Lenders' selection capabilities, patent quality and the outcome of patent backed loans

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**Abstract**
In this paper we investigate the phenomenon of patent collateralization by empirically focusing on the factors that affect the outcome of the collateralization process. In particular, we want to examine to what extent patent quality, lenders' characteristics, as well as lenders' selection capabilities (i.e. in identifying high quality patents) affect the likelihood of observing a security interest release. We identify the patents recorded in security agreements and their release from the USPTO Patent Assignment database. The final dataset is made up of a total of 8,818 security interest agreement records, involving 133,110 patents pledged as collateral for debt between 2007 and 2010. We find evidence that a security interest is more likely to be released for patents with a higher technical merit and when the lenders are more experienced and are specialty finance companies. When considering other types of lenders (i.e. banks in particular) or less experienced lenders, the positive association between the security interest release and the technical merit of the pledged patent is lower. The evidence suggests that IP-backed loans represent an effective financial channel for those firms that control valuable intangible assets and that experience and specialization allow lenders to develop better selection capabilities.

**Keywords**: patents as collateral, security interest release, lenders, screening

## 1. Introduction

For many companies, patents represent their most valuable assets. Patent rights, besides representing a tool to exclude others from using the underlying invention, can also be employed for monetarization purposes, through their transfer, sale, licensing and pledging (Caviggioli and Ughetto, 2013; Odasso and Ughetto, 2011). One way of exploiting patent rights that has become increasingly popular in the US is to use patents to secure financing in lending agreements.

Recent data from the United States Patent and Trademark Office (USPTO) have indicated a significant growth in the recorded number of patents pledged as collateral to secure financial transactions, with more than 60,000 patents per year and a peak of roughly 90,000 in the year 2013. Likewise, if we look at the number of patents with a security interest as a share of patents-in-force, this fraction has increased largely over the past three decades, and has fluctuated between 1.5 percent and 2.5 percent since 2000 (Marco et al., 2015). A number of recent studies (Hochberg et al., 2018; Loumioti, 2012; Mann, 2018) have confirmed these trends. Interestingly,

pledging patents as collateral is not limited to start-ups or small firms that lack physical assets to secure their debts (Hochberg et al., 2018), but is frequently also employed by corporations. Mann (2018) reported that 16% of the patents produced by US corporations in 2013 were pledged as collateral at some point, and that such companies cluster in those high-tech industry categories that account for 20% of aggregate R&D.

In this paper, we investigate the phenomenon of patent collateralization by empirically focusing on the factors that affect the outcome of the collateralization process. In particular, we want to examine to what extent patent quality, lenders' characteristics, as well as lenders' selection capabilities (i.e. in identifying high quality patents) affect the likelihood of observing a security interest release. A security interest release issued by a lender indicates that the existing loan agreement has terminated and that the collateral is returned to the original owner, thus pointing to a positive outcome of the deal.

In this regard, we complement the few previous studies that have analyzed the characteristics of pledged patents by comparing them with control samples of similar patents that have not been used as collateral in debt transactions (Fischer and Ringler, 2014). Despite the non-negligible use of security interests on patents in the US, there is still very limited evidence about this phenomenon, especially as far as the effectiveness of the collateralization mechanism and the characteristics of the lenders involved are concerned. To the best of our knowledge, there is no systematic evidence about the factors that affect the outcome of a patent backed credit facility.

In the present work, we address this important gap in the literature and add to the extant evidence in two ways. First, we apply a novel method to make use of particular information from the USPTO Patent Assignment database and identify those agreements in which the security interest in pledged patents is released. The final dataset is made up of a total of 8,818 security interest agreement records, in which 133,110 patents are pledged as collateral for debt. Second, we dive deeper into the determinants of a security interest release, by exploring the role of patent quality, lenders' experience, lenders' typology and their interplay in affecting the likelihood that the patent collateral is returned to the borrower. We test the assumption that the experience accumulated through repeated patent backed loan agreements, as well as specialization, allow lenders to develop better selection capabilities to discern more frequently the borrowers able to repay their debt.

Our results suggest that a security interest in a patent is more likely to be released for granted and younger patents, when the firms that pledge patents as collateral are larger, and when the lenders are more experienced and are specialty finance companies. Interestingly, we also find that - *ceteris paribus* - patents with a higher technical merit have a significantly higher likelihood of being released. This might reflect the fact that IP-backed loans represent an effective financial channel for those firms that control more valuable intangible assets. We also find that when the lender's experience is high and when the lender is a specialty finance company, the more valuable is the patented technology, the higher is the probability that the security interest in the patent is released. When considering other types of lenders (i.e. banks in particular) or less experienced lenders, the positive association between the security interest release and the technical merit of the pledged patent is lower.

The remainder of this paper is organized as follows. Section 2 illustrates the practice of using patents as collateral. Section 3 presents the background literature. Section 4 illustrates the set of hypotheses. Section 5 describes the dataset, the descriptive statistics and the empirical results. The conclusions are drawn in Section 6.

## 2. The practice of using patents as collateral

In typical lender-borrower agreements, lenders require that their loans are secured by physical assets (e.g. a property) in order to reduce the expected losses as a result of default (Besanko and Thakor, 1987; Inderst and Mueller, 2007). In the case in which a debtor fails to make a promised payment or defaults, the lender can liquidate the collateral and can, at least partially, recover the loan. Collateralization provides both a direct and an indirect advantage to lenders. The direct advantage is that secured lenders have priority against unsecured or second-lien creditors over pledged assets (De Rassenfosse and Fischer, 2016). The indirect advantage is that the collateral also serves to alleviate borrowers' adverse selection behaviors though an alignment of their incentives with those of lenders (Aghion and Bolton, 1992; Bester, 1987; Johnson and Stulz, 1985).

In agreements in which patents are pledged as collateral, the lender secures the payment on a loan by taking an interest in the patent. Moreover, the lender is given preferential rights in the disposition of the patent in the case of default of the borrower. The legal ownership of the patent continues to be held by the original owner, unless the borrower defaults. When the agreement terminates, the rights on the collateral are returned to the original owner by means of the issuance of a security release by the lender (Marco et al., 2015).

In order to assure priority over subsequent third-party claims to the collateral, creditors must "perfect" the security interest in the debtor's collateral by filing a record at the state level. In all fifty US states, the perfection of a security interest (but also in intellectual property) is governed by article 9 of the Uniform Commercial Code (UCC). At the federal level, there is no current requirement to perfect the security interest at USPTO, although the Federal Circuit advises that doing so might protect the creditor against a later bona fide purchaser (i.e. a third party purchasing the patent and claiming ignorance of the security interest) or a subsequent collateralization. Thus, recording a security interest with USPTO is still considered the best way to obtain the highest level of legal protection (Ibrahim, 2010; Mann, 1997; Marco et al., 2015; Murphy, 2002).[1]

The expansion of this credit practice has been associated with a period of credit expansion and laxer credit standards, and has been favored by the increasing dominant role of unregulated lenders on the credit market (Ivashina and Sun, 2011). Without having to comply with strict regulatory capital requirements as commercial banks have to, these financial intermediaries have been more open to lending to risky borrowers by leveraging on their intangible assets (Loumioti, 2012). Moreover, the practice of using patents as collateral has stimulated the activity of several intellectual property (IP) right intermediaries that perform financial evaluations of patent portfolios (e.g. Ocean Tomo and Patent Ratings, M-CAM, PLX, etc.).

## 3. Background literature

In this section, we discuss the literature that has examined the use of collateral assets as a mechanism to reduce information asymmetries in borrower-lender relationships, with a specific focus on patents pledged as collateral.

### 3.1. Secured lending

An extensive theoretical and empirical literature has investigated the role of collateral assets in the borrower-lender relationship context, and different theoretical predictions and empirical results have emerged. The models based on adverse selection and asymmetric information arguments have postulated that lower risk, high-quality

[1] The law on perfecting security interests in a patent is still not settled. This ambiguity goes back to the "Cybernetic Services Inc. v. Matsco Inc. 252 F.3d 1039 (9th Cir. 2001)" sentence of 2001 made by the Court of Appeals for the Ninth Circuit (the federal appeals court in California). Cybernetic Services Inc. granted Matsco Inc. and Matsco Financial Corp a security interest in all of its assets, including intangibles. Matsco perfected the security interest under the UCC in California without registering at USPTO. The court ruled that Matsco had effectively perfected a security interest, even though they had not registered it with USPTO.

firms tend to secure their debt as a signaling device to differentiate them from low quality ones (Bester, 1985; Besanko and Thakor, 1987; Chan and Thakor, 1987), and are therefore offered lower interest rates on loans. Evidence that loans secured by collateral exhibit lower credit spreads was provided by Benmelech and Bergman (2009). On the other hand, theories based on moral hazard predict that high risk borrowers are those that are required to pledge collateral when raising capital (Berger and Udell, 1990; Boot et al., 1991). In line with this second stream of literature, empirical evidence has found that loans with collateral are on average riskier and are applied higher credit spreads (e.g. Berger and Udell, 1990; 1995; Jimenez et al., 2006; John et al., 2003).

Posting collateral is often seen as a mechanism that can be used to alleviate such informational frictions. On the one hand, lenders have the legal right when the borrower fails to repay the loan, to seize and sell the collateral in order to partially recover losses. In addition, the lender enjoys priority over the pledged asset against other claimants. Lenders generally have expectations over the "liquidation" value of the collateralized asset (Shleifer and Vishny, 1992), which is a function of both the trading conditions on the secondary market for the collateral (i.e. the number of potential buyers and associated search costs) and its firm-specificity (Hochberg et al., 2018). Such expectations in turn influence the lending behavior of financial intermediaries (Benmelech and Bergman, 2009; Gavazza, 2011). On the other hand, it has been pointed out that the presence of collateral also contributes to better aligning borrowers' incentives with those of lenders (Aghion and Bolton, 1992; Bester, 1987; Johnson and Stulz, 1985). The overall theoretical analyses on the use of collateral and the conditions necessary for access to the credit market leads to different possible interpretations. In this work, we do not have information on the actual lending conditions of the IP backed transactions. However, it is necessary to take into consideration that patents constitute an asset class that is characterized by higher asymmetric information on the actual fair market value than other assets (including intangibles such as brands), and they are often very firm-specific with a limited secondary market. These aspects would be in favor of the signaling hypothesis.

## 3.2. Patents as collateral

Financial frictions between lenders and debtors become even more problematic for innovative firms, due to higher risk and pronounced information asymmetries, which can limit access to debt (Leland and Pyle, 1977; Stiglitz and Weiss, 1981). Patents can serve as collateral to help resource-constrained innovative firms to access debt financing. Using IP assets to secure financing has been adopted ever since the late 1800s, when Thomas

Edison pledged his patent on the incandescent electric light bulb as collateral to secure a bank debt. The potential of using patents as collateral is huge, given that many firms do not take advantage of their patents in this way (Jacobs, 2011). In recent years, the US market has witnessed a non-trivial growth in the number of collateralized patents (Hochberg et al., 2018; Loumioti, 2012; Mann, 2018; Marco et al., 2015)[2]. Patent-backed loans characterize not only resource-restricted innovative ventures (that generally lack physical collateral to secure their debt), but also more mature innovative firms that are willing to increase their availability of external funds to sustain their growth (Mann, 2018). Companies can pledge either a sub-set of patents from their patent portfolios or even their entire patent portfolio.

Patent collateralization is a challenging procedure for lenders, and it is not exempt of potential risks. One of the greatest risks connected to using patents as collateral is that they are hard to value ex-ante because of the difficulty involved in predicting their future cash flows, unless the patents have already been licensed with positive returns at the time of the collateralization. Moreover, their path to commercialization, as well as their market acceptance, is a risky process (Hochberg et al., 2018). The liquidation value of a patent depends on the value of the underlying technology, its redeployability to alternative uses or users, and its legal robustness (Fischer and Ringler, 2014; Gavazza, 2011; Hochberg et al., 2018; Shleifer and Vishny, 1992). Hence, many investors prefer to take a security interest in patents that yield constant licensing royalties, in order to ensure that a revenue stream is provided to eventually repay the loan. Other risks that are also transferred to the lender are those of ownership challenges and infringement (Jacobs, 2011). Lenders also have to take into account that the efficiency and liquidity of the market for technologies is not comparable with that of the financial market. The uncertainty on the secondary market is higher for the former, with limited redeployability in case the lender takes on the ownership of the patent pledged as collateral.

Despite these legal and market challenges, it has been reported that lenders are willing to consider the salvage value of patents in lending decisions (Hochberg et al., 2018; Ibrahim, 2010; Mann, 1997), although collateralized patents do not substitute the provision of tangible assets (De Rassenfosse and Fischer, 2016). In general, firms

[2] The potential effect of patent-backed loans on aggregate innovation growth in the US has been estimated to be large for two main reasons. First, there is a huge stock of untapped patents held by innovative firms. Second, the shareholders of public firms may have incentives to use collateralized debt instead of new share issues to avoid a dilution of capital and to exploit the leverage multiplier effect on their return on equity (Amable et al., 2010).

with valuable patents are better able to access finance and to raise more credit (Chava et al., 2017; Hottenrott et al., 2016; Farre-Mensa et al., 2016).

However, the literature on patents as collateral is still limited, due to the lack of reliable data on loan agreements and on the parties involved, as well as the difficulty of quantifying secondary-market patent activity. Most of the contributions have therefore been provided by legal scholars (Ibrahim, 2010; Mann, 1997). To the best of our knowledge, just three studies have exploited the USPTO Patent Assignment dataset to study patents as collateral (Fischer and Ringler, 2014; Hochberg et al., 2018; Mann, 2018). Hochberg et al. (2018) analyzed the use of loans to finance technology start-ups. They showed that among the 1,519 startups with patents in their sample, 36% had received venture debt by 2008 or prior to exit. They found that venture lending is stimulated by intensified trading on the secondary patent market, in particular for startups with more redeployable (less firm-specific) patent assets. Fischer and Ringler (2014) explored which components of patents matter in collateralization decisions. They analyzed a random sample of 837 security agreements between 2000 and 2006, corresponding to 13.085 collateralized patents. The authors found that lenders only collateralize those patents that are characterized by an underlying high-quality technology that can easily be redeployed in the case of default. They did not find that the patent's exclusion right per se mattered in lending decisions. Mann (2016) analyzed the characteristics of pledged patents and found that they score highly on citation count, originality and generality. His study also revealed that when creditor rights to patents become stronger, patenting companies raise more debt and spend more on R&D.

## 4. Hypotheses development

Information asymmetries affect the price and non-price terms of loans (e.g. credit availability, amount, spread), so that in poor information environments lenders typically charge harsher credit conditions (Francis et al., 2012). The uncertain, idiosyncratic and intangible nature of research and innovation activities creates wide information gaps that constitute relevant obstacles to the financing of innovative firms (Carpenter and Petersen, 2002; Leland and Pyle, 1977; Lev, 2000; Ughetto, 2008a). Prior literature has outlined that patents may constitute an effective tool to reduce information ambiguity about firms' R&D projects, since they provide a codified information about the content and nature of the underlying invention (Heeley et al., 2007; Hussinger and Pacher, 2019; Long, 2002). Innovation disclosure through patents provides a credible signal about firms' technological

progress (Bhattacharya and Ritter, 1983) that in turn can affect financing choices and loan negotiations (Chava et al., 2017). Pledging patents as collateral allows to mitigate information asymmetry problems and to ease, to a certain extent, credit constraints for innovative firms.

However, it is well known that the quality distribution of patents is highly skewed, and only a small percentage of patents are truly valuable (Harhoff et al., 1999; Scherer and Harhoff, 2000). As a consequence, it is not easy for uninformed lenders to determine the value and prospects of a technology underling a patent pledged as collateral. Knowledge about the quality of the patent can yield important information not only about the technical merit and effectiveness of the technology, but also on the ability of the firm itself to capture value from its innovation and ultimately to generate cashflows and payback the loan. We build on the idea that high quality patents represent a credible signal for the quality of otherwise hard-to-observe innovation (Bhattacharya and Ritter 1983; Francis et al., 2012; Hsu and Ziedonis, 2013; Hussinger and Pacher, 2019; Saidi and Žaldokas, 2018). Firms pledging high quality patents are more likely to have future competitive advantages and this will in turn lead to superior financial stability and decreased default risk (Hsu et al., 2015). Prior studies have reported that firms owning higher quality patents are associated with less volatile earnings (Pandit et al., 2011), a lower risk of default (Eisdorfer and Hsu, 2011; Hsu et al., 2015) and thus they can enjoy a lower cost of debt and better non-price loan terms (Francis et al., 2012). Consistent with this reasoning, we posit that a security interest in the patent is more likely to be released (i.e. indicating a positive outcome of the patent backed-loan) when the patent covers a more valuable technology. Accordingly, we set our first hypothesis as follows:

*H1. The more valuable is the patented technology, the higher is the probability that the security interest in the patent is released*

Lenders learn about borrowers through screening activities (Allen, 1990). Screening practices allow to identify those patent owners that are presumably able to successfully exploit the proprietary technology. The screening process involves the capability to assess both the technological and the business dimensions that are strictly intertwined in the process of value generation from innovation. This assessment can be a difficult and costly task that is expected to benefit from accumulated experience. Superior information accumulated through experience represents a competitive advantage for lenders that have to evaluate the benefits and risks of the patented technology and the financial prospects of the innovative firm asking for a loan. Indeed, Chen at al. (2016) report

that banks with innovation-lending expertise can benefit from lending to firms competing in innovation-driven markets, by lowering default risk.

We argue that, as long as lenders gather experience in dealing with patent-backed loans, they are better able to select those borrowers leading to increased chances that the deal will turn into a positive outcome. This line of argument leads to our second hypothesis:

*H2. The greater is the lender's experience, the higher is the probability that the security interest in the patent is released.*

An in-depth evaluation of the benefits and risks of innovation requires sophisticated knowledge, which is often not available across all types of lenders. Banks are typically more concerned, compared to other lenders, about borrower default risk rather than the upside potential of innovative activities. Moreover, they are not yet endowed with adequate instruments and skills to evaluate innovation related projects, even though beginning with the introduction of Basel II, they are increasingly encouraged to incorporate in their rating systems intangible information (Scellato and Ughetto, 2010; Ughetto, 2008b). On the contrary, specialized lenders acting as "financial boutiques" rather than traditional financial intermediaries, base their business on the offer of unique credit lines to innovative firms. Specialty finance companies have knowledge in areas such as IPR evaluation, trading and IP regimes, which on the contrary proves costly for banks, whose business model hardly fits with an assessment of the innovation potential of a firm. Specialization can enhance the acquisition of specific information in the area, in turn lowering loan default risk (Chava et al., 2017; Chen et al., 2016). Our third hypothesis can thus be formulated with a twofold perspective:

*H3a. The security interest in the patent is less likely to be released when the lender is a bank, with respect to the other types of lenders.*

*H3b. The security interest in the patent is more likely to be released when the lender is a specialty finance company, with respect to the other types of lenders.*

The success in the lenders' screening capability is connected to the identification of the technical merit of the pledged intangible assets and to the capacity of the firm to commercially exploit that technology. Lenders that have accumulated a long-lasting experience in dealing with patent backed loans have an advantage in learning about innovation and they are able to estimate the technical merit and a borrowers' innovation potential more accurately than others. At the same time, specialty finance companies are endowed of higher selection capabilities

than other types of lenders. As a consequence, we argue that experienced and specialty finance lenders are better able to evaluate the potential value of a technology, this in turn leading to achieve a better performance in the loan market. The hypotheses that we have so far formulated suggest the presence of some interplay between the variables at stake: the technological merit of the patent that has been pledged as collateral in the loan transaction and the experience/specialization of the lender. Since the lender's screening success relates to both the lender's characteristics (i.e. experience and specialization) and the technological merit of the pledged asset (which drives the potential financial performance of the borrower), we expect that:

*H4. All else being equal, the correlation between the lender's selection capability (i.e. the release of pledged patents) and the technical merit of the pledged patents is stronger when the lender is a specialty finance company (or it is weaker when the lender is a bank);*

*H5. Irrespective of the nature of the lender, the correlation between the selection capability (i.e. the release of pledged patents) and the technical merit of the pledged patents is stronger when the lender has accumulated experience in this type of transactions.*

# 5. Dataset and empirical results

## 5.1. Collection of data on collateralized patents

Information on lending contracts in which patents are used as collateral is often not disclosed, especially when borrowers are non-listed companies. However, an indirect way of examining the phenomenon is to look at the recording of the security interest at USPTO. In order to collect the data used in this paper, we have exploited the USPTO Patent Assignment database[3] and extracted the patents that had been pledged as collateral in security interest agreements over the 2007-2010 period. We have concentrated on this time span in order to gauge the effects of the global financial crisis on the likelihood of a security interest being released, and we have looked at how these effects vary according to the firm size and type of lender.

Beginning from Serrano (2010), the USPTO Patent Assignment database has increasingly been exploited by scholars to study the dynamics of the markets for technology (Caviggioli et al., 2017; De Marco et al., 2017; Drivas

[3] The USPTO Patent Assignment Dataset contains detailed information on 6.8 million patent assignments and other transactions recorded at USPTO since 1970 pertaining to roughly 11.1 million patents and patent applications. Further information is available at the official webpage (https://www.uspto.gov/learning-and-resources/electronic-data-products/patent-assignment-dataset). Even though there is no legal requirement to record changes in ownership with USPTO, it is common practice, due to the enhanced protection it offers the owners, in the case of litigation (Section 261 of the U.S. Patent Act). See also De Marco et al. (2017) and Serrano (2010) for details about the data management of patent transactions.

and Economidou, 2015; Figueroa and Serrano, 2013; Galasso et al., 2013; Serrano, 2013), while it has only been used marginally to investigate the issue of patent collateralization (Fisher and Ringler, 2014; Hochberg et al., 2018). A thorough analysis of the available data was provided by Marco et al. (2015). The dataset includes a specific field, "conveyance type", which identifies the nature of the assignment. Among the different conveyance types, the "security interest agreement" type describes agreements in which patents are assigned to a third party and are used as collateral against financial debt. The "release" conveyance type indicates when an existing agreement between parties terminates, and it entails the secured party releasing its dominion over the collateralized patent.

We extracted all the patents that reported the "security interest agreement" conveyance type, registered in the 2007-2010 period, from the original dataset. We decided to focus on the 2007-2010 time-frame for two main reasons: first, the selected time span allows us to obtain data that are sufficiently representative of the population of collateralized patents, and to employ both automated and manual procedures to clean the patent assignment records (in fact, in the analysis of the names of the involved patent owners, the application of automated algorithms on a coherent subset of data further limits the deviations in the "name game" and allows for manual control of the data). Second, that period includes the years before and after the 2008 financial crisis, which provides us with an exogenous shock to test our models. The problem of firm financing was in fact exacerbated during the peak period of the global financial crisis, following the collapse of Lehman Brothers in 2008[4]. In principle, the market value of IP assets, such as patents, should not be affected by a financial crisis. However, it is possible that banks and other intermediaries perceived that the legal risks connected to using patents as collateral (e.g. ownership challenge and infringement) were heightened in those times (Jacobs, 2011). This may be true, especially considering that such IP-backed credit practices emerged in a period of allegedly excessive credit expansion and laxer credit standards (Loumioti, 2012).

We collected the date the agreement was recorded (recorded date) for each record, the date of the transaction (execution date), the date of the release and the two entities involved: the lender (or patent assignee), usually a financial institution, and the borrower (or patent assignor), that is, the firm that originally owned the patent rights to the invention. We then associated bibliometric indicators (i.e. forward citations, backward citations, IPC codes),

[4] A fall in the prices of most asset classes, a sharp rise in financial volatility and a dramatic shift to safety among lenders, were recorded during that period, and this resulted in a rise in the cost of corporate borrowing and a reduced availability of capital (Ivashina and Scharfstein, 2010).

retrieved from Thomson Innovation, to each patent application and granted patent. We also identified whether the patent had expired and the corresponding date, by examining the data from the USPTO Patent Examination Research Dataset[5], which contains information about the legal status of patents, and match them to our sample.

A total of 163,689 patents recorded in 10,145 agreements were extracted. We then performed a data cleaning process aimed at checking for any inconsistencies and standardizing the text fields. We cleaned the borrower and lender names for each pledge of patents used as collateral for a loan. We dropped a set of cases considered irrelevant for the purposes of this study, including collateralized patents that reported the United States Department of the Treasury as being the entity perfecting the security interest[6]. We also excluded records in which the first release date fell into the first six months after the date of the security agreement. In addition to dropping design and plant variety patents, we also eliminated another 3,482 patents which had expired before the execution date of the security interest (it should be noted that the execution date is different from the recording date, and it can have a retroactive effect).

After this cleaning process, we ended up with a total of 8,763 security interest agreement records in which 133,110 patents were pledged as collateral for debt. Such patents can be associated with a release of security interest between 2007 and 2015. Out of these 133,110 patents, 94,380 (70.9%) had been released[7] and 7.7% had expired, according to the legal status at the date of the data collection. It is important to note that the incidence of released collateralized patents could be underestimated for two main reasons: i) a censorship effect, especially on recent agreements, and ii) the fact that it is not compulsory to record the termination of the security interest agreement in the USPTO filings[8]. In the econometric analysis, we apply survival models that are meant to address the former issue, i.e. the downward bias due to censoring of more recent security agreements. A few examples of US patents that had been pledged as collateral and then released (or not released), and the corresponding financial

[5] Available at https://www.uspto.gov/learning-and-resources/electronic-data-products/patent-examination-research-dataset-public-pair (last access June 2017).

[6] This process led to the exclusion, for example, of around 8,800 observations inherent to the collateralization of patents belonging to General Motors following a large "bail-out" by the US government.

[7] The final dataset also included around 6,600 patents that had been released more than 20 years after the filing date. In the subsequent analyses, we tested the econometric models by both including and excluding this set of observations, and very similar results were obtained.

[8] We would like to thank Andrew A. Toole for this important suggestion. As a USPTO report shows, the lack of a release record could possibly indicate that the lien on the patent is still outstanding, that the creditor no longer exists or simply that the termination was not recorded at USPTO (Marco et al., 2015). However, we believe that such a possible misreporting issue is not correlated to our variables of interest (e.g. the timing of the collateralization, the number of forward citations of the collateralized patents, etc.) and hence it should not generate biases in our estimates.

intermediaries are reported in the Appendix (Table 7), in order to better clarify the characteristics of the data on security interest agreements that are used in the paper.

## 5.2. Descriptive statistics

A by sector breakdown of the patent collateralization cases is provided in Table 1, where the concordance patent classification of the World Intellectual Property Organization (WIPO) is employed. The fields with the largest number of collateralized patents are Computer technology (18,775 patents, 14.1%), Telecommunications (10,786 patents, 8.1%) and Medical technology (10,212 patents, 7.7%). This evidence confirms the primary role played by Computers & Communications patents in driving much of the growth in the recorded patent collateralization, as reported by USPTO (Marco et al., 2015). The fields with the highest ratio of released patents on collaterals are instead: Audio-visual technology (5,635 patents, 84%) and Basic communication processes (2,410, patents, 76%). The lowest shares of released patents are those of Pharmaceuticals (2,561 patents, 61%), IT methods for management (1,421 patents, 53%) and Thermal processes and apparatus (840 patents, 51%).

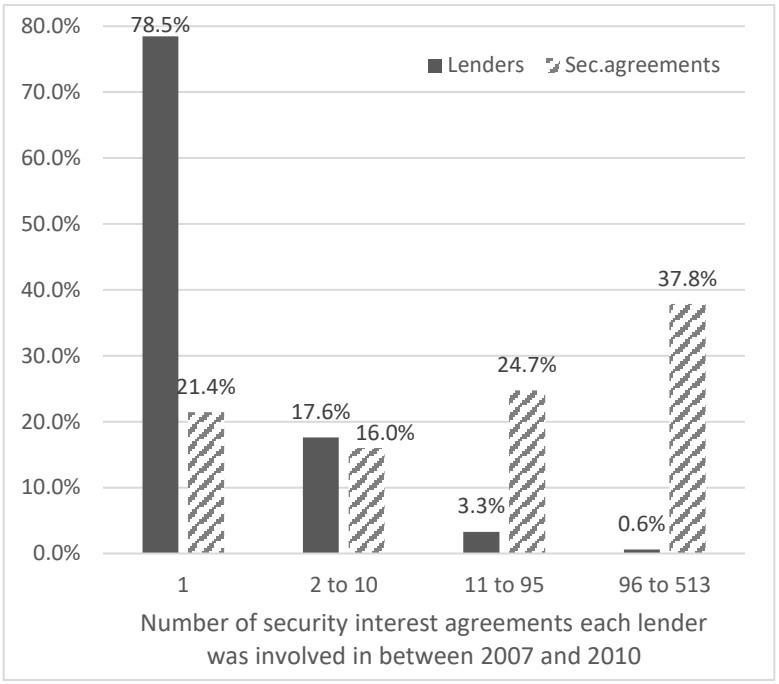
*Table 1 Number of patents observed in the selected security agreements broken down by technological field, according to the WIPO Concordance Table based on IPC codes. The fields are sorted on the basis of the share of released patents.*

| Field (WIPO Concordance Table) | Sector (WIPO Concordance Table) | Collateralized patents (number) | Percentage of released patents |
|---|---|---|---|
| Audio-visual technology | Electrical engineering | 6676 | 84% |
| Micro-structural and nano-technology | Chemistry | 51 | 84% |
| Semiconductors | Electrical engineering | 6297 | 76% |
| Basic communication processes | Electrical engineering | 3178 | 76% |
| Organic fine chemistry | Chemistry | 4102 | 75% |
| Computer technology | Electrical engineering | 18775 | 74% |
| Optics | Instruments | 3475 | 72% |
| Textile and paper machines | Mechanical engineering | 2804 | 72% |
| Environmental technology | Chemistry | 1256 | 72% |
| Transport | Mechanical engineering | 6683 | 71% |
| Machine tools | Mechanical engineering | 3147 | 71% |
| Measurement | Instruments | 7113 | 70% |
| Macromolecular chemistry, polymers | Chemistry | 5328 | 70% |
| Chemical engineering | Chemistry | 4467 | 70% |
| Engines, pumps, turbines | Mechanical engineering | 3026 | 70% |
| Medical technology | Instruments | 10212 | 69% |
| Handling | Mechanical engineering | 5218 | 69% |
| Other special machines | Mechanical engineering | 4794 | 68% |
| Furniture, games | Other fields | 4505 | 68% |
| Biotechnology | Chemistry | 3310 | 68% |
| Surface technology, coating | Chemistry | 5303 | 66% |
| Mechanical elements | Mechanical engineering | 5165 | 66% |
| Basic materials - chemistry | Chemistry | 2767 | 66% |
| Other consumer goods | Other fields | 2379 | 66% |
| Civil engineering | Other fields | 3148 | 65% |
| Food chemistry | Chemistry | 888 | 65% |
| Digital communication | Electrical engineering | 4943 | 64% |
| Telecommunications | Electrical engineering | 10786 | 63% |
| Electrical machinery, apparatus, energy | Electrical engineering | 8391 | 63% |
| Materials, metallurgy | Chemistry | 1763 | 63% |
| Control | Instruments | 3597 | 62% |
| Pharmaceuticals | Chemistry | 4213 | 61% |
| IT methods for management | Electrical engineering | 2676 | 53% |
| Thermal processes and apparatus | Mechanical engineering | 1632 | 51% |

In terms of number of signed security agreements, the market appears to be quite concentrated, with the first 15 financial intermediaries accounting for more than one third of all the observed transactions. The concentration is represented in Figure 1: the top 15 intermediaries, in terms of number of security agreements, represent 0.5%

of all the lenders in the sample, and they account for 37.8% of the identified agreements; on the other hand, there are 1,879 entities (78.5% of the total) that appear in only one transaction. Table 2 provides further details about the distribution of lenders across the sample. The first six entities that perfect the greatest number of security interests in debtor's collateral are from the US. Among the non-US entities, the most relevant are two financial institutions, Credit Suisse and Deutsche Bank, and the German company Basf.

*Figure 1 Distribution of lenders (gray bars) on the basis of the number of security agreements they have been involved in; total share of security agreements associated with those lenders (light gray bars with line motif).*




Note: They grey bars show the percentage of lenders involved in each of the four ranges of security agreements; for example, the top 15 intermediaries, each of which has been involved in more than 95 agreements and represents 0.6% of the different lenders, have a combined share of security agreements of 37.8% of the whole sample; at the opposite end, 78.5% of the identified lenders were each only involved in one agreement, and their combined number of agreements represents 21.4% of the sample (2007 – 2010).

*Table 2 Top 15 financial intermediaries involved in the security interest agreements of US patents and residual groups (years 2007-2010)*

| Rank | Financial intermediary | Country | Security agreements (count) | Percent (%) | Cumulated percent (%) | Collateralized patents (count) |
|---|---|---|---|---|---|---|
| 1 | BANK OF AMERICA | US | 513 | 5.9% | 5.9% | 14,851 |
| 2 | JPMORGAN CHASE | US | 489 | 5.6% | 11.4% | 17,848 |
| 3 | SILICON VALLEY BANK | US | 418 | 4.8% | 16.2% | 4,697 |
| 4 | WELLS FARGO | US | 371 | 4.2% | 20.4% | 5,649 |
| 5 | GENERAL ELECTRIC (Financial Service Subsidiaries) | US | 260 | 3.0% | 23.4% | 3,283 |
| 6 | COMERICA BANK | US | 175 | 2.0% | 25.4% | 1,563 |
| 7 | CREDIT SUISSE | CH | 158 | 1.8% | 27.2% | 5,630 |
| 8 | WACHOVIA BANK | US | 148 | 1.7% | 28.9% | 2,074 |
| 9 | BASF SE | DE | 139 | 1.6% | 30.5% | 148 |
| 10 | PNC BANK | US | 123 | 1.4% | 31.9% | 1,219 |
| 11 | VENTURE LENDING & LEASING | US | 118 | 1.3% | 33.2% | 1,062 |
| 12 | DEUTSCHE BANK | DE | 106 | 1.2% | 34.4% | 4,813 |
| 13 | SQUARE 1 BANK | US | 103 | 1.2% | 35.6% | 637 |
| 14 | CITIGROUP | US | 99 | 1.1% | 36.7% | 16,576 |
| 15 | U.S. BANCORP | US | 96 | 1.1% | 37.8% | 1,834 |
| 16 – 94 | Financial intermediaries, each involved in fewer than 96 and more than 10 agreements (79 entities) | | 2,167 | 24.7% | 62.6% | 28,691 |
| 75 - 518 | Other financial intermediaries, each involved in fewer than 11 and more than 1 agreement (424 entities) | | 1,401 | 16.0% | 78.6% | 9,992 |
| 499 – 2,397 | Other financial intermediaries, each involved in a security agreement only once (1879 entities) | | 1,879 | 21.4% | 100.0% | 12,543 |
| | Total sample | | 8,763 | 100.0% | | 133,110 |

The financial institutions that have been involved in agreements with a total of at least four patents have been classified into five categories: "Banks", "Specialty finance companies", "Venture lending", "Non-financial companies" and the residual group "Others"[9]. The classification was generated by manually retrieving information from official websites, reports and other public online sources. The collected data include a long tail of institutions involved in a few security agreements. For this reason, we opted to classify the entities on the basis of the frequency in the database in order to reach a minimum threshold. The process led to the classification of 218 intermediaries that accounted for more than 85% of the overall sample of collateralized patents. The top five entities in each category are reported in Table 8 of the Appendix according to number of recorded agreements.

[9] We have adopted a similar classification to the one used by Fischer and Ringler (2014).

Table 3 reports the distribution of the identified entities, in terms of collateralized patents, and the average number of patents per security interest agreement. The "Banks" category is the most frequently represented, when the collateralized patents in our sample are counted (84.6%), and the corresponding agreements are on average the largest, with more than 30 patents per transaction. The second most frequent type of intermediaries is the "Specialty finance companies" group (11.4% of patents), which also shows the second largest average size of transactions. The distribution in Fischer and Ringler (2014) showed a relatively lower incidence of banks than our sample, but their analysis referred to previous years and consisted of a sample of 837 security agreements, about one tenth of the dataset used in this study.

*Table 3 Distribution of the identified types of intermediaries and the mean size of agreement per category*

| Type of lender | Percentage of patents | Mean number of patents per agreement (size) |
|---|---|---|
| Banks | 84.6% | 32.16 |
| Specialty finance companies | 11.4% | 29.14 |
| Venture lending | 2.3% | 8.00 |
| Non-financial companies | 1.4% | 3.95 |
| Others | 0.3% | 7.85 |
| Total sample | 100.0% | 23.10 |

As previously mentioned, security interest agreements may involve single patents (21.4% of the examined transactions) or bundles of patents pledged jointly as collateral. This piece of information has been used as a proxy of the size of the borrowing firm and employed as a control variable in the regression analysis. We assume that if a significant number of patents are used as collateral to secure debt, the borrower is more likely to be a large firm. Instead, if collateral agreements are characterized by bundles of patents of smaller size, or even by a single patent, we assume that this is the typical case of small and medium enterprises (SMEs).

Most of the collateralized patents have been granted (85%). As far as the age of patents is concerned, the average number of years at the date of the security agreement from the date of filing is 6.9. We do not observe any significant contraction in the volumes of patents pledged as collateral for the period just after the beginning of the financial crisis. Table 4 reports the definition of the explanatory variables used in the empirical analysis and the related descriptive statistics. The corresponding correlation matrix is available in Table 9 in the Appendix. The explanatory variables include a set of standard patent bibliometric indicators that were derived from the

information contained in all the patent documents. The technical value of a patent is proxied by the number of forward citations, i.e. the citations received by subsequent patents (van Zeebroeck and van Pottelsberghe, 2011). The count of International Patent Classification (IPC) codes[10] measures the technological scope of a patent: the higher the number of technology classes associated with a patent, the wider the spectrum of potential fields of application (Caviggioli, 2016; Harhoff et al., 2003; Lerner, 1994). The number of backward citations to non-patent literature (i.e. to articles, books, proceedings, etc.) is used as a proxy of the link between basic scientific research and applied technological innovation (Caviggioli et al., 2016; Karvonen and Kässi, 2013).

*Table 4 List of explanatory variables used in the empirical analysis and descriptive statistics*

| Variable | Description | Mean | Median | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Technical merit (fwd cit) | Number of forward patent citations weighted by the age (in logarithm) | 0.781 | 0.635 | 0.658 | 0.000 | 5.245 |
| Dummy: Granted patent | Dummy equal to 1 if the patent had been granted before the transaction | 0.849 | 1.000 | 0.358 | 0.000 | 1.000 |
| Technological scope | Number of different IPC subclasses (in logarithm) | 0.177 | 0.000 | 0.366 | 0.000 | 2.565 |
| Backward non-patent cit. | Number of backward non-patent citations (in logarithm) | 0.752 | 0.000 | 1.147 | 0.000 | 7.946 |
| Patent age at transaction | Number of days between the filing and the security agreement date (in logarithm) | 7.306 | 7.596 | 1.164 | 0.000 | 8.945 |
| Transaction size | Number of patents pledged as collateral in the same transaction (in logarithm) | 4.779 | 4.762 | 2.103 | 0.000 | 8.651 |
| Lender's experience | Number of security agreements in which the lender was involved during the examined period (in logarithm) | 4.260 | 4.595 | 1.949 | 0.000 | 6.240 |

## 5.3. Empirical analysis

The factors that affect the time to release of the security interest agreements are investigated in our empirical analysis. In particular, the aim of the analysis is to examine whether the likelihood of observing a release, and hence a positive outcome of the patent backed loan, is associated with any specific features of the borrower's pledged technological asset (i.e. the quality and characteristics of the collateralized patent portfolio) and of the lender (i.e. the type and the experience in this kind of transactions).

In principle, the dynamics of security interest releases may only be examined after a sufficiently long period has passed since the collateralization event. The presence of a truncation effect might lead to an underestimation of the releases of patents that had been pledged as collateral in recent years. To address this issue, we have used

[10] IPC provides a structure that varies from a broad range of categories (sections and classes) to specific elements (subclasses, groups and full codes), which describes technological domains and particular subfields. Further details are available on the WIPO website (http://www.wipo.int/classifications/ipc/en/, last access in June, 2017).

parametric survival models in which the time lag between the transaction event and the date the collateralized patent was released (in days) is regressed against the variables pertaining to the characteristics of the pledged patents, the type of the lender and its experience in this kind of transactions, controlling for a set of time and technology field dummies.

*Table 5 Survival models on the determinants of the security interest release for a specific patent. Hazard rates reported.*

| VARIABLES | (1) model | (2) model | (3) model |
|---|---|---|---|
| Technical merit (fwd cit) | 1.076*** | 1.041*** | 1.041*** |
| | (0.006) | (0.006) | (0.006) |
| Dummy: Granted patent | 1.362*** | 1.306*** | 1.306*** |
| | (0.016) | (0.017) | (0.017) |
| Technological scope | 1.051*** | 1.083*** | 1.083*** |
| | (0.019) | (0.021) | (0.021) |
| Backward non-patent cit. | 1.001 | 1.011*** | 1.011*** |
| | (0.003) | (0.004) | (0.004) |
| Lender's Experience | | 1.129*** | 1.129*** |
| | | (0.004) | (0.004) |
| Dummy: Lender is a Bank | | 0.846** | 0.846** |
| | | (0.062) | (0.062) |
| Dummy: Lender is a Specialty finance company | | 1.633*** | 1.633*** |
| | | (0.120) | (0.120) |
| Dummy: Lender is a Non-financial company | | 0.520*** | 0.520*** |
| | | (0.044) | (0.044) |
| Dummy: Lender is a Venture debt provider | | 0.705*** | 0.705*** |
| | | (0.055) | (0.055) |
| Patent age at transaction | 0.937*** | 0.972*** | 0.972*** |
| | (0.003) | (0.003) | (0.003) |
| Transaction size | 1.191*** | 1.133*** | 1.133*** |
| | (0.002) | (0.002) | (0.002) |
| Dummy: Financial crisis | | | 1.165*** |
| | | | (0.019) |
| Dummies Tech fields | Y | Y | Y |
| Dummies: semesters | Y | Y | Y |
| Constant | 0.0001*** | 0.0001*** | 0.0001*** |
| | (0.000004) | (0.000004) | (0.00001) |
| Observations | 127,594 | 110,379 | 110,379 |
| Loglike | -171085 | -145254 | -145254 |
| Chi2 | 18314 | 19061 | 19061 |

Note: the results of the maximum likelihood estimation for parametric regression survival-time models with exponential distribution; a higher (lower) than one hazard rate represents a positive (negative) effect on the likelihood of observing a release of the security agreement. Omitted variable for the lender type "Others". Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10

The results of the survival models on the determinants of the likelihood of observing a release of a security interest, net the censoring effects, are reported in Table 5[11]. Model 1 includes a set of indicators on the characteristics of the collateralized patents and controls for patent age at the transaction date, the transaction size (also a proxy of the size of the borrower), time and technology field dummy variables. Patents that are more likely

[11] The model has been estimated with the "streg" routine of STATA 14.2. From the comparison of the results of the Akaike Information Criterion test, we opted to use an exponential distribution for the model.

to be released show the following characteristics: they are on average of higher technical merit (forward citations), legally robust (granted), and with a larger number of potential application fields. We find support to the hypothesis H1, namely that patents that receive more citations, and thus reflect a higher technological potential, are more likely to be associated with a release of their security interest. The release event is positively correlated also to the number of non-patent citations, proxy of science basicness, but the relation is not statistically significant. Controls on the age of the patent at the transaction date and transaction size (i.e. a proxy of firm size) are respectively negatively and positively associated to the likelihood of a security interest release. This last result is in line with the idea that large firms are typically lower risk borrowers, because of their corporate reputation, higher informational transparency, and longer track records.

Model 2 adds the variables that describe the main characteristics of the lender involved in each transaction. We find that the lender's experience (i.e. its involvement in several patent-backed transactions) is associated with a higher likelihood of release. This result is supporting our hypothesis H2. The "Banks" and "Specialty finance companies" types of lenders (the two largest groups in the sample) show a lower and higher probability of observing a release, respectively, compared to the "Others" residual type of intermediaries. We have tested the model with different comparison groups, in terms of types of intermediaries. The results have been found to be robust and show that the difference between "Banks" and "Specialty finance companies" is significant. This result is in line with our hypotheses H3a and H3b. In all model specifications we include year dummies to account for time trends. In order to verify the presence of a potential exogenous shock associated with the financial crisis, Model 3 introduces the financial crisis time dummy. On average, the probability of a patent being released is higher after the financial crisis. This might suggest a shift to safety among lenders adopting better screening practices and stricter selection criteria in the period following the financial crisis.

*Table 6 Survival models showing the hazard rates. Dependent variable: time to the security interest release for a specific patent. Models with variable splitting.*

| VARIABLES | (1) Model | (2) Model |
|---|---|---|
| Tech. merit x Dummy: Lender is a Spec. fin. comp.=1 | 1.452*** | |
| | (0.015) | |
| Tech. merit x Dummy: Lender is a Spec. fin. comp.=0 | 0.997 | |
| | (0.006) | |
| Lender's experience | 1.111*** | |
| | (0.004) | |
| Tech. merit x Dummy: Lender has high experience=1 | | 1.258*** |
| | | (0.009) |
| Tech. merit x Dummy: Lender has high experience=0 | | 0.943*** |
| | | (0.007) |
| Dummy: Lender is a Bank | | 1.016 |
| | | (0.074) |
| Dummy: Lender is a Specialty finance company | | 1.923*** |
| | | (0.142) |
| Dummy: Lender is a Non-financial company | | 0.586*** |
| | | (0.049) |
| Dummy: Lender is a Venture debt provider | | 0.842** |
| | | (0.066) |
| Dummy: Granted patent | 1.320*** | 1.300*** |
| | (0.017) | (0.017) |
| Technological scope | 1.082*** | 1.082*** |
| | (0.021) | (0.021) |
| Backward non-patent cit. | 1.006* | 1.014*** |
| | (0.004) | (0.004) |
| Patent age at transaction | 0.963*** | 0.976*** |
| | (0.003) | (0.003) |
| Transaction size | 1.140*** | 1.144*** |
| | (0.002) | (0.002) |
| Dummy: Financial crisis | 1.272*** | 1.217*** |
| | (0.021) | (0.020) |
| Dummies Tech fields | Y | Y |
| Dummies: Semesters | Y | Y |
| Constant | 0.0001*** | 0.0001*** |
| | (0.000003) | (0.000001) |
| Observations | 110,379 | 110,379 |
| Loglike | -146245 | -145263 |
| Chi2 | 17080 | 19043 |

Note: the results of the maximum likelihood estimation for parametric regression survival-time models with exponential distribution; a higher (lower) than one hazard rate represents a positive (negative) effect on the likelihood of observing a release of the security agreement. Omitted variable for the lender type: "Others". Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10

Table 6 shows the results of two model specifications in which we examine, *ceteris paribus*, the interplay between the technological merit of pledged patents and the lender's characteristics, in terms of type of lender (Model 1) and experience (Model 2), with respect to the probability of a security interest release. To this aim we employ a set of split variables. In Model 1 we split the variable "Technological merit" according to the type of lender "Specialty finance companies". The results indicate that the positive correlation between patent technical value and security interest release is much stronger when considering the sub-sample of "Specialty finance companies" with respect to the other types. As a robustness check, we have carried out the same analysis focusing on the type "Banks" and found consistent results. The evidence confirms hypothesis H4.

To further disentangle the effects of the technological quality of pledged assets and of the lender's characteristics, in Model 2 we split the effect of the technical merit by distinguishing lenders with a high level of experience (the dummy is equal to 0 when the lender's experience falls in the 75th percentile, 1 otherwise), and controlling for the different types of lenders. *Ceteris paribus*, the results show that the positive correlation between patents' technical value and the likelihood to observe a security interest release is much stronger when considering the most expert lenders, with respect to those previously involved in a lower number of transactions; for this latter group (those in the 75th percentile), the positive effect of technical quality vanishes (the hazard rate is slightly below 1.000). Results also suggest that when the lender's experience is low, the intermediary seems to be less able to identify "good borrowers", despite the technical value of pledged assets. The evidence provides support for H5.

Furthermore, Model 2 confirms that lenders which are more frequently associated to a patent release are of the type "Specialty finance companies", with respect to all the other groups.

As a robustness check, we controlled for the potential confounding effects of the presence of patents expired before the release date. All the models were tested by excluding the subsample of expired patents before the release or those already expired with no subsequent release at the date of the data collection. The results were found to hold and were very similar to those shown in the previous Tables.

# 6. Conclusion

This work has studied the practice of using patents as collateral for debt. We investigated what the determinants that affect the probability of a patent being released are, with specific focus on the role exerted by the technical value of the patent-protected technology and by lenders' characteristics (i.e. in terms of type of lenders and experience in patent backed security agreements). The evidence supports the discussion on the role of lenders and their ability to identify borrowers that would eventually fulfill their obligations.

Our results suggest that a security interest on a patent is more likely to be released for patents of higher technical merit and legally sound, younger and with a wider technological scope (i.e. redeployability). A key result of the paper is the positive and statistically robust association between a measure of technological merit of a patent and the likelihood of observing a security interest release. The count of received citations (forward citations) has been used to proxy the quality of the protected invention or technological process. Firms that own valuable

technological assets are more likely to avoid failure and re-obtain full control on the patents pledged as collateral in security agreements. The study provides empirical evidence for the claim that patent-backed loans represent an effective financial channel for those firms that control many valuable intangible assets (Jacobs, 2011; Mann, 2018).

Concerning the characteristics of lenders, "Specialty finance companies" and "Banks" are the most frequent types of involved intermediaries, with the former showing a higher ability to participate in deals ending with a release of pledged patents. This result might be due to a superior selection capability of solid borrowers. On the contrary, the negative correlation found for "Banks" might point in the opposite direction, namely to a lower selection capability, which might be associated to an inefficient regulation or to a lower ability in evaluating the potential of the pledged technological assets. The positive correlation between the lender's experience and the likelihood of a positive outcome of the collateralized loan suggests that lenders develop better selection capabilities when involved in several transactions. Lenders are able to improve their selection capabilities through iterated transactions which provide them with a better understanding of the financial and technological potential of borrowers. These results are robust when testing the interplay between lenders' characteristics and the technical merit of the technology protected by pledged patents. We highlight again that our measure of patent value is revealed ex-post, and not always a valuable invention can be easily identified ex-ante. The positive correlation with the technical quality of pledged assets is more pronounced when considering the most experienced lenders, and similarly when lenders are specialty finance companies. When lenders have limited experience or specialization (as in the case of banks), they seem less able to identify "good borrowers", despite the technical value of pledged assets.

Our study is not without limitations. First, we are not sure whether all the patents pledged as collateral in the analyzed period were recorded at USPTO, since this registration is not compulsory, as established by the sentence of the US Court of Appeals for the Ninth Circuit in 2001. Second, the incidence of released collateralized patents might have been underestimated, even after controlling for the censorship effect on recent agreements, because it is not compulsory to record the termination of the security interest agreement in the USPTO filings.

Future research could be directed towards asking and investigating some additional questions. For example, what are the different dynamics and practices, at both the firm and the financial intermediary level, that affect the observed differences in the number of collateralized patents and number of releases? Do such differences reflect

specific trading mechanisms on the market or the non-uniform adoption of security interest recording practices? Why do differences emerge across technology fields? The interconnections that exist between the characteristics of firms, the financial intermediaries, and the institutional, industrial and economic environment are all aspects that still need to be further elaborated and are rich in potential for future research. We have only started to address the complexity of these relationships.

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# 8. Appendix

*Table 7 Examples of patents involved in security agreements*

| US Patent Number | Title | Original Assignee | Security agreement date | Financial institution | Release date |
|---|---|---|---|---|---|
| 7740099 | Enhanced control of a transporter | Segway Inc. | 2008-06-05 | Bridge Bank, National Association | 2009-06-19 |
| 6794603 | Laser joint welding metal material | Dana Corporation | 2008-01-31 | Citicorp USA, Inc. | 2010-03-04 |
| 7317377 | Multiple broadcasting tag and monitoring systems including the same | Dmatek, Ltd. | 2009-10-21 | Silicon Valley Bank | 2010-10-20 |
| 6215260 | Controlling movement of linear induction motor | Baldor Electric | 2007-01-31 | BNP Paribas | Not released |
| 6009222 | Optical fibre and optical fibre grating | SPI Lasers UK Ltd | 2007-03-13 | ETV Capital S.A. | Not released |

*Table 8 Top 5 entities in each category by number of security agreements between 2007 and 2010*

| Type | Entity name | Security Agreements (count) | Percent (%) | Collateralized Patents (count) | Percent (%) |
|---|---|---|---|---|---|
| Banks | BANK OF AMERICA | 513 | 5.8 | 14851 | 10.95 |
| | JPMORGAN CHASE | 489 | 5.5 | 17848 | 13.16 |
| | SILICON VALLEY BANK | 418 | 4.7 | 4697 | 3.46 |
| | WELLS FARGO | 371 | 4.2 | 5649 | 4.16 |
| | COMERICA BANK | 175 | 2.0 | 1563 | 0.96 |
| Specialty finance companies | GENERAL ELECTRIC (Financial Service Subsidiaries) | 260 | 2.9 | 3283 | 2.42 |
| | MIDLAND LOAN SERVICES, INC. | 74 | 0.8 | 88 | 0.05 |
| | WILMINGTON TRUST | 60 | 0.7 | 6569 | 4.84 |
| | MADISON CAPITAL FUNDING LLC | 39 | 0.4 | 181 | 0.11 |
| | ABLECO FINANCE | 38 | 0.4 | 335 | 0.21 |
| Venture lending | VENTURE LENDING & LEASING | 118 | 1.3 | 1060 | 0.65 |
| | BAY CITY CAPITAL | 62 | 0.7 | 83 | 0.05 |
| | MMV FINANCE INC. | 45 | 0.5 | 195 | 0.12 |
| | PLENUS | 25 | 0.3 | 110 | 0.07 |
| | PARTNERS FOR GROWTH | 22 | 0.2 | 275 | 0.17 |
| Non-financial companies | BASF SE | 139 | 1.6 | 147 | 0.09 |
| | KNOBBE, MARTENS, OLSON & BEAR LLP | 77 | 0.9 | 380 | 0.23 |
| | HERCULES CORPORATION | 33 | 0.4 | 362 | 0.22 |
| | HORIZON TECHNOLOGY | 26 | 0.3 | 217 | 0.13 |
| | REQUISITE SOFTWARE, INC. | 20 | 0.2 | 20 | 0.01 |

*Table 9 Correlation matrix*

| No. | Variable / No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 1 | Patent age at transaction | 1.000 | | | | | | |
| 2 | Dummy: Granted patent | 0.338 | 1.000 | | | | | |
| 3 | Backward non-patent cit. | -0.062 | 0.235 | 1.000 | | | | |
| 4 | Technological scope | -0.103 | -0.190 | 0.041 | 1.000 | | | |
| 5 | Technical merit (fwd cit) | 0.258 | -0.007 | 0.081 | -0.030 | 1.000 | | |
| 6 | Transaction size | 0.141 | 0.134 | -0.044 | -0.039 | -0.047 | 1.000 | |
| 7 | Lender's Experience | 0.007 | 0.005 | 0.043 | 0.022 | 0.036 | 0.217 | 1.000 |