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Patenting Dilemma for Startups: Number of Applied Patents, Patent Imitability, and Level of VC Funding*

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ABSTRACT

Should a startup file for a patent subject to imitation in its quest to attract venture capital(VC) investors? Considering the US pharmaceutical biotechnology industry context, this paper attempts to answer this question by investigating the relations between the number of applied patents of startups, patent imitability, and the total amount of money the startups received as their first VC funding round. Data of 157 US-based pharmaceutical biotechnology startups founded in between 1995 and 2005 are analyzed. Empirical results from this study show that the number of applied patents is positively related to the total amount of money received at the time of the first funding round, and patent imitability is negatively related to the total amount of money received as first VC funding round. Nonetheless, the interaction term between the number of applied patents of startups and patent imitability came out as positive, raising interesting questions and implications for innovation-oriented startup entrepreneurs. The current study's empirical findings suggest that, in the pharmaceutical biotechnology sector, VC investors pay attention to the quantity and quality of the patents possessed by startups when they decide the level of funding. In particular, imitability of applied patents may not be a one-sided concept related to negative features such as the weak protectability of an invention. Rather, patent imitability may be a multi-facet element which also contains positive attractiveness of the startup's invention. Furthermore, it seems that the positive side of imitability can be augmented by the number of applied patents.

Keywords: startup, venture capital funding, number of applied patents, patent imitability, biotechnology.

Ⅰ. Introduction

Technological innovation is a key asset for any firm that wishes for success in this ever more competitive world. Particularly, and on the contrary to large firms, innovative startups are relying more heavily on their inventions to survive, grow and secure their place in the market(Choi, 2013). Indeed, due to their liability of newness(Stinchcombe & March, 1965), being usually short in financial resources as well as in marketing capabilities, innovative startups depend upon how they can appropriate the value of their innovations.

One of the possible appropriation mechanisms for innovative startups is to patent their inventions. Patenting innovation has two main advantages for these small companies. First, it allows them to protect innovation from imitation and to license it to earn royalties. Second, it helps them to improve their reputation by signaling their innovative capacity, which is crucial for attracting potential investors(Blind et al., 2006; De Rassenfosse, 2012; Mann & Sager, 2007).

Attracting venture capital(VC) investors are critical for innovative startups‘ growth and survival(Holgersson, 2013; Lee & Choi, 2014). Taking the definition from Gompers & Lerner(2001), venture capital investment is defined in this study as “equity or equity-related investments in young, privately held companies.” Similarly, corporate venture capital(CVC) also exists and specifically concerns corporation that wishes to invest in

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such companies for distinctive purposes(Katila et al., 2008; Zahra, 1996). In their search for growth, startups are often restrained by their size. Startups' limited resources hinder their innovative potential which is at the core of their survival, and especially in industries where Research and Development(R&D) projects are costly(Bell & McNamara, 1991). Also, their lack of assets such as manufacturing or commercial abilities prevents them from expanding their business and prospering(Sapienza, 1992). Plus, some researchers demonstrated that VC investments helped venture-backed firms to innovate better(Alvarez-Garrigo & Dushnitsky, 2016; Kortum & Lerner, 2000). In that sense, venture capitalists incarnate a godsend for these firms by supplying the necessary funds and complementary assets(Teece, 1986) to fully develop their potential.

However and aside from signaling their innovative capacity, startups engaging in patenting activity expose themselves to potential misappropriation for their innovation. Officially, patent gives legal exclusive rights to its inventor(s) for a limited period of time in exchange of publicly disclosing information. Nonetheless, this disclosure of information exposes the patenting firm to imitation from competitors, and even more when the appropriability regime[1] is weak(Teece, 1986) and when the firm does not have the resources to enforce the patent rights(Hall & Harhoff, 2012). Startups typically fall in that category; their size, their lack of resources and their usual inexperience with the patent system(Van Zeebroeck et al., 2009) prevent them from blocking competitors that imitate their patented innovations(Sattler, 2003). Plus, this problem inflates when the technology developed by the firm itself is clearly codified and creates low barriers for imitation and ease of knowledge transfer.

The ambivalent message sent by patented but imitable innovation poses a dilemma for startups willing to attract VC investors. On one hand, startups rely on patent as a signaling mechanism to reveal its innovative potential and its innovation quality in order to attract VC investments. On the other hand, patent exposes the firm's knowledge and is subject to imitation. This patent imitability is likely to influence to choice of VC investors who may ponder whether investing in an innovation capable startup in order to acquire its technology and create value in the future, or not investing in it since its technology is imitable and other industry players may already have imitated it. As Häussler et al.(2012) revealed in their study using interviews, corporations examine(or even hire experts to examine) the target firm's patent portfolio in order to decide whether to invest or not. This raises few questions for the startups before patenting: 1)Does the imitability of the patented invention affect the VC investors' choice to invest in the company? 2)Are investors more likely to consider the firm's current technological assets or the potential future value creation? Answering both of these questions will highlight what VC investors take into account before injecting funds in an innovative startup. Second, it will also provide clues on type of invention and knowledge the startups should patent to attract VCs. This question is even more relevant knowing that patent imitability closely relates to the quality of the startups' innovation. In fact, the better the quality of an invention, the more competitors will be interested in that invention and therefore the more competitors will raise funds to imitate the technology(Allison et al., 2003).

In order to answer these questions, this paper will in the first place review the literature on startups' patenting activity and the relation between patenting startups and VC investors. Another section will be devoted to investigate the pharmaceutical industry which is appropriate to investigate the topic of this study. Thereafter, hypotheses about the number of applied patents of startups, patent imitability and the level of VC funding will be developed. And lastly, the results of this study will be analyzed and discussed to lead to further theoretical and practical implications, raising new questions for future researchers.

Ⅱ. Literature review

2.1 Innovative startups' patenting activity

Literature on small firms' patenting activity is abundant. In his survey study, Mansfield(1986) brought to light that smaller firms were less prone to patent than larger firms. This lower propensity to patent has been explained by the high cost of patenting due to lack of financial resources and lack of patenting experience of small firms(Van Zeebroeck et al., 2009). Another reason may be their lack of ability to enforce their patent rights(Hall & Harhoff, 2012; Kitching & Blackburn, 1998). It is also noteworthy that smaller firms' patents tend to be more litigated than those of larger firms(Allison et al., 2003). Interestingly and completing Mansfield's study(1986), Cohen et al.(2000) pinpointed the different reasons why firms patented innovations. The results of the study showed that smaller firms viewed patent not as a viable protection mechanism but as a way to "enhance the reputation of the firm and its employees"(Cohen et al., 2000) in order to create financing relationships.

1) The appropriability regime is how much innovations and knowledge are protected from imitators. In this paper's context, it relates to intellectual property(IP) and the ability of the firm to appropriate the most value out of its innovation and knowledge.

Thumm(2004) supplanted that firms patent for reputational motives. Also, Blind et al.(2006) confirmed the findings of these studies, while other researchers suggested that patents served as a way to display information about the firm's value(Hall et al., 2005; Hsu & Ziedonis, 2008).

Hall & Harhoff(2012) argued that patenting enabled the smaller firms to display their important assets, corroborating the prior findings from Levin et al.(1987). If startups also patent for monetary reasons(De Rassenfosse, 2012), these studies congregate to a main argument: small firms patent to send a quality signal to other stakeholders in the market, and particularly VC investors.

Indeed, a patent can be considered as a quality signal for many reasons. First of all, patent applications have been related to firm performance because patent applications are related to the firm innovative capacity(Ernst, 2001). Second, a patent application publicly discloses information. Since the information is freely available, VC investors can evaluate the content of the patent application and thus decide whether to invest or not, without the grant decision being taken into account(Häussler et al., 2012). Third, for a patent to be granted, the patent application must pass through screening and examinations by the patenting office where it is applied. For example, in the US, each applied patent undergoes an evaluation by the examiners from the USPTO(United States Patent & Trademark Office).

To be successfully issued, the applied patent must satisfy three quality criteria; the applied innovation must be novel, non-obvious, and foremost useful. Since startups file patent applications and the majority of these patents end up being granted(Hoenen et al., 2014), a patent application usually checks for all the criteria of quality patent at the USPTO. Plus, after being granted, patent also confers value generation capacity, since the patentee can exert the legal rights awarded from the granted patent. Therefore, it can be considered that an applied patent is a symbol of quality(Guellec & de la Potterie, 2000).

2.2 Relations between startups and VC investors

Literature linked small firms and VC investors in multiple ways. A recurrent theme is the motive for these two protagonists to interact with each other. From the startups point of view, attracting VC investors improves the startups' chances to develop. Bell and McNamara(1991) exposed the importance of venture investments in the rise of technology development in multiple industries. Plus, many researchers explored startups' needs for VC investors. For example, Stuart et al.(1999), using social network theory, showed that VC-backed small firms were perceived better by other market players which foster their chance to survive and grow. Davila et al.(2003) backed up this finding, mentioning that VCs accelerate small firms' growth by providing out-of-reach resources to the firm. Other interesting studies(Baum & Silverman, 2004; Beckman et al., 2007) spotted the fact that skilled management team with past experiences in various companies or VC investing firm facilitated the growth of startups that often have poor experience especially in knowledge management(Van Zeebroeck et al., 2009). Also, in addition to financial resources, Gans & Stern(2003) documented the fact that startups research in well-established firms' complementary assets(Teece, 1986) such as commercialization ability, networks, and experience to spur their growth further. Moreover, allying with incumbent firms keeps small firms away from investing their already limited funds in these complementary assets, avoiding "duplicative investments"(Gans & Stern, 2003). Lastly and having recourse to resource dependency theory, Katila et al.(2008) illustrated existing pressures pushing startups to resort to well-established organizations to augment their chances to grow, even though such relations could turn out to be unfavorable.

If startups relied on VCs to grow further and prosper, VC investors also have their stake in this bilateral relationship. For example, Powell et al.(1996) study disclosed that corporations taking part in a social network–through CVC investments for example–smoothed knowledge transfer, and notably when the knowledge is complex and difficult to transfer(Simonin, 1999).

Similarly, Mowery et al.(1996) maintained that participating in CVC relationships enhanced knowledge transfer to both partners, leading to technology overlap. Supplementing these studies, Gans & Stern(2003) underlined that established firms often have network, experience, and marketing capacity but are not the most efficient at innovating, particularly compared to innovation-oriented small firms. This low R&D efficiency to spur innovation incites these large firms to establish relations with CVC to acquire the innovation and the innovative capacity of these startups. This need for innovation is clarified in Dushnitsky & Lenox's(2005) article demonstrating that incumbent firms engaging in CVC investment with innovative small firms enjoyed an increase in innovative outcomes.

Even though innovative startups and incumbent firms engaging in VC investments do not always ally for each others' interests(Gans & Stern, 2003; Katila et al., 2008), both of these entities need each other in some aspects. This interdependency pushes each actor to engage in equity-investment relations. However, the existing literature so far did not cover the existing dilemma startups face when patenting an imitable innovation nor

the likelihood that VC investors will invest in a startup publicly disclosing imitable knowledge. In order to fulfill this gap in the literature, this paper will investigate the relationship between innovative startups' patenting activity and the attractiveness of these focal startups to VC investors. Further, this paper will investigate how patent imitability will moderate the decisions of venture capitalists to invest in the innovative startups.

More precisely this study will focus its analysis on the U. S. pharmaceutical biotechnology industry. Although various studies examined this industry(Gambardella, 1995; Gilsing & Nooteboom; 2006; Häussler et al., 2012; Powell et al., 1996; Stuart et al., 1999), only a few scholars addressed the concern of patent imitability, such as De Carolis(2003) who found that technological imitation was negatively correlated with the firm performance. However, this study only considered technology imitation among large and well-established firms, leaving an avenue for further studies on the concept, and in different settings. This is why this study intends to dissect the effect of patent imitability on the biotechnology startups' choice to patent and the subsequent decision of VC investors to whether invest or not.

2.3 US Pharmaceutical Biotechnology Sector

The biotechnology and the pharmaceutical industry differ substantially. At its origin, the biotechnology sector is mainly devoted in developing biology-related innovations when the pharmaceutical industry takes root in organic chemistry and the development of therapeutic drugs. However, the biotechnology sector is not confined to biology. As the sector grew over time, it incorporated techniques and expertise from diverse fields; chemical, biochemical, genetics, and numerous others.

The biotechnology sector and the pharmaceutical sector began to converge in the course of the 1970s, where new drug discoveries started to diminish(De Carolis, 2003). At that time where health-related discoveries glimpsed promising and fruitful markets, biotechnology firms commenced to develop new therapeutic drugs based on their distinctive competencies acquired from different fields. The combination of traditional pharmaceutical research methods and techniques proper to the biotechnology fields attracted the attention of large pharmaceutical firms(Gilsing & Nooteboom, 2006). These large firms realized the potential of these innovative biotechnology firms, the competences they could get from them and the profit they could make from them.

In sum, the rise of the biotechnology sector gradually attracted large pharmaceutical firms who in turn saw their interest in funding in these firms.

Startups operating in the biotechnology sector often have a particular status. The common biotechnology startup is often smaller than medium in size(Mangematin et al., 2003) and operates at a loss, since R&D projects to develop new drug is enormous(costing tens to hundreds millions of dollars) and since the time required developing the new drug is rather long(in years)(Deeds et al., 1997). Adding the time getting the approval from the Food and Drug Administration(FDA, in the US) and marketing the new drug, the biotechnology startup needs a long enough period to be profitable or needs funds to stay afloat(Deeds et al., 1997). This predicament often pushes biotechnology startups to seek VC funds from well-established pharmaceutical firms. It also emphasizes how much startups rely on sending quality signal about their innovative capabilities to get the attention of incumbent firms(Häussler et al., 2012).

On the other side, well-established pharmaceutical firms are hampered by a different set of problems. These firms are often more competent at manufacturing and commercializing drugs, but not the most efficient(in terms of R&D expenses) in discovering new drugs. As a result, they delegate this task to biotechnology startups to which they grant VC funding. The dissimilar conditions of both actors(i.e. the biotechnology startup and the pharmaceutical firm) push them to associate through CVC investments from the incumbent firm to the startup. Once the startup provides the innovations, the pharmaceutical firm markets them and multiply the benefits by ten, as in the case of Gilead Sciences' US$567 million acquisition of Cell Design Labs to further advance its cell therapy technology (www.biotech-capital.com).

The last parameter to take into account is the value of the patent in the pharmaceutical biotechnology sector. In this study, patent is analyzed as the biotechnology startups' signaling method to attract VC investments from well-established organizations. Gauging the value of the patents in that industry is crucial for the rest of the study, since researchers stress that value of the resources depends on the context(Priem & Butler, 2001).

Many researchers agreed that patents have a high value in that industry, since firms generally rely on them to protect their technology(e.g. Mansfield, 1986; Levin et al., 1987; Cohen et al., 2000). The reason is that the pharmaceutical biotechnology sector is a discrete product industry(Cohen et al., 2000). It means that the discoveries that are patented are often well codified and clearly defined(such as chemical formulas) which in turns limit the ability of competitors to imitate by inventing around and so litigate these patents. In short, patents have a strong legal value

in this industry, granting the firm a strong appropriability on its innovations(Hall & Harhoff, 2012). As a result, the majority of discoveries in the biotechnology or pharmaceutical industry are patented(Mansfield, 1986) and patents are considered as a strong appropriability mechanism by the industry's actors(Levin et al., 1987).

The patent value is actually where the dilemma surfaces. First, small firms patent to send a quality signal to other players in the market to improve their chances of being funded by well-established corporations(Häussler et al., 2012). Plus, as mentioned earlier, the pharmaceutical biotechnology industry is a discrete product industry. Therefore, startups that patent are expected to almost fully benefit from their patented innovations. Making profit out of their innovations, these startups are more likely to interest large corporations in order to receive further VC funding. However, in the case where their patented innovation is imitable, large corporations may consider whether to further select or nurture these startups or not. Indeed, these large corporations will have to decide whether emphasizing current value capture(i.e. the potential profits from those patents) or the potential future value generation(i.e. the certification that the startup is able to innovate by patenting). This dilemma is more likely to be reflected in the pharmaceutical biotechnology sector where patents have been shown to be a reliable quality signal(Häussler et al., 2012) and where imitable technology have been shown to negatively impact firm performance(De Carolis, 2003). Therefore, startups have to decide whether it is worth patenting imitable innovation to show their innovative quality and VC investors have to decide whether to invest in those startups or not. Solving this dilemma will also contribute to the literature concerning the selection or nurturing effects of corporation to innovative biotechnology startups(Alvarez-Garrido & Dushnitsky, 2016) and the current discussion about value capture versus value generation(Bowman & Ambrosini, 2000; Lepak et al., 2007).

There are a few additional reasons to select the pharmaceutical biotechnology sector for this study's setting. First, due to the strength of the patents, firms in this sector patent intensively(Mansfield, 1986). Second, patents in this sector are well codified and contain clear information(Levin et al., 1987) which amplifies the negative effect of imitation(De Carolis, 2003). Indeed, firms attempting to imitate these patents can relatively more easily understand the patents' data, which augments their chance to successfully imitate. It is even more likely to attain small firms since studies have shown that smaller firms' patent get cited more often(Hall et al., 2005). Firms' patents getting cited are more likely to be imitated since citing entities are more likely to innovate over the cited patents. Furthermore, the sector has known a blazing growth in the recent year boosting the emergence of new biotechnology firms(Lazonick & Tulum, 2011). This growth in new firms subsequently engendered a rise in VC relationships, not to mention that these VC investments are also accounted in millions of dollars.

Ⅲ. Theory and hypotheses

3.1 The number of applied patents and VC funding

Patent is the vector for signaling the firm's reputation. Indeed, a patent serves as enhancing the startup's reputation since it conveys credibility to potential investors(Mann & Sager, 2007; Hall & Ziedonis, 2001; Häussler et al., 2012). In its nature, a patent successfully applied or granted constitutes a certified achievement and a proof of value(Rao, 1994), adding to the fact that the institution delivering the patent(in this case, the USPTO) possesses a certain and well-established legitimacy(Guellec & de la Potterie, 2000). Moreover, a firm's reputation has a recognized influence on other firms' decision to set up a partnership(Dollinger et al., 1997). The underlying implication is that a well-reputed firm will have an easier time finding a partner willing to invest(Dierickx & Cool, 1989). The logic behind is found in the transaction cost economics theory(TCE)(Williamson, 1985); a better reputation decreases the uncertainty surrounding the firm vis-à-vis potential investors. This reduction in uncertainty in return lowers the likelihood that VC investors choose the wrong target to invest in since they have guarantees that the startup is able to innovate. It also suggests that the startup is able to provide further returns consequential to VC investments. The resource-based view(RBV) also supports such assumptions; scholars argued that reputation was one of the principal resources for a firm(Grant, 1991) that could help the firm sustain its competitiveness(Barney, 1991). Lastly, researchers investigating the biotechnology sector found out that CVC investors tended to favor the most innovative partners, i.e. startups more inclined to patent their discoveries(Alvarez-Garrido & Dushnitsky, 2016).

Since this study's context is patent-financing setting, investors' perception regarding why they decide to fund the startups with active patenting activity needs to be understood. It is well established that patent ownership can be useful for startups in obtaining finance at different stages of innovation(Hall, 2019). A patent is a credible informational mechanism in situations of asymmetric information, since a patent with misinformation can

be invalidated. Filing for a patent can be signals to reduce information asymmetries as well as signals for invention quality(Conti, et al., 2013). A patent is seen as a strong value appropriation mechanism, particularly in the pharmaceutical industry(Cohen et al., 2000; Levin et al., 1987; Teece, 1986). As a result, a startup's number of applied patents provides an additional security for potential CVC investors.

In sum, we expect that biotechnology startups engaging in patenting activities will have a higher chance of success in attracting VCs. Since Hoenen et al.(2014) submitted that patent applications influenced solely the first VC funding round and failed to be correlated with subsequent funding rounds, this study will also limit itself to the effect of patent applications on the startups' first VC funding round.

Hypothesis 1: The number of applied patents of biotechnology startups will be positively related to the total amount of money received at the first VC funding round.

3.2 Influence of patent imitability

Conveying a quality signal to other industry players has a cost. Firms engaging in patenting activities publicly divulge information about their knowledge and technologies to other surrounding firms. In fact, researchers found that patenting was associated with knowledge spillovers(Ernst, 2003; Jaffe et al., 1993). Plus, startups' patents have bigger chances to be imitated(and litigated) since startups often lack financial resources to properly enforce their rights(Allison et al., 2003). Also, a higher quality patent has a higher probability of being imitated(and litigated), since it will trigger other players' attention and interest toward it(Allison et al., 2003). In sum, startups engage in patenting face a higher risk of being imitated.

Retaking the definition from De Carolis(2003), patent imitability is defined in this paper as "the extent to which rival can imitate a technology". Patent imitability is indeed important. According to the RBV, a firm can sustain its competitive advantage only if its resources are rare, valuable, and foremost inimitable(Barney, 1991). In that sense, if a startup's patents are imitable, large corporations will be less willing to invest in it since the patented innovations will not be able to generate sustainable profits. In the same vein, the resource dependence theory supports that imitable technologies will induce disinterest for VC investors. If a patent data is publicly available, well-codified, and easy to imitate, VC investors will not feel the need to spend resources for it since large corporations will be able to mimic it. Scholars have shown that large firms are interested in appropriating smaller partner's resources(Katila et al., 2008).

In that case, VC investors will be less interested in easily imitable patents and their owners. Lastly, researchers employing social network theory have demonstrated that large incumbent firms prefer to acquire knowledge from smaller firms especially if the knowledge is complex and difficult to transfer(Powell et al., 1996). To do so, these firms are more likely to establish a network with their smaller counterparts through alliances, joint-ventures or VC investments(Mowery et al., 1996). In the opposite case, if a technology information is publicly available, clearly codified, and above all not well protected and thus easy to imitate, incumbent firms will be less prone to form a network to grasp these smaller firms' knowledge.

To recapitulate, we expect that biotechnology startups' easily imitable patented innovations will impede their search for VC investors, weakening their chances to be generously funded.

Hypothesis 2: Patent imitability will be negatively related to the total amount of money received at the first VC funding round.

In the pharmaceutical industry, imitability is of great influence on the expected future profits. Indeed, since patent has a strong value in that industry, inimitable innovations guarantee colossal revenues. Actually, studies have both shown that inimitable technology lead to above-average performance(Markman et al., 2004) and that, in opposition, imitability lead to lower firm performance over time(De Carolis, 2003). For example, in case of patent expiry, the firm's stranglehold on a market is vastly compromised since the patent data become imitable(and in fact imitated) through generic drugs. Researchers have even gauged the impact of valuable patent expiry, up to 80% in revenue loss(Barrett, et al., 1999). Following this logic, when patent imitability is high, the appropriability on the innovations would be seriousy dampened, which may repel VC investors since the startups may be unable to generate exceptional benefits as intended(Teece, 1986).

Patent imitability may matter differently depending on the applied patent portfolio's size. For startups having a small number of applied patents, patent imitability may negatively affect VC investors' perception of the startups; the low number of patents coupled with high patent imitability may disclose a lack of innovative capacity in addition to low future profits. As a consequence, VC investors may be more inclined to disregard these small startups, seeing no interest for future horizons. On the other hand, a firm having a large but imitable patent portfolio may pose more questions for VC investors.

Even though an accumulation of imitable patents may be of low interest for VC investors, a large number of applied patents undeniably tell that the startup is able to innovate. However, the high patent imitability may here again raises doubts about the future profitability of the startups. In sum, it is expected that patent imitability will overall lessen the amount of money given for the first funding round by VC investors to the startups.

Hypothesis 3: Patent imitability will moderate the relationship between the number of applied patents of startup and the total amount of money received at the first VC funding round such that high patent imitability will lower the amount of funding.

IV. Methodology

4.1 Data sample

We selected the US-based pharmaceutical biotechnology startups founded in between 1995 and 2005 with at least one successfully applied patent which received at least one venture capital funding round during the first 6 years.[2] To select these firms, we used Crunchbase. Crunchbase is a free access Internet database in which each startup can voluntarily contribute by reporting information about the company(upon moderation before being published). The database intends to make a census of existing startups from diverse industries and records information about the startups' characteristics such as the startups' domains of activity, their founders, date of creation, location and about venture capital funding rounds such as the amount of money received, the series of the funding rounds, the date of the funding round and the numbers of investors and information about them. Crunchbase has previously been used in numerous studies on startups and venture capitals(Block & Sandner, 2011).

Crunchbase catalogs the startups in industry groups. To select pharmaceutical biotechnology firms, we used the following tags in the industry groups' selection: "Pharmaceutical" and "Biotechnology". Since we are interested in biotechnology startups operating in the pharmaceutical and therapeutic sectors, we excluded the companies mainly engaging in the biotechnology medical device, software, and instruments.

It is indeed possible to sort out these firms because those firms were usually listed under the "Medical Device" tag. Each company provides a brief presentation of its activities which helped us polish the data. As a third filter, going through each firm's patent using the United States Patent and Trademark Office's(USPTO) database and Google Patents gave extra information about the firm's activity which facilitated refining the data sample. After reviewing all the firms listed on Crunchbase and eliminating all the firms with missing or out-of-scope data, the final sample accounted for 157 firms. Among these 157 firms, a total of 472 patents where observed.

4.2 Variables

4.2.1 First VC funding

The dependent variable of this study is the total amount of money received by a startup at its first venture capital funding round in thousands of US dollars. Firms that did not specify the amount of money received were excluded from the sample. Also, any debt financing, grant, or non-equity financing round was not considered.

4.2.2 The number of applied patents

The first independent variable measures the number of successfully applied patents(patents that turned out to be granted by the USPTO at the end of the process) between the startup's foundation year and the date at which it received its first funding round. An interview study conducted by Häussler et al.(2012) in the biotechnology sector highlighted that VC investors pay attention to the number of applied patents in its entirety as opposed to single patent only. Researchers sometimes use a depreciation rate for the patents depending on which year they have been applied in relation to the date of the venture capital(Häussler et al., 2012).

In order to have a better distribution, the variable was natural logarithm-transformed after adding 1 to the number of applied patents not to lose any value. Plus, it also allows differentiating the measure for applied patents from the patent imitability measure described below since this measure employs the raw count of applied patents as denominator.

4.2.3 Patent imitability

Patent imitability is the second independent variable. We used De Carolis'(2003) measure of imitability accounting for the extent to which rivals can imitate a technology.

2) This paper studies the first 6 years for the following reasons. First, it represents the early stage of the startups which is a crucial period. Indeed, VC investors particularly look upon early stages startups for investments(Gompers, 1995). Concerning the startups, nearly half of them shut down within their early years. Second, limiting the timeframe to a relatively short period of time allows the startups' patents to be still relevant for VC investors, especially knowing that patents in the biotechnology and pharmaceutical industries are known for their longevity. Lastly, taking opening the time frame up to 6 years and not less inflate the sample size, which permits more precise analyses.

The measure is employed as follow. A startup A applied for N patents between its founding year and its first VC funding round. Up to 2 years after being granted, those patents received Y forward citations from other firms. Patent imitability is the ratio of the Y forward citations received by the successfully applied patents within their first 2 years after being granted on the number of N successful patent applications within the startup's creation date and its first VC(Y/N). Self-citations are excluded from the count.

Several control variables were added to improve the model, rule out alternative explanations and alleviate the analysis.

4.2.4 Investors

The number of investors was added as a control variable since a larger number of investors can reflect the quality of a firm and its technology; the bigger the number of investors, the more interesting the technology. Plus, the number of investors is likely to affect the total amount of financial resources the startup receives since the total sum of VC awarded to a startup is likely to be higher as numerous investors are involved.

4.2.5 Age

The age of the firm at the time of receiving its first funding round was also added as a control variable, ranging from 0 to 6.

4.2.6 Quality

Patent quality can influence VC investors' opinion about the quality of the startup and the potential revenues it can bring. Since this study attempts to explore the effects of imitability of venture capital decisions, patent quality was added as a control variable. To measure patent quality, we computed the number of forward citations the successfully applied patents received up until after 5 years and divided it by the number of successfully applied patents(Trajtenberg, 1990).

Since startups founded at different years are analyzed, delimiting the time frame to 5 years appeared to be necessary since older firms with older patents were more likely to receive more citations. On the contrary to patent imitability, self-citations were included since patent citation reflect the cumulative nature of innovation and self-citations have been shown to be a genuine indicator for patent quality(Hall et al., 2005).

4.2.7 Founder's experience

The founder's experience, may it be as entrepreneurial experience, managerial or academic, has been shown to have an effect on the venture capitalists' investment decision since experience reflects a positive signal for investors(Hsu, 2007). This control variable was coded using dummy variable. To collect data about the startups' founders, we used Crunchbase which, most of the time, cataloged the startups' founders. When data where missing or incomplete, we had recourse to external sources of information such as the companies' websites, Bloomberg.com which holds business persons' information or founders' personal pages such as Linkedin.

4.2.8 University spin-off

If a startup was a spin-off from a university or a public research institute, it was controlled using dummy variables(1 if spun out of a university or research institute, 0 otherwise)(Häussler et al., 2012).

4.2.9 Company spin-off

If a startup was a spin-off from a private company, it was controlled using dummy variables(1 if spun out of a company, 0 otherwise)(Häussler et al., 2012).

4.2.10 Financial crisis

Researchers have shown that the 2008 financial crisis deeply impacted the amount of VC investments during a couple of years(Block & Sandner, 2011).

The crisis, starting from 2008, lowered the amount of capital being invested in startups up until 2011. we employed dummy variables to control for the potential effect of the crisis on VC investments for the years 2008, 2009 and 2010.

4.2.11 VC cluster

VC investments concerning the biotechnology sector have been shown to be clustered in specific areas. Some clusters are well-known such as San Francisco Bay Area, the Sillicon Valley, Cambridge in Massachusetts and the Durham's Research Triangle Park in North Carolina.

Startups located in well-established or emerging clusters are more likely to grow thanks to VC investments(Powell et al., 2002). Tracking the location of the startups, indicated on the Crunchbase database, we used dummy variable coding 1 if a startup was located in one of these active VC clusters, 0 otherwise.

<Table 1> Descriptive statistics and correlations.

Variables	1	2	3	4	5	6	7	8	9	10	11
1st VC funding	1										
the number of applied patents	0.3063*	1									
Patent imitability	-0.1253	-0.0163	1								
Investors	0.4308*	-0.0235	-0.0081	1							
Age	-0.1876*	0.2342*	0.0001	-0.0727	1						
Quality	0.0681	-0.0456	0.3668*	-0.0769	-0.1679*	1					
Founder's experience	0.1338	0.0961	0.0232	-0.0485	-0.1857*	0.0106	1				
University spin-off	0.0464	-0.0862	0.1208	0.1492	0.0164	0.1910*	-0.2256*	1			
Company spin-off	0.1119	0.2455*	0.0227	-0.0058	-0.0247	-0.0901	0.1444	-0.1137	1		
Financial crisis	-0.2637*	-0.0404	0.0656	-0.3394*	0.4332*	0.0245	-0.1871*	-0.0084	-0.0236	1	
VC cluster	0.2205*	0.1881*	-0.1681*	0.0132	-0.0271	-0.1459	0.0618	-0.1112	0.1333	0.0103	1

n=157; ** p < 0.05*

4.3 Statistical method

The dependent variable, the total amount of money perceived by the startups, is a continuous variable. Thus, we use ordinary least squares regression (OLS) with robust standard error. This method corresponds to minimizing the sum of square differences between the observed and predicted values. The statistical software used for the analysis is STATA v13.

<Table 2> Ordinary least squares regression(OLS) of 1stVC(n=157) with robust standard errors.

	Model 1	Model 2	Model 3
The number of applied patents		0.534***	0.421***
		(0.000)	(0.008)
Patent imitability		-0.337**	-0.868***
		(0.011)	(0.003)
The number of applied patents x Patent imitability			0.578**
			(0.043)
Investors	0.186***	0.204***	0.206***
	(0.000)	(0.000)	(0.000)
Age	0.015	-0.069	-0.072
	(0.751)	(0.192)	(0.173)
Quality	0.014	0.021	0.020
	(0.310)	(0.120)	(0.131)
Founder's experience	0.260	0.213	0.221
	(0.242)	(0.313)	(0.305)
University spin-off	0.034	0.109	0.133
	(0.897)	(0.660)	(0.573)
Company spin-off	0.373	0.176	0.211
	(0.112)	(0.460)	(0.380)
Financial crisis	-1.880***	-0.832*	-1.022**
	(0.000)	(0.062)	(0.030)
VC cluster	0.421**	0.297*	0.294*
	(0.017)	(0.071)	(0.075)
Year Dummy	yes	yes	yes
Constant	2.269***	1.268***	1.536***
	(0.000)	(0.000)	(0.000)
Observations	157	157	157
R-squared	0.382	0.462	0.471

** p < 0.1, ** p < 0.05, *** p < 0.01.*

V. Results

<Table 1> lists the descriptive statistics for the variables used in this study. To test possible multicollinearity issue, we check variance inflation factors. The highest VIF is 1.49 with mean of 1.23. which is below the typical cutoff value of 10(Neter et al., 1990). Furthermore, the highest value of the condition index is 2.54, far below 20 as recommended in Greene(1997).

<Table 2> reports the results of the ordinary least squares regressions for 3 tested models. As a first step, Model 1 introduces all the control variables susceptible to influence the total amount of money a startup may receive at its first VC funding round. The number of investors is positive and significant, obviously translating that the total amount of money received by the startups for their first funding round increases concurrently with the number of investors. VC cluster is also positive and significant showing that biotech firms located in active VC clusters indeed received a larger amount of money for their first VC funding round(Powell et al., 2002). As we expected, financial crisis is negative and significant, which means that startups that receive their first VC funding rounds during the financial crisis were less funded.

Model 2 is improved compared to Model 1 and adds in the two independent variables; The number of applied patents and patent imitability. The number of applied patents is positive and strongly significant, meaning that it is positively correlated with a larger amount of money received as first VC investment, providing support for Hypothesis 1. This result corroborates with the findings from previous studies(Häussler et al., 2012; Hoenen et al., 2014; Mann & Sager, 2007). On the other hand, patent imitability is negative and significant, supporting Hypothesis 2. It denotes that more imitable applied patents are indeed less attractive for VC investors. Model 3 tests for the interaction term between the number of applied patents and patent imitability. Model 3 is also significantly improved compared to Model 2. The interaction term is significant, showing the concrete presence of a moderating effect of patent imitability and the main variable the number of applied patents. However, the direction is opposite to what we expected. Thus, Hypothesis 3 is not supported. The implications for these results will be discussed in the next section.

VI. Discussion and Conclusion

The findings from this study are interesting in many points. First of all, the results for Hypothesis 1 confirm that VC investors indeed pay attention to the number of applied patents of startups in the pharmaceutical biotechnology sector(Häussler et al., 2012; Hoenen et al., 2014; Hsu & Ziedonis, 2008; Mann & Sager, 2007). It also provides additional support to the utilization of patents as a tangible quality signal to attract investors, as reported by survey studies(De Rassenfosse, 2012; Häussler et al., 2012).

A second interesting point is that patent imitability was found to be negatively related to the amount of money received as first VC funding round. Here again, in spite of previous research that found a great disparity in the evaluation process of the number of applied patents(Häussler et al., 2012), this study shows evidence that VC investors scrutinize the startups' technology appropriability beforehand. This result seems logical as patents have a strong value in the pharmaceutical sector(Cohen et al., 2000; Levin et al., 1987; Mansfield, 1986) and as the primary function of a patent is to protect against imitation. In fact, De Rassenfosse(2012) found that the primary motives of US biotechnology firms are not only to attract investors but also to protect their innovations.

The truly surprising result from this study comes from the unsupported third hypothesis, which assumed that patent imitability would negatively moderate the relationship between the number of applied patents and the total amount of money received as first VC funding round. Contrary to expectations, patent imitability appears to have a moderating effect more complex than expected. Several explanations can be found to justify this outcome.

In the first place, these results can possibly match alternative theoretical explanations. According to Conti et al.(2013), patents can serve as a signal to investors about quality and appropriability of the startups. In the hypothesis 2, an imitability of patents alone may diminish the amount of VC funding due to the increase of imitators that lowers the appropriability of current value of the focal startups' patents. However, the increase of imitators can be associated with the increase of the market being served. In this situation, if the startups show that they will be solid players through large number of patents, investors may perceive the greater future appropriability of the startups. Thus, the imitability of the patents can be helpful for receiving the higher amount of founding under the condition of that the startups can signal their competence such as the high number of patents.

In sum, when startups had a smaller number of applied patents, patent imitability influenced negatively the choice of VC investors. However, the positive effect of patent imitability had an advantageous synergy when startups had a larger number of applied patents.

For a technology to be imitated, it has to be understood by other parties. Similarly, to decide whether to invest or not, VC investors has to primarily understand the startups' technology. Imitability of a technology can help reduce uncertainty and information asymmetry surrounding a startup's technology for the VC investors(Gompers, 1995). This assumption is supported by other studies. For example, Autio, Sapienza & Almeida(2000) argued that inimitable technology prevent other parties to establish communication and transferring information, which can dampen other parties to create a network with the startup. Getting visibility and creating an external network is crucial for startups to get funded(Stuart et al., 1999). More approachable patents can foster information sharing which in turn might help the startup get better funded.

The results can also be explained by the methodology employed. First, a citation can be a sign of networking and thus be an important factor both for the startup and VC investors, the fact that the patents have been cited, hints about the relevance and the applicability of the startup's technology(Hall et al., 2005). Indeed, since the knowledge provided by the startup's patents has been reapplied to other patented innovations by rivals through forward citations, it suggests that the startup is developing useful and further applicable technologies. This applicability is of great interest in the pharmaceutical sector where patents have high value(Alvarez-Garrido & Dushnitsky, 2016; Henderson & Cockburn, 1996). Third, VC investors may be aware that startups are unable to effectively protect their patents due to financial constraints(Van Zeebroeck et al., 2009). According to the "VC as coach" mechanism elaborated by Hellmann(2000) and further developed by Baum & Silverman(2004) which supports that venture capitalists provide assistance to startups in precarious situations, VC investors can focus on the brighter side of it, i.e. the technology is new and understandable. Alternatively, if other parties imitated the startup's patents, it hints that a potential market may exist for the innovations developed by the startup. Effectively, patent imitability has been measured as the propensity other firms to cite the startup's applied patents. It insinuates that competitors may need to reapply this knowledge more or less rapidly. This pace of patent citations might reflect the technology life cycle(Mogee, 1991), indicating that an industry segment is growing or a market is already well-established.

Lastly, studies have shown that the size and strength of a

patent portfolio is more important than single patents(Hall & Ziedonis, 2001; Shapiro, 2000). It means that a larger number of applied patents will be more attractive for VC investors(as shown by Hypothesis 1). Plus, even though some patents in a patent portfolio may be imitable, other patents can cover related or unrelated areas counterbalancing the possible loss incurred by the imitable patents. Moreover, Mowery et al.(1996) backed up the faculty of patents to enable network creation in diminishing barriers between the startup and VC investors.

Implications and Contributions

We believe that the current study contributes to literature of startups' innovation and VC funding by providing the following implications. The study's research question has both academic and practical implications: Would VCs find it attractive to invest in a startup with stock of patents which are imitable? The term 'imitability' has a negative connotation. as it implies lack of protection of the firm's knowledge assets. However, if no other firm imitates a firm's patents at all, what does that imply in terms of the patents' quality?

In terms of research implications, imitability may not be a one-sided concept related to negative features such as the weak protectability of an invention. The current study's empirical results imply that patent imitability is a multi-facet element which also contains rather positive attractiveness of the startup's invention. Furthermore, it seems that the positive side of imitability can be augmented by the number of applied patents. Results of this study show that imitable patents, when in low number, are negatively related to the total amount of VC funding. It implies that, when a startup has few tangible quality assets, the value-depreciating effect of imitability impacts more severely the decision-making process of VC investors.

More interestingly, when a startup has a large number of applied patents, this large patent portfolio can be used as a mean to create a denser network, which is of critical importance for startups to attract VCs and be adequately funded.

The practical implications for startups are twofold. First, when patenting extensively, the negative effect of patent imitability is compensated by the number of applied patents. As a consequence, startups having a low number of applied patents may want to limit the negative effect of patent imitability on VC funding by trying to protect their innovations through other methods such as making these patent data more complex or, oppositely, relying on data secrecy(by providing less clue on critical information) to prevent imitation as much as possible. Second, the benefits of large numbe of applied patents allow the “positive facet” of patent imitability to create an advantageous professional network and, thus, help to get sufficiently funded. Rothaermel & Boeker’s(2008) study uncovered that pharmaceutical and biotechnology companies were more likely to cooperate when they shared technological complementarities, i.e. shared understanding about specific technology. Transposing it to the VC case, it suggests that VC investors understanding better the startups technology will be more prone to cooperate with the startups, resulting in higher fundings. It suggests that startups, when profusely filing for patents, should minimize their fear of being imitated as it can also contribute to receive adequate funding from VC investors.

In addition, a practical implication for VC investors is that they should be able to distinguish imitability of a patent from its quality. A largely imitated patent exposes the interest of rivals for the patent while a quality patent is more likely to attract potential imitators. Despite these notions being closely intertwined(Allison et al., 2003), it validates the fact that VC investors may be able to tell apart the patent value from its likelihood of being imitated and that they take these two criteria into account before investing.

Limitations and Future Direction

Our study has several limitations which suggests the direction of future research. First, methodologically, this study may be subject to the sample selection bias because getting funded is not random. Future studies need to address this issue using correction measures such as Heckman's(1979) two-step procedure. Second, funding amounts may be the function of elements other than number of patent such as the valuation of startups and other technological competences. Also, number of patents are intertwined with the size of startups such as employees. Without considering those elements, we may not be able to argue the direct relationship between funding amounts and number of patents. Future studies should at least control these additional variables.

Finally, the current study controls the experience of an entrepreneur as the VC funding decision may be associated with the quality of entrepreneurs and entrepreneurial team. Including the entrepreneurs' education level and experience of successful exit can be an important addition.

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스타트업의 특허 딜레마: 특허수, 모방 가능성, 그리고 벤처 캐피털리스트 펀딩 수준*

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국 문 요 약

스타트업은 벤처캐피털 투자자들의 투자를 얻기 위해서 모방의 위험성을 감수하고서도 기술을 특허로 출원해야 하는가? 이러한 질문에 답하기 위하여 본 연구에서는 미국 제약바이오산업에서 스타트업이 출원한 특허와 특허 기술에 대한 모방가능성과 벤처캐피털로부터 받은 1차 펀딩 금액과의 관계를 연구하였다. 미국을 기반으로 1995년에서 2005년 사이 설립된 157개의 제약바이오 스타트업들의 데이터를 실증 분석하였다. 본 연구의 결과는 특허출원수가 많을수록 벤처캐피털로부터 받은 1차 펀딩 금액이 컸으며, 특허기술의 모방가능성이 높을수록 벤처캐피털로부터 받은 1차 펀딩 금액이 적었다. 특허출원수와 특허기술의 모방가능성의 상호작용 효과는 기대했던 것과는 달리 모방가능성이 높을수록 특허출원수와 벤처캐피털로부터 받은 1차 펀딩 금액의 긍정적인 관계를 더욱 강화하는 것으로 나타났다. 본 연구의 실증분석 결과에 의하면, 미국 제약바이오 섹터에 투자하는 벤처캐피털리스트들은 펀딩의 수준을 결정함에 있어서 스타트업이 보유한 특허의 양과 질을 동시에 고려하는 것으로 보인다. 특히, 출원 특허의 모방가능성은 회사의 발명에 대한 보호가능성을 낮추는 부정적인 측면만을 포함하는 단순한 개념이 아닌 것으로 나타났다. 오히려, 특허의 모방가능성은 스타트업의 특허가 다른 회사들에게도 매력적이라는 긍정적인 측면도 동시에 포함할 수 있다. 또한, 출원 특허의 수는 모방가능성의 긍정적인 측면을 더욱 강화하는 역할을 하는 것으로 나타났다.

핵심주제어: 스타트업, 벤처 캐피털 펀딩, 특허수, 특허 모방성, 생명공학

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