Selling Innovation in Bankruptcy*

Song Ma† Joy Tianjiao Tong‡ Wei Wang§

Abstract

We construct a comprehensive dataset of patent sales in Chapter 11 bankruptcies in all US public firms from 1981 to 2012. We document that 40% of firms sell, on average 18% of, their patents during bankruptcy reorganizations. Innovation sales concentrate in the first two quarters after bankruptcy filing. Firms sell more redeployable and liquid patents, as opposed to selling underexploited patents. This pattern is driven by firms that face "fire-sale" pressures and lack access to external financing. Our results suggest that imminent financing needs in bankruptcy drive innovation sales, and firms proactively avoid market trading frictions in the process.

JEL Classification: G33 O34

Keywords: Bankruptcy, Innovation, Patent, Asset Allocation, §363, Liquidity

*We thank David Abrams, Emanuele Colonnelli, Espen Eckbo, Florian Ederer, Julian Franks, Pengjie Gao, Xavier Giroud, Edith Hotchkiss, Po-Hsuan Hsu, Yawen Jiao, William Mann, Filippo Mezzanotti, Frank Milne, Marina Niessner, Gordon Phillips, David Schoenherr, Alan Schwartz, Kelly Shue, David Skeel, Wing Wah Tham, Heather Tookes, Dong Yan, and seminar participants at CICF (Hangzhou), Economics of Entrepreneurship and Innovation Conference, EFA (Mannheim), MFA (Chicago), NBER Summer Institute, NFA (Halifax), Queen's, 2nd Rome Junior Finance Conference, Tenth Searle Center/USPTO Conference on Innovation Economics, Tsinghua PBC, Wharton, and Yale for their helpful suggestions. Elaine Cui, Vania Shi, and Shimei Zhou provided valuable research assistance. Ma and Wang acknowledge the financial support of the Social Sciences and Humanities Research Council of Canada (SSHRC). All remaining errors are our own.

†Ma: Yale University, song.ma@yale.edu, (203) 436-4687, corresponding author;

‡Tong: Duke University, tianjiao.tong@duke.edu, (919) 937-4680;

§Wang: Queen's University, wwang@queensu.ca, (613) 533-3248.

The intensity of asset sales in Chapter 11 bankruptcy reorganizations has increased dramatically in past decades (Gilson, Hotchkiss, and Osborn, 2016). As one of the defining features of the reorganization process, asset sales have direct implications not only for an individual firm's ability to recover from adverse situations but also for the functioning of the economy as a whole.[1]

Innovation assets, despite being regarded as the engine of economic growth (Schumpeter, 1942) and estimated to make up 34% of firms' total capital in recent years (Corrado and Hulten, 2010), have been left out of the discussion on asset reallocation in bankruptcy. This is largely due to the impression that innovation is unlikely to be actively reallocated. On the one hand, innovations are largely irreplaceable assets that are critical to the going-concern value and recovery of the firm (Jaffe and Trajtenberg, 2002), and thus firms seeking reorganization may be reluctant to sell them. On the other hand, innovations are endowed with a high degree of information asymmetry and firm- (industry-) specificity, making them challenging to trade in the market for technologies (MFT) (Arora and Gambardella, 2010; Gans and Stern, 2010), particularly during the hectic period of bankruptcies (Shleifer and Vishny, 1992).

However, recent high-profile cases such as Eastman Kodak revealed the important role of selling innovation in corporate bankruptcies. More broadly, as the economy becomes more reliant on knowledge and technologies (Peters and Taylor, 2017), innovation emerges as an asset class that is closely evaluated by the equity market (Brav, Jiang, Ma, and Tian, 2017; Kogan, Papanikolaou, Seru, and Stoffman, 2017), and that influences debt financing (Hochberg, Serrano, and Ziedonis, 2017; Mann, 2017). Selling innovation in bankruptcy—sitting at the intersection of the bankruptcy institution, capital markets, and the market for technologies—thus becomes increasingly relevant to policy makers, investors, and stakeholders alike. Yet our understanding of this topic is very limited.

This paper provides, to the best of our knowledge, the first study on selling innovation in bankruptcy. We proceed in two steps. First, we establish basic facts—how often, how intense, and how fast do bankrupt firms sell their innovations, and is this just a recent phenomenon? Second, we explore the economic motivation for selling innovation in bankruptcy and the frictions firms face in this process, by investigating the types of innovation sold and the selling process.

To do so, we construct a comprehensive data set that consists of all Chapter 11 cases filed

[1] See, for example, Maksimovic and Phillips (1998), Pulvino (1998), Eckbo and Thorburn (2008), Benmelech and Bergman (2011), Bernstein, Colonnelli, Giroud, and Iverson (2017a), Bernstein, Colonnelli, and Iverson (2017b), and Granja, Matvos, and Seru (2017).

by US public firms from 1981 to 2012, covering firms ranging from large corporations to small entrepreneurial companies that just went through the IPO. We capture innovation using patents, which are widely used in the economics literature and are systematically recorded with profile and utilization information. For each bankrupt firm, we construct its patent portfolio by identifying all patents it possesses in each year using data from the United States Patent and Trademark Office (USPTO). We retrieve detailed histories on each patent's transaction events, which serve as our base to identify patent sales in bankruptcy. In addition, we obtain asset sale motions, asset sale orders, and master sale agreements from US bankruptcy courts through Public Access to Court Electronic Records (PACER). We manually code key information on asset sale auctions (including patent sales) conducted in bankruptcy. Together, these records allow us to observe the complete patent holdings of Chapter 11 firms and the entire process of patent sales during bankruptcy reorganizations.

Our analysis begins with establishing stylized facts. In the first place, selling innovation in bankruptcy is by no means a new nor uncommon phenomenon and is far broader than the recent anecdotal cases. There have been substantial innovation sales in bankruptcy since the 1980s in almost all industries, and the selling intensity has been fairly stable. At the extensive margin, more than 40% of bankrupt firms sell parts of their patent portfolios from the date of bankruptcy filing to the date of confirmation of a reorganization/liquidation plan (i.e., during the bankruptcy reorganization process). At the intensive margin, firms sell 18% of their patent portfolios on average.

Patent transactions concentrate in a short time window, largely within the first two quarters after the bankruptcy filing. In fact, the selling intensity in the four quarters leading up to the bankruptcy filing stays comparable to normal times; and the selling intensity returns to normal level after the emergence from bankruptcy. The spike of innovation sales after the bankruptcy filing reflects the use of Section 363 of the Bankruptcy Code as a favorable channel for firms to redeploy assets during bankruptcy reorganizations, which allows firms to sell assets without creditors' votes and to sell them "free and clear of liens" (Baird and Rasmussen, 2002; Ayotte and Skeel, 2013).

Having established the pervasiveness of selling innovation in bankruptcy, the next question is: What types of patents do Chapter 11 firms sell? Theoretically, in a frictionless bankruptcy process, firms use the Bankruptcy Code to sell underexploited assets to improve their going-concern value (Jackson, 1986; Aghion et al., 1992; Hart and Moore, 1998). Economic frictions may interfere with this process, however. For example, as raising external capital becomes costly due to information

problems and restrictions faced by lending institutions, innovation sales in bankruptcy can help partially fulfill the financing needs for working capital and debt restructuring (Ayotte and Skeel, 2013; Edmans and Mann, 2016). The imminent financing needs compel firms to sell more liquid assets (Lang, Poulsen, and Stulz, 1995; Schlingemann, Stulz, and Walkling, 2002). Meanwhile, selling assets that are less redeployable (Williamson, 1988) or that can only be traded in a thin market (Gavazza, 2011) results in fire-sale costs (Shleifer and Vishny, 1992), and thus firms are further incentivized to sell more redeployable and liquid assets.

Our baseline analysis investigates how these economic forces affect bankrupt firms' patent selling decisions. We follow the prior literature and construct four measures to capture the redeployability, liquidity, exploitation, and strategic value of a patent. The first measure, *Redeployability*, exploiting the idea of asset redeployability, measures the ratio of non-self citations scaled by total citations (Jaffe and Trajtenberg, 2002). The second measure, *Market for Technology (MFT) Liquidity*, calculates the annual ratio of patent transaction volume to total patent stock of the technology class to which a patent belongs, thereby capturing the liquidity determined by class-specific natures (Hochberg, Serrano, and Ziedonis, 2017). Third, we use the number of citations received by each patent in the most recent three years, *Utilization*, as the main measure of patent productivity and utilization in the owning firm. Finally, we use *TechCloseness*, developed by Akcigit, Celik, and Greenwood (2016) in order to measure the technological proximity between a patent and the owning firm's core innovation expertise, to capture a patent's strategic value to the firm.

We find that bankrupt firms sell innovations that are more redeployable and more liquid in the market for technology. Quantitatively, a one standard deviation change in Redeployability (MFT Liquidity) increases the probability that a patent will be sold by 10.9% (5.6%). Our results are not driven by the piecemeal liquidation decisions of firms, which can lead to a mechanical relation between liquidity and probability of selling. In contrast, we find little evidence that bankrupt firms reallocate underexploited innovation. In fact, bankrupt firms reallocate strategically important patents, which are shown to be valuable and less likely to be sold by healthy firms (Akcigit, Celik, and Greenwood, 2016) and by firms undergoing asset restructuring without financing needs (Brav et al., 2017).

The baseline results signify the role of trading frictions in the asset reallocation process and imminent financing needs in bankruptcy. On the one hand, selling more liquid patents helps firms to

avoid trading frictions associated with innovation assets. On the other hand, such a selling strategy allows bankrupt firms to satisfy imminent financing needs while other sources of financing are limited. We perform additional tests for supporting evidence that these two forces both affect firms' decisions in selling innovation.

First, we zoom in on the severity of the trading frictions by exploring heterogeneous financial conditions of industry peers, who are potential patent buyers (Shleifer and Vishny, 1992; Bernstein et al., 2017b). Since the fire-sale pressure is more pronounced during industry distress, bankrupt firms are more incentivized to reallocate liquid patents under such conditions. We find that industry distress, captured by either abnormally low industry stock returns or low sales growth (following prior literature), exacerbates a firm's tendency to sell more liquid innovation to avoid trading frictions.

Second, we examine the effect of bankrupt firms' access to external capital markets on the tendency to sell liquid patents. Debtor-in-possession (DIP) financing allows a debtor to raise capital immediately after filing for bankruptcy (Dahiya et al., 2003; Li and Wang, 2016) but may carry high interest and fees and impose excessive constraints on a firm's business decision making (Ayotte and Morrison, 2009). We find that the effect of patent liquidity on selling decisions is weaker for firms with DIP financing. This means that obtaining access to external financing grants a firm more time to market and sell innovation and thus mitigates its need to redeploy assets immediately.

Third, we provide further insights by investigating the citation pattern of sold patents. Bankrupt firms continue to cite sold patents after the transaction, indicating that those innovations are sold for financing or market friction-avoiding motives, but not due to lack of importance. This is consistent with anecdotal evidence that bankrupt firms often license back patents after sale to avoid production interruptions, similar to the "sale and leaseback" mechanism for firms raising financing through the sale of tangible assets (Slovin, Sushka, and Polonchek, 1990; Sharpe and Nguyen, 1995).

After documenting the economic motives for a firm's decision to sell redeployable and liquid innovations, we delve into the selling process. We aim to uncover actions that firms undertake to sell patents by redeployment and liquidity, and to examine the outcomes of such actions. We start by identifying litigated patents using data from Lex Machina, Derwent LitAlert, and the RPX database. Litigated patents are typically more frequently used and thus more redeployable in markets for technologies (Galasso, Schankerman, and Serrano, 2013). We find that litigated patents are more

likely to be sold, above and beyond the effects of Redeployability and MFT Liquidity. Furthermore, among patents that are eventually sold, the average value of Redeployability and MFT Liquidity exhibits a clear declining trend from the quarter of bankruptcy filing to the fourth quarter after filing. The evidence indicates that firms follow a liquidity pecking order in reallocating patents. Moreover, we investigate whether firms achieve more favorable outcomes by selling more redeployable and liquid patents. Using manually coded court records of §363 sales, we find that more redeployable and liquid patents attract more bidders to participate in auctions, and assets are sold with a larger increase in price from the initial bidding price.[2]

In the last part of the analysis, we show that the general pattern of innovation sales differs across firms by the reasons and causes for the Chapter 11 filings. Specifically, Chapter 11 firms are partitioned into those that suffer financial distress alone and those that potentially suffer economic distress (Asquith, Gertner, and Scharfstein, 1994; Andrade and Kaplan, 1998; Lemmon, Ma, and Tashjian, 2009). We find that the intention to sell more redeployable and liquid patents is pronounced in all firms but is stronger in financially distressed firms. Firms in economic distress appear to redeploy underutilized patents in their core innovation areas.

The paper concludes with a discussion of broader implications. We provide suggestive evidence that innovation sales are front-loaded in the overall asset reallocation process. This fact can be reconciled by that innovation reallocation involves little physical asset adjustment, and that innovation can be used in production by different firms, thus avoiding production interruption in the bankrupt firm. We also show that bankrupt firms diligently avoid loss of innovative human capital while selling patents. This suggests that Chapter 11 firms devote efforts to maintaining long-term corporate innovativeness.

In sum, this paper provides the first study on innovation reallocation in bankruptcy. We document the pervasiveness of the phenomenon, explore the economic motivations and frictions in the process, and investigate firms' overall strategy to maintain innovation ability in bankruptcies. As technological innovation becomes central to economic growth and leads to accelerated creative destruction, these findings are more relevant to policy makers who pay attention to the frictions and

[2]As far as we know, this is one of the few papers to investigate the auction process of asset allocation in bankruptcy; others are Eckbo and Thorburn (2003, 2008) and Gilson, Hotchkiss, and Osborn (2016). One limitation of the data on innovation sale, common to all innovation-related studies, is that it is hard to determine the fair value of patents (Kogan et al., 2017), as opposed to real assets such as airplanes. Therefore it is difficult to calculate the potential discount in asset sales.

the efficiency of the bankruptcy process (Jackson, 1986), to financiers whose investment decisions tightly hinge on asset reallocations in distress (Shleifer and Vishny, 1992; Schwartz, 2005), and to stakeholders who are concerned with the going-concern value (Franks and Torous, 1989; Hotchkiss et al., 2008).

This paper relates to studies of asset allocations in bankruptcy. Maksimovic and Phillips (1998), Pulvino (1999), Ramey and Shapiro (2001), and Bernstein et al. (2017b) study how trading frictions affect the costs and decisions of allocating capital. Benmelech and Bergman (2011), Meier and Servaes (2016), and Bernstein et al. (2017a) show that such costs not only affect the bankrupt firms but also spill over to other firms. Our paper complements this literature in several ways. First, our study focuses on the reallocation of patents, arguably the most important form of intellectual property for innovative firms, whereas the existing research largely studies specific types of tangible assets. Second, in terms of the research design, our analysis focuses on the ex ante motivation and decision to sell or retain individual assets, as opposed to investigating the ex post costs of reallocation. Third, from a methodological perspective, we lay out a framework for analyzing bankruptcy court records; this further improves our ability to provide a granular analysis of the reallocation process and hopefully stimulates future studies.

This paper also speaks to the literature on the market for technology and its interactions with financial markets. A growing body of empirical literature studies how firms use the market for technology to reallocate innovation and create value (Serrano, 2010; Akcigit, Celik, and Greenwood, 2016; Brav, Jiang, Ma, and Tian, 2017) and studies how innovation can be used as collateral to raise financing (Mann, 2017; Farre-Mensa et al., 2016; Hochberg et al., 2017). Importantly, one needs to understand an asset in distress states to determine its value in capital markets. We provide empirical evidence that the redeployability and liquidity of patents are key determinants of innovation allocation during bankruptcy. This mechanism may distort the functioning of the market for technology to efficiently allocate innovation and deter the diffusion of knowledge. Our findings also have implications for the types of innovation that firms are incentivized to produce in order to minimize distress costs (Ederer and Manso, 2011; Manso, 2011).

The remainder of the paper is organized as follows: Section 1 provides background information; Section 2 discusses sample construction and measurements; Section 3 establishes facts for innovation sales in bankruptcy; Section 4 presents the empirical analysis and discussions; Section 5 concludes.

1. Innovation Sales Through §363 of the Bankruptcy Code

Sales of innovation during Chapter 11 reorganizations are conducted through Section 363 (§363) of the Bankruptcy Code (Baird and Rasmussen, 2002; Gilson et al., 2016).[3] The §363 sales provide a particularly appealing setting to understand firms' selling strategies as it allows firms to sell assets with a high degree of discretion and enhanced asset salability.

On the one hand, selling assets through §363 requires only debtor's discretion and judge's approval, but not creditors' votes. Loan contracts often have restrictions and mandatory prepayment clauses on asset sales, and thus firms are given limited freedom to the type and quantity of assets to sell outside bankruptcy court. In contrast, a Chapter 11 firm possesses a large degree of freedom to what assets to redeploy.[4]

On the other hand, the "free and clear of liens and encumbrances" provision of §363 greatly improves the salability of the assets. Without §363, lenders may claim to have a lien on both the collateralized assets that are sold and the proceeds from the sale in asset transactions outside bankruptcy. Selling assets "free and clear of liens and encumbrances" through §363 restricts the lender to have security interest on the proceeds of the sale only (§552(b)), thereby exempting the buyer from the old lender's security interest (Ayotte and Skeel, 2013).[5]

[Insert Figure 1 Here.]

An additional desirable feature of the §363 asset sale process is that it is closely monitored and documented by the bankruptcy court. This allows us to manually code detailed information on the sale process, which is discussed in Section 2. The sale process starts with the bankrupt firm filing a sale motion to the bankruptcy judge. A stalking horse—the initial interested buyer—is usually

[3]For example, well-known innovation sales in bankruptcy, such as those of Eastman Kodak, were conducted through §363.

[4]For example, §363(b) allows the sale of a debtor's assets outside of a firm's ordinary course of business in bankruptcy, after notice and a hearing. §363(c) further authorizes the sale of properties of the estate, in the ordinary course of the business, without notice or hearing, under certain conditions. These provisions authorize the sale without approval of creditors but require a "sound business purpose."

[5]The provision for the debtor to use or sell collateralized assets free and clear of liens is explicitly laid out in §363(f) by the following statement: *"The trustee may sell property under subsection (b) or (c) of this section free and clear of any interest in such property of an entity other than the estate, only if—1. Applicable non-bankruptcy law permits sale of such property free and clear of such interest; 2. Such entity consents; 3. Such interest is a lien and the price at which such property is to be sold is greater than the aggregate value of all liens on such property; 4. Such interest is in bona fide dispute; or 5. Such entity could be compelled, in a legal or equitable proceeding, to accept a money satisfaction of such interest."*

identified by the firm and notified to the judge. The sale motion describes the bidding and selling procedures, which are up to the judge's approval. A public hearing date on the sale procedures is specified in the sale motion. Key stakeholders of the bankrupt firm, including secured creditors, unsecured creditors, and United States Trustees, among others, can file formal objections to the proposed sale to the bankruptcy judge under Rule 6004(b) of the Federal Rules of Bankruptcy. After the public hearing is held, the judge decides whether to approve the bidding procedure so that other potential buyers may submit bids. After the bankrupt firm solicits other potential bids and conducts an auction for the sale, the successful bidder is identified. A final sale hearing is held before the judge then approves the sale to the successful bidder. The whole §363 sale process generally takes a few weeks to complete. A graphic illustration of the sale process is provided in Figure 1.

In addition, unlike transactions of other assets, innovation sales are also recorded by the USPTO through the formal patent reassignment process. Graham, Marco, and Myers (2017) provide a detailed discussion on the USPTO patent reassignment records from the perspective of the data administrator. One potential limitation of this process is that recording a transaction in the USPTO is not mandatory. However, both statute and federal regulations provide strong incentives for reporting in order to claim property rights. These incentives to completely report are particularly strong for firms in distress and bankruptcy when clean property rights are desirable.

2. Data and Measurements

2.1. The Bankruptcy Sample

We retrieve all Chapter 11 bankruptcies filed by US public firms from 1981 to 2012 from New Generation Research's Bankruptcydata.com. We manually match the sample firms with Compustat using firm names and company information and remove firms that lack a valid identifier in Compustat. This initial screening results in a sample of 2,169 Chapter 11 cases. We remove cases that were dismissed (146 cases), were pending as of mid-2016 (5 cases), were merged into another leading case (2 cases), and had unknown outcomes (158 cases). We also remove financial firms (161 cases), which are less relevant in a study of innovation. We then exclude cases with unavailable or incomplete dockets from Public Access to Court Electronic Records (PACER) and Bloomberg Law

(74 cases). This process leaves us with a sample of 1,623 cases.[6]

The following key information is then collected for each case: the date of Chapter 11 filing, the court where the case is filed, the judge overseeing the case, whether the case is prepackaged or renegotiated, assets at bankruptcy filing, the outcome of reorganization, the confirmation date and effective date of the reorganization or liquidation plan, and the conversion date for those cases converted to Chapter 7.

We determine whether a Chapter 11 firm obtains DIP financing using court dockets retrieved from PACER. We search for key phrases that can help to identify whether the debtor filed a motion on DIP financing and whether a judge approved it.[7] For cases with incomplete dockets, we search bankruptcy plans and news in LexisNexis and Factiva to verify whether the bankruptcy court granted DIP financing.

We use Compustat for financial statement data reported as of the last fiscal year before the bankruptcy filing. The key financial variables we construct include leverage (debt in current liabilities and long-term debt, scaled by book assets), sales growth (sales of the current year minus sales of the previous year and scaled by the previous year's sales), ROA (the ratio of EBITDA to book assets), and R&D expenses scaled by book assets. All variables are winsorized at the 1% and 99% levels.

Following prior literature, industry conditions are measured based on how distressed the industry (three-digit SIC) is in the bankruptcy filing year. Following Gilson, John, and Lang (1990) and Acharya, Bharath, and Srinivasan (2007), we label an industry "distressed" if its median annual stock return in a year is less than or equal to -20%. We also measure industry distress based on the product market performance of the industry. A distressed industry is defined as being in the bottom decile of annual sales growth (Gilson, Hotchkiss, and Osborn, 2016) among all three-digit SIC industries. Detailed variable definitions are described in Appendix Section 5.

[6] Our data set is the largest bankruptcy data set for US public firms with detailed case information, twice as large as that listed in the widely used UCLA-LoPucki Bankruptcy Research Database, which covers Chapter 11 filings by US public firms with $100 million in assets in constant 1980 dollars for the sample period. The ability to include smaller firms is particularly important because many smaller entrepreneurial firms own many innovation assets.

[7] These key phrases include: *debtor-in-possession financing*, *DIP financing*, *post-petition financing*, *secured financing*, *secured lending*, *post-petition finance*, and *secured finance*.

2.2. Patent Profiles and Patent Transactions

We construct patent-holding information of each firm using the National Bureau of Economic Research (NBER) patent database and Bhaven Sampat's patent and citation data, both of which are originally extracted from the USPTO. The combined data are linked to the public firm universe using the bridge file provided by NBER, allowing us to establish the full list of patents that a firm owns at each point in time between 1976 and 2012. The database categorizes each patent into one of 430 technology classes based on the underlying fundamental feature of the innovation. It also records the number of lifetime citations received by each patent as well as the source of those citations, which helps identify the level of utilization and potential users of each patent.

When owners sell their patents, they are required to file patent reassignment documents with the USPTO. The original USPTO patent reassignment database provides information useful for identifying patent transactions: the assignment date; the participating parties, including the transaction assignee ("buyer") and assignor ("seller"); and comments on the reason for the assignment. We merge the raw assignment data with the Harvard Business School inventor database and the USPTO patent database to gather additional information on the original assignees.

We then follow a procedure, similar to that of Ma (2016) and Brav et al. (2017), in which we identify patent transactions from all patent reassignment records from 1976 to 2015. Importantly, the identified patent transactions do not include cases involving an internal patent transfer, either from an inventor to his/her employer or between two firm subsidiaries. This step is crucial for our study because bankrupt firms are more likely to undergo organizational changes during this period. For example, we ensure that such cases as "General Motors Corporation" reassigning its patents to "General Motors Global Technology Operations" are not counted as patent transactions. We provide a detailed description of the data and methodology in Appendix Section A1.

2.3. Manual Coding of Court Records on §363 Sale

Since §363 sales must be filed to and approved by a bankruptcy judge, key elements associated with the sale process are transparent. They provide a great opportunity to study the auction process of asset allocation in bankruptcy. We examine the detailed process of asset sales through §363 by manually reading the motions and orders retrieved from court dockets on PACER as well as

Bloomberg Law. We manually code key variables of §363 sales, such as the motion date of the sale, nature of assets to be sold, identity of the stalking horse, number of bidders in an auction, identity of competitive bidders and the winning bidder, initial bidding price, final price, date of sale order, patent numbers of patents sold, and, if available, prices paid for patents.

2.4. Key Variables

Our analysis requires patent-level measures that could help identify the economic forces behind the decision to retain or sell a specific patent. To capture the liquidity of a patent, we construct two measures, *Redeployability* and *MFT Liquidity*. To measure the utilization and strategic importance of a patent to the owning firm, we use *Utilization* and *TechCloseness*.

2.4.1. Redeployability. $Redeployability_p$ is a patent-level measure that intends to capture the extent to which a patent p is redeployable and valuable to other potential users of the innovation. As in the real asset market (Benmelech and Bergman, 2008; Benmelech, 2009; Bernstein, Colonnelli, and Iverson, 2017b), substantial adjustment costs are associated with exploiting a new type of innovation, and this in turn affects the value of the patent in new users' hands when the firm fails. The presumption here is that firm-specific (less redeployable) innovations are less liquid in the market.

We build on the idea of the "self-citation" of innovation to capture the redeployability of patents (Jaffe and Trajtenberg, 2002). Specifically, we compute the share of citations that patent p receives from the follow-on patents issued to the same company (that is, the proportion of "self-cites"). To be consistent with the literature (Lerner, Sorensen, and Strömberg, 2011), we focus on the self-citing intensity within three years of a patent being granted, a factor that is shown to be relevant in measuring such concepts. A higher self-cite ratio is assumed to correlate with a more limited redeployability in the market for technology, in the same spirit as Hoetker and Agarwal (2007) and Marx, Strumsky, and Fleming (2009). We, therefore, define patent-level $Redeployability_p$ as one minus self-cite ratio.

2.4.2. Market for Technology Liquidity. Patents are largely traded in decentralized markets, in which buyers and sellers face fixed costs to search for the right trading partner (Hagiu and

Yoffie, 2013). Market thickness reduces search costs and facilitates reallocation, thus increasing the liquidity of capital. Gavazza (2011) shows that the thickness of the market and the liquidity of capital can be captured by the activeness of trading in this market. We use $MFTLiquidity_{pt}$, a patent-year-level variable, to capture the annual likelihood that a patent p could be sold in year t in the market for technology.

We follow Hochberg, Serrano, and Ziedonis (2017) to compute this MFT Liquidity measure using the trading activities in the market for each technology class. We exploit the USPTO patent assignment and reassignment data to identify the number of patents transacted each year in each technology class. Patent transactions are defined as including sales of patents as stand-alone assets as well as transfers bundled through corporate acquisitions (similar to Serrano (2010) and Galasso, Schankerman, and Serrano (2013)). The constructed data set is merged with the population of tradable patents in each technology class-year cell. The ratio of transacted patents over the patent population gives us the MFT Liquidity measure for each technology class and issue year, which we can then uniquely map to each patent p at each time point t.

2.4.3. Utilization. We use citation-based measures to capture the utilization of a patent in the owning firm. Specifically, we construct *Utilization* of patent p in year t as the number of citations received by p in the three years preceding the bankruptcy filing—that is, $t-3$ to $t-1$. The premise is that a higher number of recent citations is a sign of better utilization of the patent by the owning firm. In principle, a higher number of citations indicates that the underlying patent becomes more visible and popular, possibly because it is commercialized more successfully by the owner or better fits the owner's overall innovation profile.

2.4.4. Technological Closeness. We follow Akcigit, Celik, and Greenwood (2016) to construct the *TechCloseness* measure, which formalizes the distance between a patent p and a firm i's overall technological expertise using a generalized mean of distances between p and every other patent in firm i's patent portfolio. Intuitively, the higher this measure is, the closer the patent is to the firm's core innovation assets. Akcigit, Celik, and Greenwood (2016) and Brav et al. (2017) show that patents with higher *TechCloseness* are of greater strategic value to the firm. They also provide evidence that when firms undergo asset restructuring without liquidity needs, such as after hedge

fund interventions, they tend to sell patents that are less close.[8]

3. Stylized Facts

We merge our sample of 1,623 Chapter 11 filings by US public firms with the USPTO patent database and require each Chapter 11 firm to own at least one patent at the time of bankruptcy filing. The screening results in a final sample of 518 innovative firms for our study. Given the novelty of the setting, we provide an overview of selling innovation in bankruptcy. These stylized facts also provide guidance for our main analysis.

Stylized Fact 1: *Selling innovation in bankruptcy is pervasive.*

We investigate how often firms sell innovation during the bankruptcy reorganization process (from the bankruptcy filing to the confirmation of the reorganization or liquidation plan). Table 1 presents bankrupt firms' intensity of selling innovation, tabulated based on their industries, defined by the Fama-French 12 Industry categorization (Panel A), and on the year of bankruptcy filing (Panel B). In each panel, we show the total number of cases, the number of cases filed by innovative firms, the proportion of firms that sold patents during bankruptcy reorganization, and the percentage of patents sold.[9]

[Insert Table 1 Here.]

Selling innovation during bankruptcy is a surprisingly pervasive phenomenon. Forty percent of bankrupt innovative firms sell at least one patent in the reorganization process, and patents transacted account for about 18% of their patent stock. Cross-sectional comparison in Panel A suggests that the intensity of selling innovation in bankruptcy varies across industries. Health care, drug, and medical device companies sell their innovation more than any other industries, with 56% of firms conducting such activities and almost 30% of their patent portfolios being sold. But even in the industries that are the least likely to sell patents in bankruptcy (Wholesale and Retail, Consumer Non-durables), nearly 25% of bankrupt firms sell more than 15% of their patent holdings. Time-series analysis in Panel B suggests that selling innovation, even though largely overlooked

[8] Appendix Section A2 provides a detailed description of how the measure is constructed.
[9] Naturally, the ratio of sold patents is defined as zero for firms that sold no patents.

in academic studies, is not a new phenomenon. The proportion of firms that sell patents and the percentage of patents transacted has remained at a fairly stable level since the early 1980s.

[Insert Table 2 Here.]

We also statistically examine the selling intensity of bankrupt firms compared to others. We construct a firm-quarter panel of all US public firms that have at least one valid patent grant from the USPTO (that is, a firm is included in the sample after its first patent is issued). The key independent variable is a dummy variable, *I(In Bankruptcy)*, indicating whether the firm is undergoing a bankruptcy reorganization in that quarter.[10] The results are shown in Table 2 columns (1) and (3). The intensity of selling innovation during bankruptcy is significantly higher compared to the panel of innovative public firms that are not in bankruptcy. The 0.039 in column (1) indicates that bankrupt firms are 3.9% more likely to sell a patent in each quarter. This is a 76% increase from the base rate of patent selling outside bankruptcy. Those firms are predicted to sell approximately 2.2% more of their patent portfolios every quarter during bankruptcy reorganizations. Overall, we find that innovation is actively traded in bankruptcy.

Stylized Fact 2: *Innovation sales concentrate within a short time window after the bankruptcy filing.*

We extend the analysis to characterize the dynamics of selling innovation around bankruptcy. We exploit the following model in the same panel sample of firm i and quarter t:

$$Selling_{it} = \sum_{k=-4}^{4} \beta_k \cdot d[t+k]_{it} + \lambda \times Control_{it} + \alpha_i + \alpha_t + \varepsilon_{it}, \tag{1}$$

where the key difference is that the independent variables of interest are now the set of dummies, $d[t-4], ..., d[t+4]$, indicating whether the firm-quarter observation fits into the $[-4,+4]$ time frame of the bankruptcy event.

Results are reported in Table 2 columns (2) and (4). The effects are positive and significant from t to $t+4$. In column (2), the coefficient of 0.096 associated with $d[t+1]$ suggests that in the quarter immediately following the bankruptcy filing, the probability of selling a patent is 9.6% higher than the benchmark. Comparing coefficients of $t-1$ and $t+1$, we find that the probability

[10] We categorize the dummy as one for cases in which the firm's bankruptcy process occurs in part of the quarter.

of selling increases more than sixfold. The F-test suggests that the six-time increase in probability is statistically significant at the 1% level; at the intensive margin (column (4)), the increase is even more dramatic.

[Insert Figure 2 Here.]

The increase in post-filing innovation sales concentrates in the first two quarters after the bankruptcy filing, as indicated by the strongest results in $t+1$ and $t+2$, and it decays quickly afterward. Importantly, we do not observe any secular trends before bankruptcy filings when we visualize the regression estimates in Figure 2. In sum, these results suggest that the sale of innovation is conducted soon after filing.

We are now in a position to highlight that the large increase of selling immediately after Chapter 11 filing reflects unique features of §363 of the Bankruptcy Code to facilitate asset sales. The §363 sale allows a firm to expeditiously redeploy assets at the firm's discretion and with a judge's approval, and the firm is able to sell patents "free and clear of liens and encumbrances" (see Section 1). This effectively provides the potential buyer an attractive option to purchase the assets clear of uncertainty and largely enhances the salability of patents for sale.

4. Empirical Analysis

4.1. Baseline Results

The baseline analysis explores the type of innovation sold in bankruptcy. The analysis is performed on a patent-level cross-sectional data set. Each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing. We estimate the following linear probability model:

$$\begin{aligned} Sold_{ip} = {} & \beta_1 \cdot Redeployability_{ip} + \beta_2 \cdot MFTLiquidity_{ip} \\ & + \gamma_1 \cdot Utilization_{ip} + \gamma_2 \cdot TechCloseness_{ip} \\ & + \lambda \times Control_{ip} + \alpha_i + \varepsilon_{ip}. \end{aligned} \tag{2}$$

$Sold_{ip}$ is a dummy variable indicating whether patent p is sold during the bankruptcy reorganization process by its owning firm i. We use the redeployability of the patent (*Redeployability*) and liquidity

of the market for technology (*MFTLiquidity*) to capture the liquidity of each patent. $Utilization$ captures the utilization of the patent in the owning firm. *TechCloseness* measures the strategic value of patent p to firm i. To make sure that those measures are not simply capturing the value or potential of a patent, we also control for such patent characteristics as the number of total lifetime citations and patent age, as well as for firm-specific patent transaction intensities using firm-level fixed effects.

[Insert Table 3 Here.]

We first report summary statistics of this patent-level data set in Table 3 Panel A. This data set covers all patents owned by 518 innovative bankrupt firms that have non-missing values of key patent-level variables. The average value of redeployability is 0.783; this suggests that, on average, 78.3% of citations received by a patent are made by other firms, i.e., external citations. The average *MFT Liquidity* of a patent is 0.033, which means that, on average, 3.3% of patents in a technological class are transacted in a specific year. There is also a large cross-sectional variation in this liquidity measure, with standard deviations of around 0.022, and a large jump from the 0.021 at the 25th percentile to 0.039 at the 75th percentile. The average utilization rate suggests that each patent is cited twice within three years. The technological closeness measure between a patent and the whole patent portfolio owned by the firm is 0.578.

Panel B of Table 3 describes the 518 innovative bankrupt firms in the sample. About 20% of the cases are prepackaged filings and more than half of our sample firms receive DIP financing. The bankruptcy cases, on average, stay in the reorganization process for 511 days. The case outcomes are: 13% acquired, 12% converted to Chapter 7, 51% emerged, and 24% liquidated in Chapter 11. Our sample firms own, on average, 175 patents at the time of filing for bankruptcy; the median patent holding is 13, suggesting a highly skewed distribution of firm size and patent stock. In addition, a typical firm in our sample experiences negative ROA and sales growth and carries high leverage at the time of Chapter 11 filing.[11]

Table 4 presents the regression results of equation (2). Column (1) shows that $Redeployability$ is a strong determinant of whether a patent is likely to be reallocated during bankruptcy reorganization.

[11] In Table A.1 we compare those innovative bankrupt firms with other bankrupt firms. Those firms are very similar to each other in terms of case and firm characteristics. Innovative bankrupt firms are, however, more R&D heavy, more likely to obtain DIP financing, and less likely to be converted from Chapter 11 to Chapter 7 liquidations.

The coefficient of 0.025 translates a one standard deviation change to a 0.83% (0.025×0.330) increase in probability of selling, which is a 10.86% jump based on the unconditional probability (7.6%). In column (2), *MTF Liquidity* of a patent is positively and significantly associated with a higher probability of it being sold during bankruptcy. The estimate, 0.194, suggests that a standard deviation increase of the market liquidity of the patent's market will increase the probability of it being sold in bankruptcy by 0.42% (0.194×0.022). This economic magnitude equates to a 5.62% increase based on the unconditional probability that a patent is sold in bankruptcy (7.6%).

[Insert Table 4 Here.]

In terms of *Utilization* and *TechCloseness*, we do not find supporting evidence that firms systematically sell underexploited patents or those that are strategically less valuable to the firm. If anything, firms seem to sell those patents that perform well recently and are in their core business. Specifically, patent utilization is positive and significantly associated with the decision to sell a patent. Similarly, *TechCloseness* predicts a higher probability of selling, which is different from the findings of Akcigit, Celik, and Greenwood (2016), who show that firms sell more technologically distant patents in normal times, and of Brav et al. (2017), who show a pattern of selling distant patents in corporate restructuring initiated by hedge fund activists.[12]

Column (5) shows that the estimations are qualitatively and quantitatively similar when all four measures are included in the regressions. These stable estimations confirm that those measures, all derived using the USPTO records, can successfully capture different dimensions of a patent. Moreover, Table A.2 in the Appendix presents the correlation structure among those measures, and the correlations are, in general, small in magnitude.

In columns (6) and (7), we repeat the analysis using only firms that eventually emerged from the bankruptcy process and that were not prepackaged, respectively. The goal of the emerging-firm analysis is to mitigate the concern that firms that are eventually liquidated may place everything for sale without discretion. The liquidation decision can mechanically lead to the result that more liquid assets are sold first on the market (Gavazza, 2011). Similarly, the goal of excluding prepackaged bankruptcies is to ensure that the decision is most likely made by a debtor after bankruptcy filing, rather than through a prepackaged agreement between the debtor firm and the buyer before the

[12] We will revisit and explore this result regarding *TechCloseness* below.

debtor files for bankruptcy.[13] The results are both qualitatively and quantitatively similar to the full sample presented in column (5).

Note that Table 4 includes firm fixed effects in all analyses. Therefore, the relation between liquidity and the probability that a patent will be sold is identified using within-firm patent-level variations in characteristics rather than cross-firm variations. In other words, the results are unlikely to be driven by some firm-level characteristics that determine liquidity and bankruptcy behaviors at the same time.

4.2. Exploring Trading Frictions and the Financing Motive

Table 4 presents the dominating effects of redeployability and MFT liquidity on the patent selling decision of a bankrupt firm, which are deviations from the frictionless benchmark. As discussed above, this is consistent with two economic forces—the incentives to avoid real asset market frictions through selling liquid assets, and the incentives to overcome imminent financing difficulties through selling more sellable assets. We conduct additional analyses to explore how those frictions are exacerbated or mitigated in different subsamples.

4.2.1. Industry Conditions. Shleifer and Vishny (1992) show that poor industry conditions exacerbate trading frictions and discount the liquidation value of assets. When a firm needs to sell assets in bankruptcy, industry peers that could be efficient users of and bidders on those assets are themselves likely to experience distress, resulting in so-called fire sales.[14] Following this logic, we investigate whether the intention to sell liquid innovation for financing is aggravated by the financial constraints of industry peers.

Table 5 presents the subsample results by splitting firms according to industry condition. In

[13] A bankruptcy case is defined as prepackaged if the debtor drafted the plan, submitted it to a vote of the impaired classes, and claimed to have obtained the acceptance necessary for consensual confirmation before filing. If the debtor negotiates the plan with fewer than all classes or obtains the acceptance of fewer than all classes necessary to confirm the plan before the bankruptcy case is filed, then the case is regarded as prenegotiated. We exclude both prepackaged and prenegotiated cases from our analysis.

[14] On the empirical side, Asquith, Gertner, and Scharfstein (1994) document that workout is more likely than liquidation when industry conditions are poor; Maksimovic and Phillips (1998) show that incentives to reorganize depend on industry conditions; and Granja, Matvos, and Seru (2017) show that industry conditions represent in fact, a great proportion of the costs incurred in selling failed banks. Schlingemann, Stulz, and Walkling (2002) show in a more general setting that industry conditions determine the allocation of corporate divestment. Bernstein, Colonnelli, and Iverson (2017b) show that market thickness and local economic conditions jointly determine the ex post efficiency of allocation in bankruptcy.

Panel A, we split the sample using the industry distress measure based on stock returns. In columns (1) and (2), we show that the probability that a patent will be sold during bankruptcy increases with its redeployability, in both distressed and non-distressed industries. However, the effect is nearly three times stronger when the industry condition is poor. In columns (4) and (5), we show that the influence of a patent's redeployability on the probability that it will be sold when the industry is in distress is more than three times greater than when it is non-distressed. In columns (3) and (6), we report t-tests that show the statistical significance between the estimated coefficients in distressed and nondistressed industry subsamples.

[Insert Table 5 Here.]

In Panel B, we split the sample based on whether the industry is at the bottom decile of sales growth among all industries in that year. The role of trading frictions is again much stronger for firms in poorer industrial environments. Overall, Table 5 shows that firms' incentives to avoid trading frictions in reallocating assets are amplified in distressed industries.

4.2.2. Access to External Finance. The empirical evidence on fast selling of redeployable and liquid innovation is consistent with a firm's financing motives. It is also true that a Chapter 11 firm is able to borrow externally using DIP financing under §364 of the Bankruptcy Code (Dahiya et al., 2003). However, due to information problems (Edmans and Mann, 2016) and restrictions that lending institutions face, it can be costly or even infeasible for a firm to raise such financing from bank lenders. As a result, alternative investors such as hedge funds and PE firms become the "lenders of last resort" and provide DIP financing with an objective of controlling the reorganization process and achieving "loan-to-own" (Li and Wang, 2016). These loan contracts often carry high interest and fees as well as stringent requirements on collateral, covenants, and default clauses.[15] Naturally, raising financing through asset sales may become an alternative.

[Insert Table 6 Here.]

Since firms with DIP financing have capital available for short-term liquidity needs, they are given more time to market assets for sale (Ayotte and Morrison, 2009). Thus patent liquidity

[15] See "Chapter 11: Debtor-in-Possession Lending Report," Debtwire Analytics, 2014; Skeel (2003), Ayotte and Morrison (2009), and Roe and Tung (2013).

becomes less of a concern when these firms choose to sell innovation. Table 6 shows how patent liquidity determines the innovation reallocation decision in a subsample of firms with and without DIP financing. In firms with DIP financing, the sensitivity of selling patents to *Redeployability* is 0.024, and the R-squared is 0.112; in the subsample without DIP financing, the sensitivity jumps by more than 50%, to 0.039, and the R-squared increases to 0.506. This shows that trading frictions have a stronger effect on innovation reallocation decisions in firms that do not access external capital markets (the No DIP sample). The results are similar in columns (4) to (6), in which *MFTLiquidity* is used to measure patent liquidity. Our results suggest that the imminent financing need induces bankrupt firms to sell liquid assets.[16]

4.2.3. Innovation Sales and Future Usage. To shed more light on selling innovation as a potential financing transaction, we document the utilization pattern of those patents sold in bankruptcy. Figure 3 plots the coefficients β_k from the following regression at the patent (p)-year (t) level:

$$Citation_{pt} = \sum_{k=-3}^{+3} \beta_k \cdot d[t+k]_{pt} + \gamma \cdot Controls_{pt} + \alpha_p + \alpha_t + \varepsilon_{pt}. \tag{3}$$

$Citation_{pt}$ is the number of new citations a patent receives in a given year, and we separately estimate using the total citations received by the patent (Panel (a)) and those received from the bankrupt firm itself (Panel (b)). The dummy variable $d[t+k]$ equals one if the patent observation is k years from the sale of the patent, and zero otherwise. We control for patent age, measured as the logarithm of the patent age in year t. We also include year and patent fixed effects, α_t and α_p. Standard errors are clustered at the firm level.

[Insert Figure 3 Here.]

We find that even though the overall utilization of the patents sold during the bankruptcy process experiences an "up and down" dynamic,[17] the number of citations made by the bankrupt firm remains flat after the sale. The flat citation pattern suggests that those sold patents continue to be utilized by

[16] In Appendix Table A.3, we relate the probability of a firm selling innovation to DIP financing. We find that firms without DIP financing are, in general, more likely to conduct patent sales than firms with DIP financing.

[17] One interpretation is that bankrupt firms sell better-utilized hot patents (the "up" part) that can be more redeployable or liquid, yet those patents do not necessarily better fit the buyer or are not necessarily better managed under new management, and therefore fall in total citations (the "down" part).

the firm. In other words, they remain an important technology for the firm. Moreover, despite patent licensing information being largely unavailable for our sample firms, we find anecdotal evidence that firms often license back the patents after the sale.[18] This type of transaction is similar to the sale and leaseback mechanism for other types of assets that are used primarily for financing (Slovin, Sushka, and Polonchek, 1990; Sharpe and Nguyen, 1995). Overall, this again supports the idea that innovation sales are incentivized by a financing and fire sale avoidance motive, rather than by the intention to restructure underexploited assets.

4.3. Evidence from the Selling Process

Thus far we have established that bankrupt firms sell more redeployable and liquid patents to avoid frictions in the real asset market and financial market. In this section we look more deeply into how firms manage the selling process. Specifically, we investigate §363 asset auctions, sale of litigated patents, and the time-series dynamics of liquidity of patents sold.

4.3.1. Patent Litigation. We study how patent litigation helps explain patent sales in bankruptcy. Patents give owners the legal right to sue for potential infringement, and patent litigation has become increasingly important in recent decades. Some patents are transacted for reasons of litigation (Galasso, Schankerman, and Serrano, 2013; Akcigit, Celik, and Greenwood, 2016). For example, a firm might buy a patent if it is being sued by the firm owning this patent to resolve uncertainty associated with the litigation. This argument fits naturally with the framework of trading frictions—litigated patents are typically heavily used and redeployable by one or a few identifiable firms and thus more likely to be reallocated if offered for sale.

To capture a patent's litigation status when its owning firm files for bankruptcy, we obtain data from Lex Machina, Derwent LitAlert, and the RPX database. In the sample of all patents owned by our bankrupt firms, the dummy variable *Litigation* is defined as one if the patent was litigated before the bankruptcy filing, and zero otherwise. We include this dummy variable together with our patent liquidity, utilization measures, and other controls in the same setting as in Table 4.

[Insert Table 7 Here.]

[18] For example, in its sale of AlmoPlus technology through §363, Chapter 11 firm Dana Corp. and the buyer BTU International entered into a patent licensing agreement for Dana to continue to use the technology. See Appendix Section A4 for the case illustration.

Table 7 presents the results. Even though patent litigation is uncommon in our sample (1% of patents are in litigation), it has strong explanatory power in patent allocation in bankruptcy. A litigated patent is about 4% more likely to be sold than other patents, even after controlling for other liquidity measures.

4.3.2. The Liquidity Pecking Order. If firms sell liquid innovation assets to raise financing during bankruptcy reorganization, the selling sequence can have a dynamic pecking order based on the liquidity of each patent. That is, firms can choose to sell more liquid assets before less liquid ones. To examine this implication, we focus on patents that are eventually sold and plot the average liquidity of those patents sorted by the quarter of their sale, ranging from quarter zero (the quarter of the filing) to one year after the filing (if the reorganization plan was not yet confirmed).

[Insert Figure 4 Here.]

Figure 4 presents the results. In Panel (a), the reported variable is *Redeployability*, which shows a clear decline from the quarter of the bankruptcy filing to the fourth quarter after the filing, and the difference is statistically significant. In Panel (b), the reported liquidity measure is *MFT Liquidity*, and a smoother pattern holds in general. Overall, the analysis is consistent with the concept that bankrupt firms dynamically manage the innovation reallocation decision based on the liquidity of a patent.

4.3.3. Evidence from §363 Asset Auctions. To confirm that liquid innovations facilitate sales, we briefly turn to examining whether patent liquidity affects the outcomes of bankruptcy auctions in redeploying innovation. As presented in Section 2, we collect all sale-related bankruptcy filings, regardless of the nature of assets sold, from court dockets through PACER for cases that are filed after 2002, when most US bankruptcy court dockets began e-filing. We are particularly interested in the number of bidders that participated in each auction and the incremental change from the stalking horse's initial bidding price to the winning bidder's final price. The assumption is that both a larger number of bidders and a greater initial-to-final price jump signal a competitive auction process and a potentially more efficient allocation.

[Insert Table 8 Here.]

Table 8 shows the results. In this analysis, each observation represents one auction (which could involve one or more patents sold), and the dependent variables are the number of bidders bidding for the underlying innovation, including the stalking horse, and the price increase from the initial to the final price. We find that more liquid patents attract more bidders to auctions, and the final selling price of a patent represents a larger increase over the starting price. This is consistent with findings in the real asset market that liquid assets are sold more efficiently. To our knowledge, our paper is one of the first to investigate the auction process of asset allocation in US bankruptcies (see also Gilson, Hotchkiss, and Osborn (2016)).[19]

4.4. Financial versus Economic Distress

In the last part of the analysis, we further explore heterogeneities in innovation sales patterns. In specific, we are interested in understanding how the general innovation sale decisions vary by the causes for the Chapter 11 filings.

Firms file for bankruptcy for various reasons. They generally suffer financial distress, economic distress, or a combination of the two. Firms suffering primarily financial distress are economically viable and try to use the bankruptcy process to resolve liquidity and capital structure issues, whereas firms in economic distress tend to use bankruptcy to restructure their businesses, potentially through asset restructuring. Thus, economically distressed firms are expected to have a stronger motive to sell underexploited assets.

Empirically, it is challenging to distinguish firms in financial distress from those in economic distress (Gertner and Scharfstein, 1991). Prior empirical studies use a combination of financial leverage and operating performance to determine the categorization (Asquith, Gertner, and Scharfstein, 1994; Andrade and Kaplan, 1998). According to those studies, firms with high leverage and high operating performance are likely to suffer financial (but not economic) distress. In Table 9, we divide our sample of Chapter 11 firms into terciles using the leverage ratio, and then we create terciles using ROA within each leverage tercile for a total of nine buckets of sample firms. We treat, as being financially distressed, firms in the three buckets that are in both the top tercile of leverage and top tercile of ROA, in the top tercile of ROA and middle tercile of leverage, and in the top

[19] Prior work on bankruptcy auctions is mainly based on the Scandinavian style of mandatory auctions. See Thorburn (2000); Hotchkiss and Mooradian (2003); Eckbo and Thorburn (2003, 2008).

tercile of leverage and middle tercile of ROA as financially distressed firms (Lemmon, Ma, and Tashjian, 2009).

[Insert Table 9 Here.]

Table 9 presents the regression results for the two subsamples of bankrupt firms that suffer financial distress (columns (1) to (3)) and nonfinancial distress (columns (4) to (6)), respectively. The estimates exhibit striking differences. The probability of selling innovation for firms suffering only financial distress is much more sensitive to patent redeployability and market liquidity. These firms also tend to sell better utilized patents. However, the coefficient of *TechCloseness* is no longer statistically significant for these firms. In contrast, firms that suffer economic distress tend to sell patents that are underutilized and are close to their core of innovation. Intuitively, economically distressed firms suffer poor operating performance, potentially due to non-performing core assets. As a result, these firms redeploy such assets for restructuring purposes. However, even in these firms, the tendency to sell liquid patents in order to avoid trading frictions is still pronounced.

The evidence overall suggests that financially distressed firms sell liquid assets to meet financing needs, perhaps at the expense of divesting better utilized patents. Selling strategically core but under-performing patents applies only to firms that suffer potential economic distress and thus have a larger need for asset restructuring.

4.5. Discussions

In this section, we discuss the results documented above and their connections to the broader bankruptcy process.

4.5.1. Sales of Innovation versus Other Assets. The intensity of selling innovation that we document in this study is comparable to that of other asset types, as documented in the literature. For instance, Maksimovic and Phillips (1998) show that manufacturing firms sell 44% to 59% of their plants during bankruptcy reorganization. Bernstein, Colonnelli, and Iverson (2017b) show that 70% of Chapter 11 plants continue to operate under their original owner (and, therefore, 30% of plants are effectively reallocated through asset sales or reassignments of leases) after one year of filing. Gilson, Hotchkiss, and Osborn (2016) show that 53% of their sample firms involve the

sale of some or all of a debtor's assets through §363 sale during reorganization, with 21% of firms selling substantially all their assets as going-concern businesses.

[Insert Figure 5 Here.]

We compare the dynamics of innovation sales and other asset sales in bankruptcy using manually collected US court records. We treat each §363 sale as either "innovation" or "no innovation" by examining the descriptions of assets on sale from §363 sale motions. Figure 5 plots both the total number of these sales from the quarter of filing to four quarters after filing and the quarterly ratio of innovation-related §363 sales to total §363 sales. We find a similar timeliness of asset sales in the quarterly number of §363 sale motions. More interestingly, innovation-related sales occur with greater intensity immediately after bankruptcy filings. In the quarter of filing, nearly 60% of §363 sales are innovation-related, but by the fourth quarter after filing, this ratio drops to 17%. Overall, bankrupt firms sell a disproportionately large number of patents at the early stage of the asset reallocation process. In other words, patents appear to be front-loaded in asset sales.

Why are innovation assets sold particularly actively, and how is this pattern consistent with firms' intentions to avoid trading frictions and to raise financing? There are several reasons to believe that innovation is a unique asset class that best serves the purpose. First, patent reallocation involves minimal adjustment of physical assets and labor, and this significantly lowers the adjustment cost; second, certain innovations in production are mutually nonexclusive among firms, which means that reallocating innovation does not necessarily mandate the termination of related production in the selling firm.

4.5.2. Human Capital Costs of Bankruptcy. One interesting question that remains to be answered is how firms manage the talent loss during the reallocation process of patents (Baghai et al., 2017). Specifically, examining the reallocation of inventors can help us draw inferences on how firms manage the human capital costs of bankruptcy in the asset sale process. It may also help us speak to the importance of the sold innovation to the firm. We conduct the analysis in Table 10 using an inventor-firm-year-level data set extracted from the HBS Patent Database, and each observation

is an inventor l in a firm i for a particular year t. We estimate the following specification:

$$\begin{aligned} InventorMobility_{lit} = \beta_1 \cdot I(PatentBeingSold)_{lit} \times I(InBankruptcy)_{it} \\ + \beta_2 \cdot I(PatentBeingSold)_{lit} + \beta_3 \cdot I(InBankruptcy)_{it} \\ + \lambda \times Control_{lt} + \alpha_l + \varepsilon_{lit}. \end{aligned} \tag{4}$$

$InventorMobility_{lit}$ is a dummy variable indicating whether inventor i at year t moves to another firm in the next three (or five) years. $I(PatentBeingSold)$ equals one if the inventor l has one or more patents sold in year t to a firm at which the inventor is not currently working. $I(InBankruptcy)$ indicates whether year t is the year that firm i files for bankruptcy.

[Insert Table 10 Here.]

In Panel A, we study whether the inventor's patent being sold and the inventor's firm being in bankruptcy affect the inventor's reallocation decision. Normally, inventors of sold innovation leave the firm with a much higher intensity. Inventors also tend to leave a company after it files for bankruptcy—that is, there is a loss of talent and human capital (Graham et al., 2016; Baghai et al., 2017). Interestingly, coefficients associated with $I(PatentBeingSold)_{lit} \times I(InBankruptcy)_{it}$ are negative and marginally significant. This evidence suggests that bankrupt firms retain the inventors of their sold patents after patent deployment. This is in line with the interpretation that firms sell patents for financial reasons but keep the talents associated with them.

In Panel B, we look further at whether a firm's adoption of a Key Employee Retention Plan (KERP) during bankruptcy affects inventor mobility. We find that adopting such plan is an important mechanism for retaining critical employees (Goyal and Wang, 2016). Firms that adopt these plans are better able to retain inventors after patents are sold. The combined evidence suggests that firms undertake necessary actions to avoid loss of talents when selling liquid innovation in consideration of trading frictions and financing needs.

5. Conclusion

This paper provides the first empirical study of innovation reallocation during corporate bankruptcy. We document stylized facts about selling innovation in bankruptcy—its pervasiveness, immedia-

cy, and front-loading in asset reallocations. We then test two alternative economic rationales behind these activities: the asset restructuring view and the financing through asset sales view. We find that firms reallocate patents that are subject to fewer trading frictions—as opposed to selling peripheral or underexploited patents. The effect is stronger for firms that suffer financial (but not economic) distress, have no access to external financing, and experience industry-wide distress. Our evidence is consistent with the view that bankrupt firms sell innovation to satisfy imminent financing needs as opposed to the traditional view of restructuring underexploited assets. We provide corroborating evidence by examining inventor mobility and post-sale patent citations.

Key Variable Definitions

Variable	Definition and Construction
	a. Innovation and Its Liquidity
MFT Liquidity	A patent-year level variable, calculated as the ratio of transacted patents in the patent's technology class over the patent stock in that class.
Redeployability	Proxy for the degree to which the value of a patent is redeployable by other firms—measured as the share of citations to that patent within three years that are made by other firms (i.e., non-self citations).
Patent Utilization	Total citations received in the past three years.
Tech Closeness	Calculated as the generalized mean between the patent and the whole patent portfolio owned by the firm, following Akcigit, Celik, and Greenwood (2016).
Young Patent	Equals one if the patent is granted no earlier than six years prior.
Scaled Citations	Citations received in the first three years of a patent's life scaled by this three-year citation of patents from its own vintage and technology class.
Litigation	Equals one if the patent is in litigation, and zero otherwise.
	b. Bankruptcy Case Characteristics
Prepack	An indicator variable that takes a value of one if a bankruptcy is prepackaged or prenegotiated. According to the definition by LoPucki UCLA database, a case is prepackaged if the debtor drafted the plan, submitted it to a vote of the impaired classes, and claimed to have obtained the acceptance necessary for consensual confirmation before filing. On the other hand, if the debtor negotiates the plan with fewer than all groups or obtains the acceptance of fewer than all groups necessary to confirm before the bankruptcy case is filed, then the case is regarded as prenegotiated.
DIP Financing	An indicator variable that takes a value of one if the bankrupt firm receives court approval of debtor-in-possession (DIP) financing.
Financial Distress	An indicator variable that takes a value of one if the bankrupt firm experiences financial (but not economic) distress, which is defined as firms in the top tercile in ROA and the top tercile in leverage, or in the top tercile in ROA/leverage and middle tercile in leverage of our sample firms.
Duration	Number of days in bankruptcy, from the date of filing to the date of plan confirmation.
	c. Industry Conditions
Distress (Return)	An indicator variable showing whether the median stock return for an industry (3-digit SIC) in that year is less than or equal to -20%, in the spirit of Gilson, John, and Lang (1990) and Acharya, Bharath, and Srinivasan (2007).
Distress (Sales)	An indicator variable showing whether an industry (3-digit SIC) is at the bottom decile of sales growth in that year (Gilson, Hotchkiss, and Osborn, 2016).
	d. Firm Characteristics

Assets	Total book assets in millions, adjusted to 2007 US dollars.
Size	The natural logarithm of total book assets, in millions, adjusted to 2007 US dollars.
Leverage	Book debt value scaled by total assets.
Sales growth	The growth of net sales from t to t-1.
ROA	Earnings before interest, taxes, depreciation, and amortization scaled by total assets.
R&D/Assets	Research and development expenses scaled by total assets.

REFERENCES

Acharya, Viral V, Sreedhar T Bharath, and Anand Srinivasan, 2007, Does industry-wide distress affect defaulted firms? evidence from creditor recoveries, *Journal of Financial Economics* 85, 787–821.

Aghion, Philippe, Oliver Hart, and John Moore, 1992, The economics of bankruptcy reform, *Journal of Law, Economics, & Organization* 8, 523–546.

Akcigit, Ufuk, Murat Alp Celik, and Jeremy Greenwood, 2016, Buy, keep, or sell: Economic growth and the market for ideas, *Econometrica* 84, 943–984.

Andrade, Gregor, and Steven N. Kaplan, 1998, How costly is financial (not economic) distress? evidence from highly leveraged transactions that became distressed, *Journal of Finance* 53, 1443–1493.

Arora, Ashish, and Alfonso Gambardella, 2010, The market for technology, *Handbook of the Economics of Innovation* 1, 641–678.

Asquith, Paul, Robert Gertner, and David Scharfstein, 1994, Anatomy of financial distress: An examination of junk-bond issuers, *The Quarterly Journal of Economics* 109, 625–658.

Ayotte, Kenneth, and David A Skeel, 2013, Bankruptcy law as a liquidity provider, *The University of Chicago Law Review* 1557–1624.

Ayotte, Kenneth M, and Edward R Morrison, 2009, Creditor control and conflict in chapter 11, *Journal of Legal Analysis* 1, 511–551.

Baghai, Ramin, Rui Silva, Viktor Thell, and Vikrant Vig, 2017, Talent in distressed firms: investigating the labor costs of financial distress1, *Available at SSRN 2854858* .

Baird, Douglas G, and Bob Rasmussen, 2002, The end of bankruptcy, *Stanford Law Review* 55.

Benmelech, Efraim, 2009, Asset salability and debt maturity: Evidence from nineteenth-century american railroads, *Review of Financial studies* 22, 1545–1584.

Benmelech, Efraim, and Nittai K Bergman, 2008, Liquidation values and the credibility of financial contract renegotiation: Evidence from us airlines, *The Quarterly Journal of Economics* 1635–1677.

Benmelech, Efraim, and Nittai K Bergman, 2011, Bankruptcy and the collateral channel, *Journal of Finance* 66, 337–378.

Bernstein, Shai, Emanuele Colonnelli, Xavier Giroud, and Benjamin Charles Iverson, 2017a, Bankruptcy spillovers, *Available at SSRN* .

Bernstein, Shai, Emanuele Colonnelli, and Benjamin Charles Iverson, 2017b, Asset reallocation in bankruptcy, *Journal of Finance* Forthcoming.

Brav, Alon, Wei Jiang, Song Ma, and Xuan Tian, 2017, How does hedge fund activism reshape corporate innovation, *Journal of Financial Economics* Forthcoming.

Corrado, Carol A, and Charles R Hulten, 2010, How do you measure a" technological revolution"?, *The American Economic Review* 100, 99–104.

Dahiya, Sandeep, Kose John, Manju Puri, and Gabriel Ramırez, 2003, Debtor-in-possession financing and bankruptcy resolution: Empirical evidence, *Journal of Financial Economics* 69, 259–280.

Eckbo, Espen, and Karin Thorburn, 2003, Control benefits and ceo discipline in automatic bankruptcy auctions, *Journal of Financial Economics* 69, 227–258.

Eckbo, Espen, and Karin Thorburn, 2008, Automatic bankruptcy auctions and fire-sales, *Journal of Financial Economics* 89, 409–422.

Ederer, Florian, and Gustavo Manso, 2011, Incentives for innovation: Bankruptcy, corporate governance, and compensation systems, *Handbook of Law, Innovation, and Growth* 90–111.

Edmans, Alex, and William Mann, 2016, Financing through asset sales, *NBER Working Paper Series* 18677.

Farre-Mensa, Joan, Deepak Hegde, and Alexander Ljungqvist, 2016, The bright side of patents, *Available at SSRN* .

Franks, Julian R, and Walter N Torous, 1989, An empirical investigation of us firms in reorganization, *Journal of Finance* 44, 747–769.

Galasso, Alberto, Mark Schankerman, and Carlos J Serrano, 2013, Trading and enforcing patent rights, *The RAND Journal of Economics* 44, 275–312.

Gans, Joshua, and Scott Stern, 2010, Is there a market for ideas?, *Industrial and Corporate Change* 19, 805–837.

Gavazza, Alessandro, 2011, The role of trading frictions in real asset markets, *American Economic Review* 101, 1106–1143.

Gertner, Robert, and David Scharfstein, 1991, A theory of workouts and the effects of reorganization law, *Journal of Finance* 46, 1189–1222.

Gilson, Stuart C, Edith S Hotchkiss, and Matthew G Osborn, 2016, Cashing out: The rise of m&a in bankruptcy, *Available at SSRN 2547168* .

Gilson, Stuart C, Kose John, and Larry HP Lang, 1990, Troubled debt restructurings: An empirical study of private reorganization of firms in default, *Journal of Financial Economics* 27, 315–353.

Goyal, Vidhan, and Wei Wang, 2016, Provision of management incentives in bankrupt firms, *Journal of Law, Finance, and Accounting* .

Graham, John, Hyunseob Kim, Si Li, and Jiaping Qiu, 2016, Employee costs of corporate bankruptcy, *Available at SSRN 2276753* .

Graham, Stuart JH, Alan C Marco, and Amanda F Myers, 2017, Lessons from the uspto patent assignment dataset, *Journal of Economics and Management Strategy* Forthcoming.

Granja, Joao, Gregor Matvos, and Amit Seru, 2017, Selling failed banks, *Journal of Finance* 72, 1723–1784.

Hagiu, Andrei, and David B Yoffie, 2013, The new patent intermediaries: platforms, defensive aggregators, and super-aggregators, *The Journal of Economic Perspectives* 27, 45–65.

Hart, Oliver, and John Moore, 1998, Default and renegotiation: a dynamic model of debt, *Quarterly Journal of Economics* 113, 1–41.

Hochberg, Yael V, Carlos J Serrano, and Rosemarie H Ziedonis, 2017, Patent collateral, investor commitment, and the market for venture lending, *Journal of Financial Economics* Forthcoming.

Hoetker, Glenn, and Rajshree Agarwal, 2007, Death hurts, but it isn't fatal: The postexit diffusion of knowledge created by innovative companies, *Academy of Management Journal* 50, 446–467.

Hotchkiss, Edith S, Kose John, Karin S Thorburn, and Robert M Mooradian, 2008, Bankruptcy and the resolution of financial distress, *Handbook of Empirical Corporate Finance: Empirical Corporate Finance* 2, 235.

Hotchkiss, Edith S., and Robert T Mooradian, 2003, Auctions in bankruptcy, *Journal of Corporate Finance* 9, 555–574.

Jackson, Thomas H., 1986, *The Logit and Limits of Bankruptcy Law* (Harvard University Press, Cambridge).

Jaffe, Adam B., and Manuel Trajtenberg, 2002, *Patents, citations, and innovations: A window on the knowledge economy* (MIT Press: Cambridge, MA).

Kogan, Leonid, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman, 2017, Technological innovation, resource allocation, and growth, *The Quarterly Journal of Economics* 132, 665–712.

Lang, Larry, Annette Poulsen, and Rene Stulz, 1995, Asset sales, firm performance, and the agency costs of managerial discretion, *Journal of financial economics* 37, 3–37.

Lemmon, Michael L., Yung-Yu Ma, and Elizabeth Tashjian, 2009, Survival of the fittest? financial and economic distress and restructuring outcomes in chapter 11, *Available at SSRN 1325562* .

Lerner, Josh, Morten Sorensen, and Per Strömberg, 2011, Private equity and long-run investment: The case of innovation, *Journal of Finance* 66, 445–477.

Li, Kai, and Wei Wang, 2016, Debtor-in-possession financing, loan-to-loan, and loan-to-own, *Journal of Corporate Finance* 39, 121–138.

Ma, Song, 2016, The life cycle of corporate venture capital, *Available at SSRN 2691210* .

Maksimovic, Vojislav, and Gordon Phillips, 1998, Asset efficiency and reallocation decisions of bankrupt firms, *Journal of Finance* 53, 1495–1532.

Mann, William, 2017, Creditor rights and innovation: Evidence from patent collateral, *Journal of Financial Economics* Forthcoming.

Manso, Gustavo, 2011, Motivating innovation, *Journal of Finance* 66, 1823–1860.

Marx, Matt, Deborah Strumsky, and Lee Fleming, 2009, Mobility, skills, and the michigan non-compete experiment, *Management Science* 55, 875–889.

Meier, Jean-Marie A, and Henri Servaes, 2016, The bright side of fire sales, *Management Science* Forthcoming.

Peters, Ryan H, and Lucian A Taylor, 2017, Intangible capital and the investment-q relation, *Journal of Financial Economics* 123, 251–272.

Pulvino, Todd C, 1998, Do asset fire sales exist? an empirical investigation of commercial aircraft transactions, *Journal of Finance* 53, 939–978.

Pulvino, Todd C, 1999, Effects of bankruptcy court protection on asset sales, *Journal of Financial Economics* 52, 151–186.

Ramey, Valerie A, and Matthew D Shapiro, 2001, Displaced capital: A study of aerospace plant closings, *Journal of Political Economy* 109, 958–992.

Roe, Mark J, and Frederick Tung, 2013, Breaking bankruptcy priority: How rent-seeking upends the creditors'bargain, *Virginia Law Review* 1235–1290.

Schlingemann, Frederik P, Rene M Stulz, and Ralph A Walkling, 2002, Divestitures and the liquidity of the market for corporate assets, *Journal of Financial Economics* 64, 117–144.

Schumpeter, Joseph Alois, 1942, *Socialism, capitalism and democracy* (Harper and Brothers).

Schwartz, Alan, 2005, A normative theory of business bankruptcy, *Virginia Law Review* 1199–1265.

Serrano, Carlos J., 2010, The dynamics of the transfer and renewal of patents, *RAND Journal of Economics* 41, 686–708.

Sharpe, Steven A, and Hien H Nguyen, 1995, Capital market imperfections and the incentive to lease, *Journal of Financial Economics* 39, 271–294.

Shleifer, Andrei, and Robert W Vishny, 1992, Liquidation values and debt capacity: A market equilibrium approach, *Journal of Finance* 47, 1343–1366.

Skeel, David A, 2003, The past, present, and future of debtor-in-possession financing, *Cardozo Law Review* 1905–1934.

Slovin, Myron B, Marie E Sushka, and John A Polonchek, 1990, Corporate sale-and-leasebacks and shareholder wealth, *Journal of Finance* 45, 289–299.

Thorburn, Karin, 2000, Bankruptcy auctions: costs, debt recovery, and firm survival, *Journal of Financial Economics* 58, 337–368.

Williamson, Oliver, 1988, Corporate finance and corporate governance, *Journal of Finance* 43, 567–91.

Figure 1. Legal Process of Selling Innovation through §363 in Bankruptcy

This figure illustrates the legal process of selling innovation through §363 in bankruptcy. The starting point is when the §363 sale motion is filed, and the ending point is the judicial order approving the sale. The illustrated process can be generalized to sales of other assets.

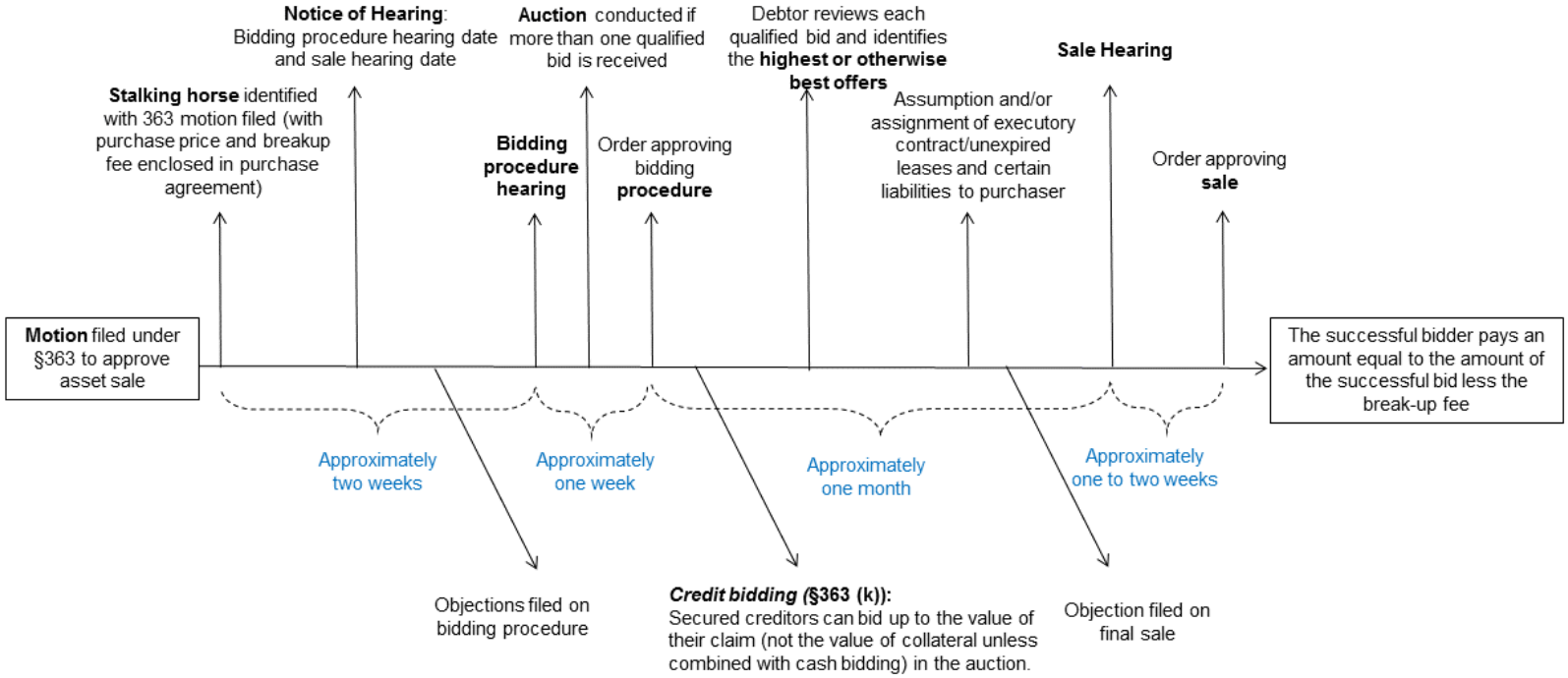
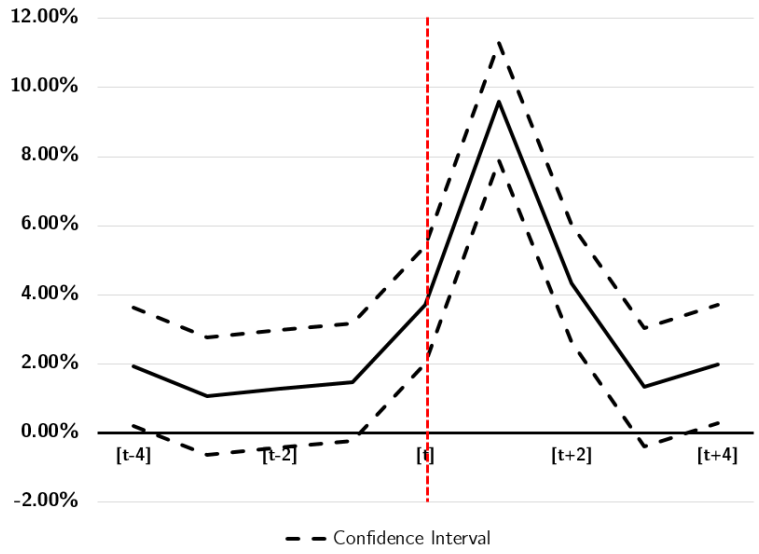


Figure 2. Selling Patents around Bankruptcy Filings

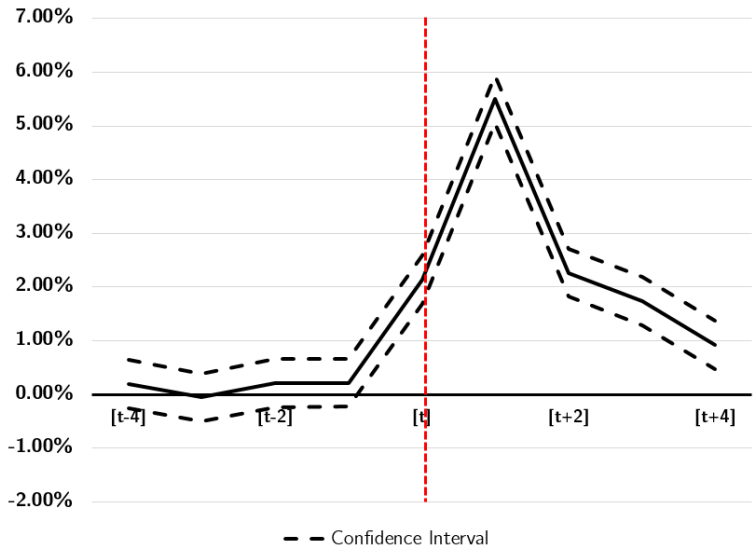
This figure presents the dynamics of the intensity of selling innovation from four quarters before the filing of bankruptcy to four quarters after the filing. We perform the analysis on a firm-quarter panel of all US public firms that have at least one valid patent grant from the USPTO (that is, a firm is included into the sample after its first patent is issued). Dependent variables are the dummy variable indicating whether the firm sold any patents in that quarter (Panel (a)) and the ratio (can be 0) of patents sold over the size of the firm's patent stock as of the beginning of the quarter (Panel (b)). The coefficients and 95% confidence intervals are estimated from the following specification:

$$Selling_{it} = \sum_{k=-4}^{4} \beta_k \, d[t+k] + \lambda \times Control_{it} + \alpha_i + \alpha_t + \varepsilon_{it}.$$

Independent variables of interest are the set of dummies, $d[t-4], \ldots, d[t+4]$, indicating whether the firm-quarter observation fits into the $[-4,+4]$ time frame of the bankruptcy event. We plot the β_k coefficients, which are the estimates representing the differences in trends in selling between bankrupt firms and the benchmark of public firms. We include both firm and year fixed effects in the estimation to absorb time-invariant selling intensity at the firm level, as well as time trends in the market for innovation. Standard errors are clustered at the firm level.



(a) Probability of Selling Innovation



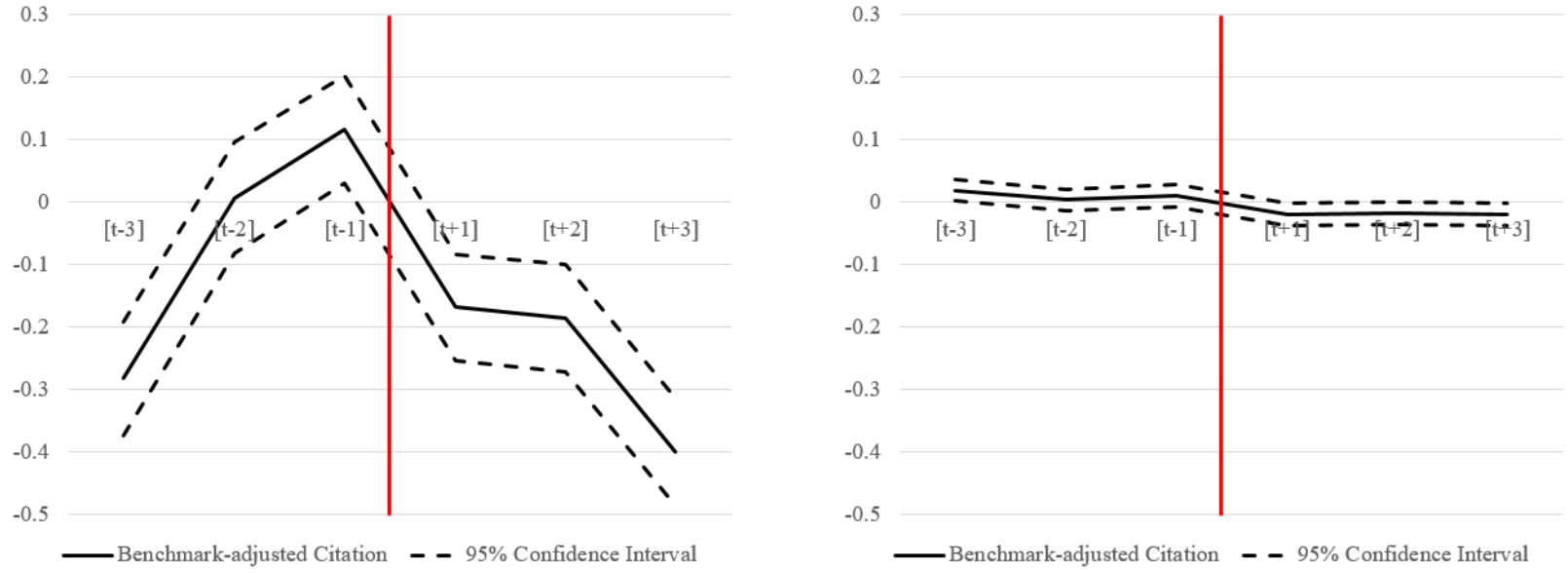
(b) Ratio of Innovation Sold (%)

Figure 3. Citation Dynamics around Patent Transactions of Bankrupt Firms

This figure plots the coefficients β_k from the following regression at the patent (p)-year (t) level:

$$Citation_{pt} = \sum_{k=-3}^{+3} \beta_k \cdot d[t+k]_{pt} + \gamma \cdot Controls_{pt} + \alpha_p + \alpha_t + \varepsilon_{pt}.$$

$Citation_{pt}$ is the number of new citations a patent receives in a given year, and we separately estimate using the total citations received by the patent (Panel (a)) and those received from the bankrupt firm that sold the patent (Panel (b)). The dummy variable $d[t+k]$ is equal to one if the patent observation is k years from the sale of the patent, and zero otherwise. We run the regression for patents sold by bankrupt firms around the bankruptcy filing. We control for patent age, measured as the logarithm of the patent age in year t. We also include year and patent fixed effects, α_t and α_p. Standard errors are clustered at the firm level.

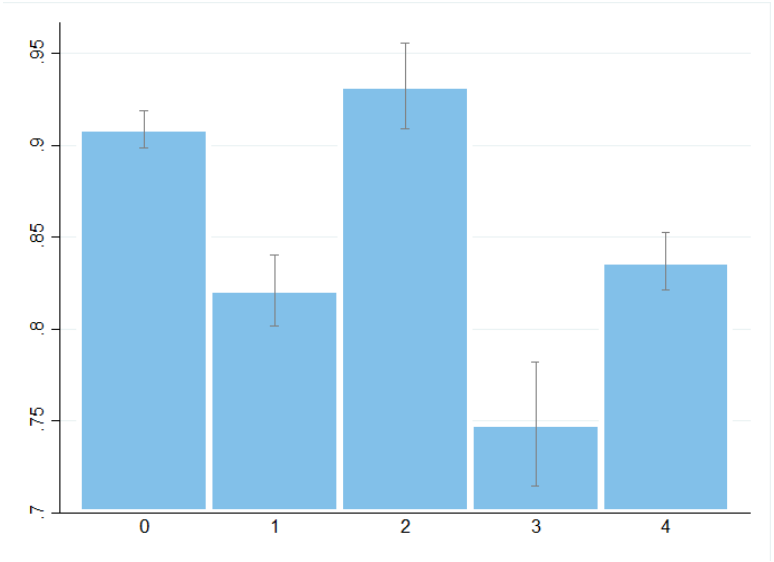


(a) Total Citations Received by the Patent

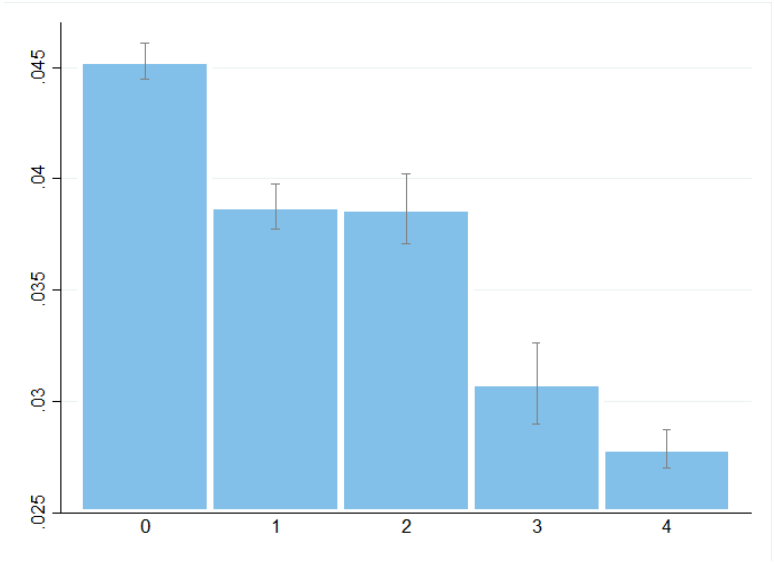
(b) Citations Received from the Bankrupt Firm Itself

Figure 4. Liquidity Pecking Order of Patents Sold in Bankruptcy

This figure studies the time-series trend of sold patents' *Redeployability* (Panel (a)) and *MFT Liquidity* (Panel (b)) during the bankruptcy restructuring processes. The y-axis is the mean of these measures, the x-axis indicates the quarter relative to the bankruptcy filing date. Mean estimates are plotted (in bars) along with their 95% confidence intervals (in lines).



(a) Redeployability



(b) MFT Liquidity

Figure 5. Innovation-Related Sales in §363 Asset Sales

This figure plots both the total number of §363 sales from the quarter of filing to four quarters after the filing, and the quarterly ratio of innovation-related §363 sales to total §363 sales. §363 sales cases are manually collected from US court records, and each of the collected §363 sales is coded as "innovation" or "no innovation" based on asset descriptions in the motion of sales and order of sales. The percentage of sales with innovation is presented in bars, and the total number of sales is presented in dots.

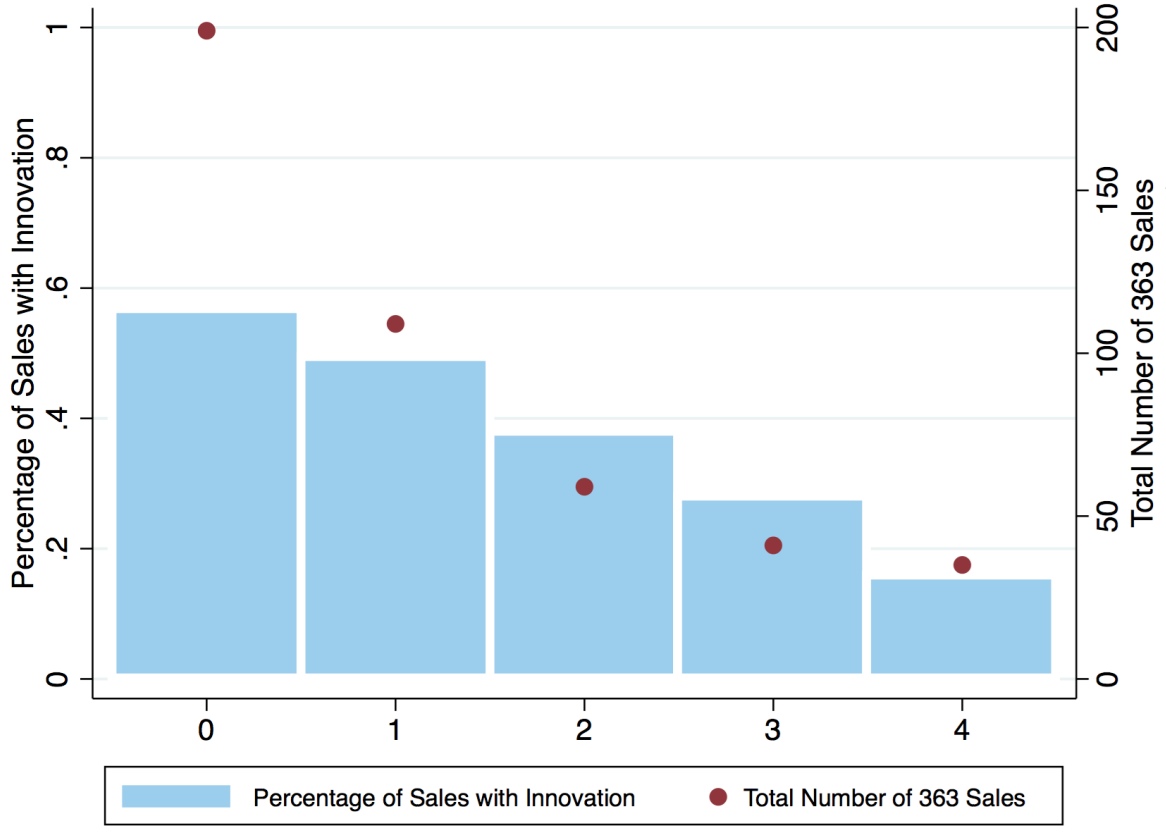


Table 1
Overview of Bankrupt Firms and Innovation Transactions

This table provides an overview of the sample of bankrupt firms and their innovation (patents)-selling activities during the bankruptcy reorganization process. The sample is tabulated by the Fama-French 12 industry classification (Panel A) and by year (Panel B). The sample covers all Chapter 11 bankruptcies filed by US public companies from 1981 to 2012, resolved as of mid-2016, and is manually matched with Compustat. We remove cases of financial corporations. Financial, operation, and case information is collected from case petitions, Compustat/CRSP, CapitalIQ, and PACER. The patent-holding information of each firm from 1976 to 2006 is accessed using the NBER patent database; we extend that database to 2012 using Bhaven Sampat's USPTO patent and citation data. Patent transactions are obtained from the USPTO patent reassignment database from 1976 to 2015.

In each panel, we report the number of bankrupt firms in each industry/year and the number of innovative firms (defined as those owning at least one patent at the time of bankruptcy filing). We report the proportion of firms that sold at least one patent during bankruptcy periods, and the ratio of patents that were sold (the ratio of sold patents is defined as zero for firms that sold no patents). Patent-selling activities are reported for the bankruptcy reorganization process—that is, between the bankruptcy filing date and the confirmation date of the reorganizing plan.

Panel A: Bankruptcy Cases and Patent Transactions by Fama-French 12 Industries

	Number of Observations		Selling [Filing, Confirmation]	
	Full Sample	Innovative Sample	% of Firms	% of Patents
Consumer Non-durables	132	49	29%	18%
Consumer Durables	77	44	52%	11%
Manufacturing	192	117	33%	10%
Oil	68	5	40%	40%
Chemicals	36	16	38%	6%
Business Equipment	231	127	46%	24%
Telecommunication	126	16	38%	31%
Utilities	24	9	44%	24%
Wholesale and Retail	305	33	24%	15%
Health care	127	48	56%	29%
Other Industries	305	54	35%	15%
Total	1,623	518	40%	18%

Panel B: Bankruptcy Cases and Patent Transactions by Filing Year

	Number of Observations		Selling [Filing, Confirmation]	
	Full Sample	Innovative Sample	% of Firms	% of Patents
1981	0	0	-	-
1982	3	1	0%	0%
1983	1	0	-	-
1984	0	0	-	-
1985	5	2	0%	0%
1986	8	4	50%	17%
1987	6	2	100%	29%
1988	14	5	20%	10%
1989	20	6	50%	21%
1990	30	10	20%	10%
1991	40	11	18%	9%
1992	41	11	18%	1%
1993	48	12	33%	5%
1994	34	8	38%	26%
1995	44	6	67%	20%
1996	43	13	31%	14%
1997	42	7	57%	36%
1998	61	18	33%	20%
1999	99	21	48%	21%
2000	118	33	52%	23%
2001	187	49	45%	22%
2002	160	57	39%	21%
2003	113	48	44%	22%
2004	62	25	32%	15%
2005	59	27	44%	15%
2006	42	17	47%	15%
2007	38	15	27%	17%
2008	67	24	25%	15%
2009	122	52	50%	16%
2010	45	11	18%	12%
2011	40	14	14%	10%
2012	31	9	67%	43%
Total	1,623	518	40%	18%

Table 2
The Dynamics of Innovation Sales in Bankruptcy

This table tests whether bankrupt firms are more likely to sell patents during bankruptcy and the time-series dynamics of such transactions. We construct a firm-quarter panel of all US public firms that have at least one valid patent grant from the USPTO (that is, a firm is included in the sample after its first patent is issued). The dependent variable is the dummy variable indicating whether the firm sells any patent in that quarter (columns (1) and (2)) and the ratio (can be 0) of patents sold over the size of the firm's patent stock as of the beginning of the quarter (columns (3) and (4)). In columns (1) and (3), the key independent variable is a dummy variable, *I(InBankruptcy)*, indicating whether the firm is undergoing bankruptcy in that quarter (between the bankruptcy filing and the confirmation of the reorganization plan). Specifically, we exploit the following model:

$$Selling_{it} = \beta\ I(InBankruptcy)_{it} + \lambda \times Control_{it} + \alpha_i + \alpha_t + \varepsilon_{it}.$$

In columns (2) and (4), the analysis is extended to characterize the dynamics of selling innovation around bankruptcy. Specifically, we exploit the following model:

$$Selling_{it} = \sum_{k=-4}^{4} \beta_k\ d[t+k]_{it} + \lambda \times Control_{it} + \alpha_i + \alpha_t + \varepsilon_{it}.$$

Independent variables of interest are the set of dummies, $d[t-4], ..., d[t+4]$, indicating whether the firm-quarter observation fits into the $[-4,+4]$ time frame of the bankruptcy filing. We include both firm and year fixed effects to absorb time-invariant selling intensity at the firm level, as well as time trends in the market for innovation. The t-statistics based on standard errors clustered at the firm level are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
	Patent Being Sold		% of Patents Sold	
I(In Bankruptcy)	0.039***		0.022***	
	(10.828)		(23.784)	
d[t-4]		0.019**		0.002
		(2.192)		(0.842)
d[t-3]		0.011		-0.001
		(1.219)		(-0.245)
d[t-2]		0.013		0.002
		(1.465)		(0.948)
d[t-1]		0.015*		0.002
		(1.695)		(0.969)
d[t]		0.037***		0.021***
		(4.274)		(9.427)
d[t+1]		0.096***		0.055***
		(11.054)		(24.207)
d[t+2]		0.043***		0.023***
		(4.984)		(9.961)
d[t+3]		0.013		0.017***
		(1.521)		(7.621)
d[t+4]		0.020**		0.009***
		(2.273)		(4.012)
Observations	732,208	732,208	732,208	732,208
R-squared	0.246	0.246	0.021	0.021
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
F-Test				
d[t]-d[t-1]		3.349		36.12
p-value		0.067*		0.000***
d[t+1]-d[t-1]		44.28		273.10
p-value		0.000***		0.000***
d[t+2]-d[t-1]		5.484		40.97
p-value		0.019**		0.000***

Table 3
Summary of Bankrupt Firms and Their Patents

This table reports summary statistics of bankrupt firms and their patents owned at the time of filing bankruptcy. The sample covers all Chapter 11 bankruptcies filed by US public companies from 1981 to 2012, resolved as of mid-2016, and is manually matched with Compustat. We remove cases of financial corporations. The patent-holding information of each firm from 1976 to 2006 is accessed using the NBER patent database; we extend that database to 2012 using Bhaven Sampat's USPTO patent and citation data. Patent transactions are obtained from the USPTO patent reassignment database from 1976 to 2015.

Panel A reports patent-level information. Panel B reports firm-level information collected from case petitions, Compustat/CRSP, CapitalIQ, and PACER. Detailed variable definitions can be found in Section 2 of the paper and the Appendix. The variable values are measured as of the year before bankruptcy filing. For each variable, we report the mean, standard deviation, and 25th, 50th, and 75th percentiles.

Panel A: Summary Statistics of Patents Owned by Bankrupt Firms

	Patents(N=59,589)				
	Mean	Std.Dev	p25	p50	p75
Redeployability	0.783	0.330	0.667	1.000	1.000
MFT Liquidity	0.033	0.022	0.021	0.030	0.039
Tech Closeness	0.578	0.303	0.331	0.564	0.863
Patent Utilization	1.930	4.819	0	0	2
Scaled Citations	1.314	1.608	0.449	0.864	1.614
Patent Age (Years)	15.142	8.076	9	14	20

Panel B: Summary Statistics of Bankrupt Innovative Firms

	Number of Cases (N=518)				
	Mean	Std.Dev	p25	p50	p75
Prepack	0.197	0.398	0.000	0.000	0.000
DIP Financing	0.550	0.498	0.000	1.000	1.000
Duration (days)	511	538	203	369	641
Outcome (Acquired)	0.127	0.334	0.000	0.000	0.000
Outcome (Converted)	0.122	0.327	0.000	0.000	0.000
Outcome (Emerged)	0.512	0.500	0.000	1.000	1.000
Outcome (Liquidated)	0.239	0.427	0.000	0.000	0.000
Assets	972.825	5569.812	23.160	93.974	302.130
Leverage	0.589	0.502	0.232	0.507	0.806
Sales growth	0.275	1.612	-0.198	-0.025	0.159
ROA	-0.294	0.530	-0.412	-0.140	0.004
R&D/Assets	0.114	0.201	0.004	0.028	0.133
Patent Stock	175.145	1284.467	3.000	13.000	39.000
Distress (Stock Return)	0.288	0.453	0.000	0.000	1.000
Distress (Sales)	0.158	0.365	0.000	0.000	0.000

Table 4
The Determinants of Patent Sales in Bankruptcy

This table presents how innovation reallocation decisions in bankruptcy are affected by patent-level characteristics. The analysis is conducted on a patent-level data set, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of bankruptcy filing, using the following model:

$$\begin{aligned} Sold_{ip} = {} & \beta_1 \cdot Redeployability_{ip} + \beta_2 \cdot MFTLiquidity_{ip} \\ & + \gamma_1 \cdot Utilization_{ip} + \gamma_2 \cdot TechCloseness_{ip} \\ & + \lambda \times Control_{ip} + \alpha_i + \varepsilon_{ip}. \end{aligned}$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating whether patent p is sold during the bankruptcy reorganization process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. *Redeployability* captures the extent that the patent is utilized by firms other than the owning firm, and *MFT Liquidity* captures the liquidity of the market specific to the patent's technology class; *Utilization* is the number of total citations received by the patents in the most recent three years, and *Tech Closeness*, which is the distance between the patent and the firm's core technological expertise. For patent age, *Young Patent* equals one if the patent was granted up to six years before the bankruptcy filing. Scaled citations is the number of citations received in the first three years of a patent's life, scaled by this three-year citation of patents from its own vintage and technology class. More details regarding those variables are described in the Appendix. In columns (1) to (5), the sample includes patents owned by all bankrupt public firms between 1980 and 2012; in column (6), we include patents owned by the sample of bankrupt firms that eventually emerged from bankruptcy; in column (7), we exclude cases that are prepackaged. All specifications include firm fixed effects. The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Patent Being Sold						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Redeployability	0.025***				0.026***	0.023***	0.027***
	(8.655)				(8.868)	(8.093)	(8.356)
MFT Liquidity		0.194***			0.212***	0.086**	0.240***
		(4.424)			(4.809)	(2.038)	(5.152)
Patent Utilization			0.000*		0.000	0.000	0.001*
			(1.831)		(1.289)	(1.161)	(1.760)
Tech Closeness				0.018***	0.022***	0.014***	0.023***
				(5.489)	(6.556)	(4.194)	(6.100)
Young Patent	0.037***	0.037***	0.037***	0.037***	0.037***	0.021***	0.050***
	(11.583)	(11.555)	(11.692)	(11.711)	(11.529)	(6.609)	(13.299)
Scaled Citations	0.004***	0.004***	0.003***	0.004***	0.003***	0.003***	0.004***
	(6.031)	(6.123)	(4.690)	(6.256)	(4.996)	(4.977)	(5.050)
Observations	59,589	59,589	59,589	59,589	59,589	50,850	51,868
R-squared	0.285	0.284	0.284	0.284	0.285	0.097	0.290
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
All Firms	Yes	Yes	Yes	Yes	Yes		
Emerged Firms Only						Yes	
Exclude Prepackaged							Yes

Table 5
The Effect of Industry Conditions

This table presents how innovation reallocation decisions in bankruptcy are affected by the redeployability and MFT liquidity associated with a specific patent, conditional on industry conditions. The analysis is conducted on a patent-level data set, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model:

$$\begin{aligned} Sold_{ip} = {} & \beta_1 \cdot Redeployability_{ip} + \beta_2 \cdot MFTLiquidity_{ip} \\ & + \gamma_1 \cdot Utilization_{ip} + \gamma_2 \cdot TechCloseness_{ip} \\ & + \lambda \times Control_{ip} + \alpha_i + \varepsilon_{ip}. \end{aligned}$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating whether patent p is sold during the bankruptcy reorganization process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. *Redeployability* captures the extent that the patent is utilized by firms other than the owning firm, and *MFT Liquidity* captures the liquidity of the market specific to the patent's technology class; *Utilization* is the number of total citations received by the patents in the most recent three years, and *Tech Closeness*, which is the distance between the patent and the firm's core technological expertise. In Panel A, we split the sample based on whether the median stock return for this industry in that year is less than or equal to -20%, in the spirit of Gilson, John, and Lang (1990) and Acharya, Bharath, and Srinivasan (2007). In Panel B, we split the sample based on whether the industry is at the bottom decile of sales growth in that year (Gilson, Hotchkiss, and Osborn, 2016). We control for *Young Patent* and total scaled citations for all columns. All specifications include firm fixed effects. The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Industry Distress Defined by Median Industry Stock Returns

	Patent Being Sold					
	(1)	(2)	(3)	(4)	(5)	(6)
	Distress	Non-distress	T-Test	Distress	Non-distress	T-Test
Redeployability	0.064***	0.023***	0.041***			
	(4.845)	(7.771)	(3.502)			
MFT Liquidity				0.679**	0.211***	0.468**
				(2.210)	(4.872)	(2.414)
Observations	5,181	54,406		5,181	54,406	
R-squared	0.335	0.265		0.333	0.265	
Controls	Yes	Yes		Yes	Yes	
Firm FE	Yes	Yes		Yes	Yes	

Panel B: Industry Distress Defined by Median Industry Sales Growth

	(1)	(2)	(3)	(4)	(5)	(6)
	Distress	Non-distress	T-Test	Distress	Non-distress	T-Test
Redeployability	0.114***	0.022***	0.092***			
	(4.892)	(7.987)	(5.802)			
MFT Liquidity				3.913***	0.075*	3.838***
				(9.763)	(1.789)	(16.121)
Observations	4,480	55,109		4,480	55,109	
R-squared	0.361	0.203		0.371	0.203	
Controls	Yes	Yes		Yes	Yes	
Firm FE	Yes	Yes		Yes	Yes	

Table 6
The Role of DIP Financing

This table presents how innovation reallocation decisions in bankruptcy are affected by the liquidity associated with a specific patent, conditional on whether the firms have DIP financing during bankruptcy. The analysis is conducted using a patent-level data set, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model:

$$\begin{aligned} Sold_{ip} = {} & \beta_1 \cdot Redeployability_{ip} + \beta_2 \cdot MFTLiquidity_{ip} \\ & + \gamma_1 \cdot Utilization_{ip} + \gamma_2 \cdot TechCloseness_{ip} \\ & + \lambda \times Control_{ip} + \alpha_i + \varepsilon_{ip}. \end{aligned}$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating whether patent p is sold during the bankruptcy reorganization process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. *Redeployability* captures the extent that the patent is utilized by firms other than the owning firm, and *MFT Liquidity* captures the liquidity of the market specific to the patent's technology class; *Utilization* is the number of total citations received by the patents in the most recent three years, and *Tech Closeness*, which is the distance between the patent and the firm's core technological expertise. The sample is split into "With DIP" and "No DIP" based on whether the bankrupt firm receives DIP financing during the bankruptcy reorganization process (from bankruptcy filing to the confirmation of the restructuring plan). We control for *Young Patent* and total scaled citations for all columns. All specifications include firm fixed effects. The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Patent Being Sold					
	(1)	(2)	(3)	(4)	(5)	(6)
	With DIP	No DIP	T-Test	With DIP	No DIP	T-Test
Redeployability	0.024***	0.039***	-0.015**			
	(8.052)	(4.211)	(-2.213)			
MFT Liquidity				0.093**	1.836***	-1.743***
				(2.119)	(9.844)	(-9.314)
Observations	47,171	12,416		47,171	12,416	
R-squared	0.112	0.506		0.111	0.509	
Controls	Yes	Yes		Yes	Yes	
Firm FE	Yes	Yes		Yes	Yes	

Table 7
Patent Litigation and the Reallocation of Innovation in Bankruptcy

This table presents how innovation reallocation decisions in bankruptcy are affected by the litigation status of a patent, in addition to its asset liquidity. The analysis is conducted on a patent-level data set, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model:

$$\begin{aligned} Sold_{ip} = {} & \beta_L \cdot Litigation \\ & + \beta_1 \cdot Redeployability_{ip} + \beta_2 \cdot MFTLiquidity_{ip} \\ & + \gamma_1 \cdot Utilization_{ip} + \gamma_2 \cdot TechCloseness_{ip} \\ & + \lambda \times Control_{ip} + \alpha_i + \varepsilon_{ip}. \end{aligned}$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating whether patent p is sold during the bankruptcy reorganization process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. *Litigation* is a dummy variable indicating whether a patent is in litigation at the time of the bankruptcy filing. *Redeployability* captures the extent that the patent is utilized by firms other than the owning firm, and *MFT Liquidity* captures the liquidity of the market specific to the patent's technology class; *Utilization* is the number of total citations received by the patents in the most recent three years, and *Tech Closeness*, which is the distance between the patent and the firm's core technological expertise. We control for *Young Patent* and total scaled citations for all columns. All specifications include firm fixed effects. The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Patent Being Sold				
	(1)	(2)	(3)	(4)	(5)
Litigation	0.040***	0.040***	0.038***	0.039***	0.037***
	(4.042)	(4.042)	(3.628)	(3.858)	(3.520)
Redeployability	0.030***				0.026***
	(10.449)				(8.857)
MFT Liquidity		0.193***			0.211***
		(4.432)			(4.786)
Patent Utilization			0.000**		0.000
			(1.976)		(1.126)
Tech Closeness				0.019***	0.022***
				(5.859)	(6.531)
Observations	59,589	59,589	59,589	59,589	59,589
R-squared	0.296	0.295	0.287	0.293	0.287
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes

Table 8
Evidence from §363 Asset Auctions

This table studies how the auction process of innovation sales by bankrupt firms. The analysis is conducted in a setting of selling innovation by bankrupt firms using a transaction-deal data set, and each observation is a transaction. We estimate the following model:

$$AuctionFeature = \beta_1 \cdot Redeployability_i + \beta_2 \cdot \ MFTLiquidity_i + \lambda \times Control_i + \varepsilon_i.$$

The dependent variable, *AuctionFeature*, includes the number of bidders bidding in each deal (columns (1) and (2)) and the price jump from starting price to final selling price (columns (3) and (4)). This information is hand-coded from bankruptcy filings of PACER. *Liquidity* is the firm-level measure aggregated from all patents in the firm's innovation portfolio. *Redeployability* captures the extent that the patent is utilized by firms other than the owning firm, and *MFT Liquidity* captures the liquidity of the market specific to the patent's technology class. The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Number of Bidders		Final Price/Starting Price	
	(1)	(2)	(3)	(4)
Redeployability	0.458**		0.146**	
	(2.029)		(2.130)	
MFT Liquidity		0.416***		0.054
		(2.958)		(1.130)
Observations	190	190	135	135
R-squared	0.086	0.157	0.124	0.037

Table 9
Financial (Not Economic) Distress

This table presents how innovation reallocation decisions in bankruptcy are affected by patent-level characteristics, conditional on whether bankruptcy is due to financial or nonfinancial distress. The analysis is conducted on a patent-level data set, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model:

$$\begin{aligned} Sold_{ip} = {} & \beta_1 \cdot Redeployability_{ip} + \beta_2 \cdot MFTLiquidity_{ip} \\ & + \gamma_1 \cdot Utilization_{ip} + \gamma_2 \cdot TechCloseness_{ip} \\ & + \lambda \times Control_{ip} + \alpha_i + \varepsilon_{ip}. \end{aligned}$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating whether patent p is sold during the bankruptcy reorganization process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. *Redeployability* captures the extent that the patent is utilized by firms other than the owning firm, and *MFT Liquidity* captures the liquidity of the market specific to the patent's technology class; *Utilization* is the number of total citations received by the patents in the most recent three years, and *Tech Closeness*, which is the distance between the patent and the firm's core technological expertise. We split the sample into the *Financial Distress* subsample in columns (1) to (3) and the *Nonfinancial Distress* subsample in columns (4) to (6). The *Financial Distress* sample is defined as having the top tercile in ROA and top tercile in book leverage, and having the top tercile in ROA/book leverage and the middle tercile in book leverage/ROA. We control for *Young Patent* and total scaled citations for all columns. All specifications include firm fixed effects. The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Patent Being Sold					
	(1)	(2)	(3)	(4)	(5)	(6)
	Financial Distress			Nonfinancial Distress		
Redeployability	0.050***		0.048***	0.018***		0.017***
	(6.019)		(5.765)	(5.983)		(5.958)
MFT Liquidity		0.502**	0.357*		0.058	0.053
		(2.438)	(1.723)		(1.382)	(1.271)
Patent Utilization	0.003***	0.003***	0.003***	-0.000*	-0.000	-0.000*
	(4.738)	(4.631)	(4.428)	(-1.683)	(-1.642)	(-1.729)
Tech Closeness	-0.013	-0.015	-0.012	0.019***	0.019***	0.020***
	(-1.411)	(-1.596)	(-1.236)	(5.784)	(5.539)	(5.904)
Observations	7,893	7,893	7,893	48,639	48,639	48,639
R-squared	0.295	0.292	0.295	0.205	0.204	0.205
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 10
Inventor Mobility and Innovation Reallocation around Bankruptcy

This table studies how inventor reallocation in a firm is affected by the reallocation of the inventor's patent and the bankruptcy status of the firm. We track inventor mobility using an inventor-firm-year-level data set, and each observation is an inventor l in a firm i for a particular year t. The sample includes inventors from all public firms between 1980 and 2010. We estimate the following specification:

$$\begin{aligned} InventorMobility_{lit} = {} & \beta_1 \cdot I(PatentBeingSold)_{lit} \times I(InBankruptcy)_{it} \\ & + \beta_2 \cdot I(PatentBeingSold)_{lit} + \beta_3 \cdot I(InBankruptcy)_{it} \\ & + \lambda \times Control_{lt} + \alpha_l + \varepsilon_{lit}. \end{aligned}$$

$InventorMobility_{lit}$ is a dummy variable indicating whether inventor l at year t moves to another firm in the next three to five years. $I(PatentBeingSold)$ equals one if the inventor has one or more patents sold to a firm at which the inventor is not currently working. $I(InBankruptcy)$ indicates whether year t is the year that firm i files for bankruptcy. In Panel A, we look at whether the inventor's patent being sold and the inventor's firm being in bankruptcy affect an inventor's reallocation decision. In Panel B, we look at whether a Key Employee Retention Plan (KERP) offered during bankruptcy affects inventor mobility. We control for inventor productivity by measuring new patents granted and the number of citations in the most recent three years. The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Intensity of Inventor Mobility

	(1)	(2)	(3)	(4)	(5)	(6)
	I(Move within 3 Years)			I(Move within 5 Years)		
I(Patent Being Sold) × I(In Bankruptcy)			-0.035			-0.046*
			(-1.463)			(-1.807)
I(Patent Being Sold)	0.021***		0.021***	0.021***		0.021***
	(32.508)		(32.552)	(30.211)		(30.265)
I(In Bankruptcy)		0.047***	0.048***		0.050***	0.051***
		(12.717)	(12.830)		(12.424)	(12.592)
Inventor Productivity (Quantity)	0.002***	0.002***	0.002***	0.001***	0.001***	0.001***
	(54.604)	(55.444)	(54.605)	(35.572)	(36.350)	(35.571)
Inventor Productivity (Quality)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(50.364)	(50.479)	(50.406)	(48.127)	(48.237)	(48.168)
Constant	0.027***	0.027***	0.027***	0.034***	0.035***	0.034***
	(186.797)	(189.408)	(186.432)	(223.376)	(225.914)	(223.007)
Observations	3,714,594	3,714,594	3,714,594	3,714,594	3,714,594	3,714,594
R-squared	0.019	0.019	0.019	0.018	0.017	0.018

Panel B: Intensity of Inventor Mobility and Key Employee Retention Plan

	(1)	(2)	(3)	(4)
	I(Move within 3 Years)		I(Move within 5 Years)	
I(Patent Being Sold)	0.025***	0.026***	0.027***	0.027***
	(6.935)	(7.037)	(6.732)	(6.846)
I(In Bankruptcy)	0.089***	0.089***	0.089***	0.089***
	(16.750)	(16.751)	(15.273)	(15.274)
I(In Bankruptcy) × KERP	-0.082***	-0.080***	-0.086***	-0.083***
	(-9.320)	(-8.957)	(-8.876)	(-8.503)
I(Patent Being Sold) × I(In Bankruptcy) × KERP		-0.045		-0.053
		(-1.327)		(-1.422)
Inventor Productivity (Quantity)	0.003***	0.003***	0.003***	0.003***
	(21.398)	(21.383)	(17.066)	(17.050)
Inventor Productivity (Quality)	0.001***	0.001***	0.001***	0.001***
	(14.367)	(14.367)	(14.264)	(14.265)
Constant	0.033***	0.033***	0.043***	0.043***
	(49.859)	(49.843)	(59.128)	(59.112)
Observations	138,720	138,720	138,720	138,720
R-squared	0.008	0.008	0.006	0.006
Controls	Yes	Yes	Yes	Yes

Appendix (Not For Publication)

A1. Identifying Patent Reallocations from USPTO Documents

This appendix provides a detailed description of the method used to identify patent transactions. We first introduce the raw data set on patent assignments and then present the methodology used to identify patent transactions; that is, patent assignments other than transfers from an inventor to the firm at which she works or from a subsidiary to its corporate parent.

A1.1. Data Sources

We begin with the raw patent assignment database, downloaded from the USPTO patent assignment files, hosted by Google Patents. A patent assignment is the transfer of (part of) an owner's property rights in a given patent or patents, and any applications for such patents. The patent transfer may occur on its own or as part of a larger asset sale or purchase. These files contain all records of assignments made to US patents from the late 1970s. The original files are then parsed and combined to serve as the starting raw data set, including all patents assigned from an inventor to the firm, from a firm to an inventor, and from one inventor (firm) to another inventor (firm).

We make use of the following information for the purpose of identifying patent transactions. First, in regard to patent assignment information, we retrieve information on the assignment date, the participating parties, including the assignee—the "buyer" in a transaction—and the assignor—the "seller" in a transaction, and comments on the reason for the assignment. Some important reasons include assignment of assignor's interest, security agreement, merger, and change of names. Second, in regard to patent information, we retrieve information on patent application and grant dates, identification numbers (patent number and application number), and patent title. We then merge the raw assignment data with the USPTO patent databases to gather additional information on the original assignee and patent technology classes. We also combine the data set with the inventor-level data maintained at HBS, which allows us to identify the inventor(s) of any given patent. Since we focus on utility patents, we remove entries for design patents.

Next, we standardize the names of the assignee and assignor in the raw patent assignment data set, original assignee names reported in the USPTO databases, and inventor names in the HBS inventor database. Specifically, we employ the name standardization algorithm developed by the NBER Patent Data Project. This algorithm standardizes common company prefixes and suffixes,

strips names of punctuation and capitalization, and it also isolates a company's stem name (the main body of the company name), excluding these prefixes and suffixes. We keep only assignment records for which the assignment brief is included under "assignment of assignor's interest" or "merger"—that is, we remove cases in which the reason for the assignment is clearly not a "change of names."

A1.2. Identifying Patent Transactions

In identifying patent transactions, we use several basic principles that predict predict how patent transactions appear in the data. First, the initial assignment in a patent's history is less likely to be a patent transaction; it is more likely to be an original assignment to the inventing firm. Note that this principle is more helpful with patents granted after 1980, when the raw data set began to be systematically updated. Second, if an assignment record regards only one patent with the brief reason "assignment of assignor's interest," it is less likely to be a transaction because it is rare that two parties transact only one patent in a deal (see Serrano (2010)). Third, if the assignor of an assignment is the inventor of the patent, it is less likely that this assignment is a transaction; instead it is more likely to be an employee inventor who assigns the patent to her employer. Fourth, if both the assignor and the assignee are corporations, it is likely that this assignment is a transaction, with the exception that the patent is transferred within a large corporation (from a subsidiary to the parent, or between subsidiaries). Based on these principles, the algorithm below is a process in which we remove cases that are unlikely to be patent transactions. The steps we take are as follows:

1. Check whether the assignment record date coincides with the original grant date of the patent (the date the patent was first issued). If it does, we label the assignment as a "non-transaction," and it is removed from the data set. Otherwise, we move to Step 2.

2. Check whether the patent assignment record contains only one patent, and is the first record for this patent, with "assignment of assignor's interest" as the assignment reason. If the answer is affirmative, we move to Step 3. Otherwise, the record is labeled as a "potential transaction," and we move to Step 4.

3. Compare the assignee in the assignment record with the assignee in the original patent assignment in the USPTO. Similarly, compare the assignor in the assignment record with the

inventor names in the HBS patent database. If the assignee names match, or if the assignor is the patent inventor(s) plus the assignee is a firm, we then categorize the assignment as a "non-transaction," and it is removed from the data set. This constraint covers cases in which either the assignee or the assignor has slightly different names in different databases. Otherwise, the record is labeled as a "potential transaction," and we move to Step 4.

4. Perform the analysis described in Step 3 on the "potential transactions," with one minor change: when comparing the assignee in the assignment record with the assignee in the original patent assignment in the USPTO patent database, and when comparing the assignor in the assignment record with the inventor names in the HBS patent database, we allow for spelling errors captured by Levenshtein: edit distance less than or equal to 10% of the average length of the two strings under comparison, and we denote these name as "roughly equal to each other." Then, if the assignee names roughly match, or the assignor is roughly the patent inventor(s) plus the assignee is a firm, then assignment is categorized as a "non-transaction" and is removed from the data set. Otherwise, the record is kept as a "potential transaction," and we move to Step 5.

5. Compare the standardized names and stem names of the assignee and assignor in records in the "potential transactions." If the names match, this is consistent with an internal transfer, and the record is labeled as a "non-transaction." If the names do not match, the record is labeled as a "transaction."

A2. Measure of Technological Closeness

Tech Closeness is adapted from Akcigit, Celik, and Greenwood (2016), who formalize the distance between a patent p and a firm i's overall technological expertise using a generalized mean of distances between p and each other patent in firm i's patent portfolio, using the following definition:

$$d^{\iota}(p,i) = [\frac{1}{\|P_i\|} \sum_{p' \in P_i} d_{class}(Class_p, Class_{p'})^{\iota}]^{\frac{1}{\iota}}, \tag{A.1}$$

where P_i denotes the patent portfolio of all patents that were ever invented by firm i before patent p ($\|P_i\|$ is the size of the portfolio). $\iota \in (0,1]$ is the power of the generalized mean operator, and we report our results using $\iota = 0.33, 0.66, 1.00$.

The key component in the definition, $d_{class}(Class_p, Class_{p'})$, stands for the distance between a patent p and p'. The distance operator $d_{class}(X,Y)$, as defined in Akcigit, Celik, and Greenwood (2016), is the symmetric distance metric between two technology classes, X and Y, and is calculated based on citation patterns of X and Y. Let $\#(X \cap Y)$ denote the number of all patents that cite at least one patent from classes X and Y simultaneously, and $\#(X \cup Y)$ denote the number of all patents that cite at least one patent from either class X or/and Y, and

$$d_{class}(X,Y) = 1 - \frac{\#(X \cap Y)}{\#(X \cup Y)}. \tag{A.2}$$

Intuitively, this measure means that if each patent that cites X also cites Y ($d_{class}(X,Y) = 0$), then X and Y are highly close in their role in the innovation space, and vice versa. $d_{class}(Class_p, Class_{p'})$ in formula (A.1), therefore, is calculated based on the technological classes of p and p'. We define $1 - d^{\iota}(p,i)$ as the *Tech Closeness* between patent p and firm i, and the higher this measure is, the closer the patent is to the firm's core innovation assets.

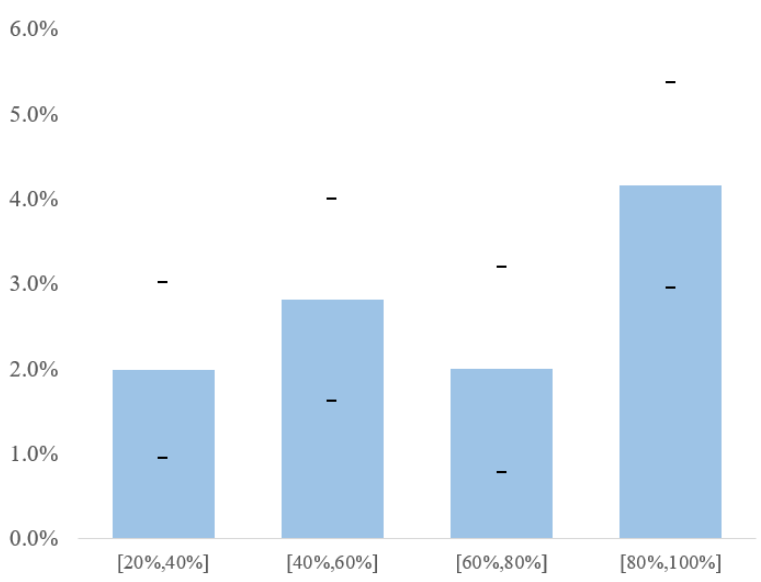
A3. Supplementary Tables and Results

Figure A.1. The Probability of Patent Sales across Quintiles of Patent Liquidity

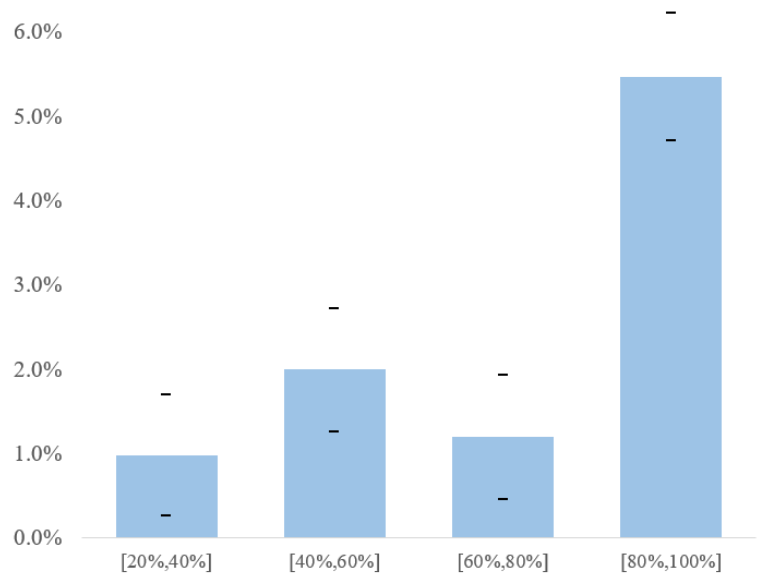
This figure shows the probability that a patent is sold during the bankruptcy restructuring of its firm. The dependent variable is a dummy variable indicating whether the firm sold the patent in bankruptcy. We perform patent-level regressions, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing. The coefficients and 95% confidence intervals are estimated from the following specification:

$$Sold_{ip} = \sum_{q=2}^{5} \beta^q \, I^q(Liquidity)_{ip} + \lambda \times Control_p + \alpha_{ip} + \varepsilon_{ip}$$

where $I^q(Liquidity)_{ip}$ indicates whether the measure of patent p stands at the q-th quintile in firm i's patent portfolio. That is, the highest quintile of *Redeployability* includes the most redeployable patents owned by the firm (Panel (a)), and the highest quantile of *MFT Liquidity* includes patents from technology classes that are the most liquid. The lowest-quintile dummy is omitted from the specification to work as the benchmark. β^q estimates are plotted (in bars) along with their 95% confidence intervals (in hyphens). The subsumed lowest quintile can be considered to hold value 0 in this figure. The control variables are patent age and scaled citation. We include firm fixed effects in the estimation to absorb time-invariant selling intensity at the firm-level. Standard errors are clustered at the firm level.



(a) Selling Probability across Redeployability



(b) Selling Probability across MFTLiquidity

Table A.1
Summary of Bankrupt Firms with No Innovation

This table reports summary statistics of bankrupt firms that do not own any patent at the time of bankruptcy filing. The sample covers all Chapter 11 bankruptcies filed by US public companies from 1981 to 2012, resolved as of mid-2016, and is manually matched with Compustat. We remove cases of financial corporations. This table reports firm-level information collected from case petitions, Compustat/CRSP, CapitalIQ, and PACER. Detailed variable definitions can be found in Section 2 of the paper and in the Appendix. The variable values are measured as of the year before the bankruptcy filing. For each variable, we report the mean, standard deviation, and 25th, 50th, and 75th percentiles. The last two columns report the differences between bankrupt firms with no patent and innovative bankrupt firms and T-test on their means.

	Number of Cases=1,105					Non-innovative − Innovative	
	Mean	Std.Dev	p25	p50	p75	Difference	T-test
Prepack	0.212	0.409	0.000	0.000	0.000	0.015	(0.681)
DIP Financing	0.471	0.499	0.000	0.000	1.000	-0.080	(-2.996)**
Duration (Days)	488.992	549.284	180.000	355.000	607.500	-21.780	(-0.749)
Outcome (Acquired)	0.109	0.311	0.000	0.000	0.000	-0.019	(-1.109)
Outcome (Converted)	0.162	0.369	0.000	0.000	0.000	0.040	(2.130)*
Outcome (Emerged)	0.500	0.500	0.000	0.000	1.000	-0.012	(-0.452)
Outcome (Liquidated)	0.230	0.421	0.000	0.000	0.000	-0.010	(-0.423)
Assets	591.160	4581.978	25.955	88.393	222.100	-381.665	(-1.252)
Leverage	0.629	0.461	0.306	0.566	0.834	0.044	(1.656)
Sales growth	0.349	1.516	-0.151	-0.007	0.249	0.077	(0.865)
ROA	-0.242	0.589	-0.285	-0.104	0.007	0.053	(1.630)
R&D/Assets	0.060	0.202	0.000	0.000	0.006	-0.055	(-3.883)***
Patent Stock	0	.	.	.	.		
Distress (Stock Return)	0.291	0.455	0.000	0.000	1.000	0.003	(0.131)
Distress (Sales)	0.108	0.311	0.000	0.000	0.000	-0.049	(-2.771)**

Table A.2
Pairwise Correlation for Key Patent Measurements

This table reports the pairwise correlation between the key patent measurements used in the paper; the sample is described in Table 3. The numbers in parentheses report significance levels in p-value.

	Sold	Redeployability	MFT Liquidity	Tech Closeness	Patent Utilization	Scaled Citations
Redeployability	0.057					
	(0.000)					
MFT Liquidity	0.052	0.080				
	(0.000)	(0.000)				
Tech Closeness	0.039	0.099	0.083			
	(0.000)	(0.000)	(0.000)			
Patent Utilization	0.023	-0.123	-0.054	0.051		
	(0.000)	(0.000)	(0.000)	(0.000)		
Scaled Citations	0.050	0.060	0.035	0.167	-0.008	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.052)	
Patent Age (Years)	0.021	-0.001	0.013	0.406	-0.025	0.032
	(0.000)	(0.849)	(0.001)	(0.000)	(0.000)	(0.000)

Table A.3
Firm-Level Evidence on the Effect of DIP Financing

This table presents firm-level evidence of how innovation reallocation of a bankrupt firm is affected by whether the firm receives DIP financing in the bankruptcy reorganization process. The analysis is conducted in a setting of firm-level dataset, and each observation is a firm *i*. We estimate a firm-level regression to predict whether a bankrupt firm sells its innovation portfolio and how much of it, using

$$Selling_i = \beta \cdot DIP_i + \lambda \times Control_i + \varepsilon_i.$$

The dependent variable, $Selling_i$, is a dummy variable indicating whether the firm sold any patents during the bankruptcy restructuring process (columns (1)) and a ratio variable of the percentage sold (columns (2)). *DIP* is a dummy variable indicating whether the firm receives DIP financing during the bankruptcy reorganization process. All other independent variables are defined in the Appendix of and measured as of the year before the bankruptcy filing. The t-statistics are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Patent Being Sold (1)	Ratio of Patents Sold (2)
DIP Financing	-0.0757*	-0.0669**
	(-1.752)	(-2.260)
Observations	490	490
R-squared	0.079	0.026

A4. Case Illustration of a Patent Sale through §363: Dana Corporation

Dana Corporation is a large, original equipment manufacturer (OEM) that engages in the engineering, manufacturing, supply, and distribution of automotive systems and components. Dana's products are used in passenger cars and vans; SUVs; light, median, and heavy trucks; recreational vehicles; and motor homes. Due to financial difficulties and ongoing asbestos litigations, the company filed for Chapter 11 in the US Bankruptcy Court for the Southern District of New York on March 3, 2006. It had assets of more than $9 billion, revenue of $7.7 billion, approximately 45,000 employees, and a stock of more than 1,500 patents at the time of filing.

Dana conducted several §363 sales of its patents during restructuring. One notable case is the sale of the AtmoPlas™ microwave atmospheric plasma technology in May 2006. Dana sold the technology, including more than 20 granted and pending-for-approval patents, to BTU International, a leading supplier of advanced thermal-processing equipment for the electronics, manufacturing, and energy generation markets. The AtmoPlas™ technology was initially developed to initiate combustion in an internal combustion engine. It uses microwave energy to enhance fuel ignition, which has the potential to substantially change the internal combustion engine and to improve fuel-cell and hybrid vehicles. The technology not only is unique but also has general applications. For example, the AtmoPlas™ technology was licensed by ALD Vacuum Technologies, a leading supplier of process technologies and services in the field of vacuum metallurgy and vacuum heat treatment in Germany, to develop next-generation heat-treating equipment. For its uniqueness and applicability, the AtmoPlas™ technology was showcased in the 61st International Motor Show in 2005.

BTU intended to apply the technology to its wide range of products, including printed circuit-board assemblies and the manufacturing of solar cells. Notably, in addition to the purchase agreement, Dana and BTU International entered into a patent and technology license agreement for Dana to license the technology back from BTU for its continual use in engine development and production.[20]

Dana's sale of AtmoPlas™ illustrates several important features and stylized facts that represent what this paper documents in general. First, innovation sales through §363 can occur shortly

[20] See Schedule 1 of "Patent and Technology License Agreement between Dana and BTU International," attached to "Notice of Debtor Dana Corporation of the Proposed Sale of Assets Related to AtmoPlas™ Technology."

after bankruptcy filing. Second, a bankrupt firm sells technologies that have higher liquidity and redeployability. Third, the technologies sold for liquidity reasons can be strategically important to the bankrupt firm, as otherwise it would not have licensed back the technology after the sale.[21]

[21] Besides AtmoPlas^{TM} technology, Dana sold several other technologies including the intelligent hydraulic drive technology, and technologies associated with the fluid products group, engine products group, advanced pumps engineering group, and trailer axles business via §363. As of its emergence from bankruptcy in February 2008, Dana had sold approximately five percent of its total patent stock.