-2.633	33.037**	-2.716	-5.132	-2.633
	(1.297)	(0.631)	(0.693)	(0.672)	(6.422)	(0.703)	(0.693)	(0.761)	(1.583)	(2.161)	(2.236)	(2.640)	(10.729)	(2.637)	(2.236)	(2.640)
F-value	8.01	7.92	8.65	10.51	12.02	7.87	8.65	9.30	4.90	7.96	6.99	10.03	11.34	7.15	6.99	10.03
Adj. R^2 (within)	0.249	0.569	0.603	0.613	0.429	0.564	0.603	0.623	0.187	0.262	0.266	0.288	0.340	0.273	0.266	0.288
N	199	198	198	198	197	196	198	196	282	278	278	278	257	253	278	253

*there were no dominant biotech firms in the sample; +≤0.1 *≤0.05 ** p≤0.01 *** p≤0.001