Selling Innovation in Bankruptcy*

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Abstract

This paper provides the first empirical study on innovation reallocation during corporate bankruptcies, using a comprehensive dataset of US Chapter 11 filings, USPTO documents, and US court records. We first document stylized facts of selling innovation in bankruptcy—its pervasiveness, immediateness, and front-loading in asset reallocations. We then test two alternative economic rationales behind these activities. We find that firms reallocate patents that are subject to less trading frictions—as opposed to selling peripheral or under-exploited 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. The evidence on inventor mobility shows that firms selling innovation have the tenancy to retain talents to avoid human capital costs of bankruptcy. 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 under-exploited assets.

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1 Introduction

Many assets remain valuable and can be redeployed even when the owning firm goes bankrupt, and this reallocation process is important for both the bankrupt firm and the revolving economy. The past few decades witnessed the emergence of selling innovation, arguably the most important form of intangible assets for individual firms and the aggregate growth, during bankruptcy reorganizations. This phenomenon also echoes the growth of innovation into a unique asset class in financial markets, and the development of the market for technologies.[1] In spite of its importance, little is known about the economic facts and underlying economic rationales of selling innovation in bankruptcy—these are what this paper attempts to shed light on.

To study innovation reallocation in bankruptcy, this paper identifies a comprehensive sample of all US public firms that filed for Chapter 11 bankruptcies from 1981 to 2012. For each firm, we collect detailed information from the United States Patent and Trademark Office (USPTO) to characterize its patent profiles, all patent transactions, and patent utilization information. Furthermore, we retrieve asset sale motions, orders, and master purchase agreements from US court records. These documents allow us to clearly observe complete information of patent holding and the whole process of patent sales conducted by bankrupt firms.

We first document that more than 40% of bankrupt firms sell part of their patent portfolios from the date of bankruptcy filing to the date of reorganization/liquidation plan confirmation. At the intensive margin, they sell on average 18% of the total patent portfolios. Furthermore, patent transactions occur within a very short time-window, largely within two quarters after the bankruptcy filing. The highest innovation selling intensity appears in the first two quarters subsequent to the filing, when the selling probability increases by nearly twofold compared to the quarters prior to bankruptcy. Moreover, bankrupt firms front-load their innovation in asset sales—we observe that a dis-proportionally high portion of innovation is sold in the early period of asset sales.

What motivates these intense and immediate sales of innovation in bankruptcy? The-

[1] See, e.g., Gans, Hsu, and Stern (2008), Arora and Gambardella (2010), Akcigit, Celik, and Greenwood (2016), Mann (2015), and Brav, Jiang, Ma, and Tian (2017).

oretically, economists and legal scholars argue that one major function of the Bankruptcy Code is to provide a mechanism for insolvent firms to restructure their assets and financial claims (Jackson, 1986; Gertner and Scharfstein, 1991; Aghion, Hart, and Moore, 1992). This traditional "asset restructuring view" suggests that firms sell assets to reorganize their operations in bankruptcy, with the intention of maximizing the going-concern value of the estate. Accordingly, firms tend to deploy under-exploited and under-performing assets to better users. The alternative "financing through asset sales view" suggests that bankrupt firm sell assets to meet liquidity needs for ongoing business operations because they face tremendous pressure in capital raising from financial markets (Ayotte and Skeel, 2013; Edmans and Mann, 2016). Accordingly, the asset redeployment decisions are expected to vary systematically with trading frictions associated with particular types of assets.

In reflection of these two views, we empirically explore the specific characteristics of patents that bankrupt firms choose to retain or sell. We construct two measures to capture the trading frictions associated with each patent, and two measures to gauge patent utilization and strategic value of a patent to the firm. The first measure exploits the idea of asset redeployability. We measure the *Redeployability* of a specific patent using the ratio of non-self citations received by a patent scaled by total citations, similar to Jaffe and Trajtenberg (2002) in an innovation setting and in the same spirit as Bernstein, Colonnelli, and Iverson (2015) in the real estate setting. 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. The idea is that the realized transaction volume reflects the potential frictions in trading the specific class of innovation, and more liquid assets are traded more frequently (Gavazza, 2011; Hochberg, Serrano, and Ziedonis, 2014). We use the number of citations received by each patent in the recent three years, *Patent Utilization*, to measure the productivity of the patent. *Tech Closeness*, developed by Akcigit, Celik, and Greenwood (2016) to capture the technological proximity between a patent and its owning firm's core innovation expertise, is used to measure the strategic value of a patent.

We find that bankrupt firms reallocate innovations that are more redeployable and are subject to less trading frictions. Quantitatively, a one standard deviation change in Redeployability (MFT Liquidity) increases the probability of thw patent being sold by 9.2%

(4.7%). The results are robust to using only firms that eventually emerged from bankruptcy, guarding against the concern that our results are driven by the piecemeal liquidation decisions of firms, which may result in a mechanical relationship between measures of trading frictions and the probability of redeployment. Dynamically, we document a pecking order in the decision of selling innovation across the dimension of trading fractions. The evidence shows that the average value of redepoyability and liquidity of patents sold tends to exhibit a declining trend throughout the bankruptcy process, i.e., firms sell more liquid innovations first. The evidence lends support to the view that bankrupt firms' innovation reallocation decisions are significantly driven by the rationale of raising financing through asset sales.

In contrast, we find little evidence that the utilization or the strategic value of a patent determines the reallocation decision to support the asset restructuring view. In fact, we find a positive relation between the patent selling decision and the recent patent utilization. Surprisingly, we do not find that bankrupt firms sell non-strategic patents, which are shown to be less valuable and more 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). Overall, the empirical evidence shows that the intense innovation reallocations during bankruptcy seems to be more consistent with the view that firms sell more liquid assets to raise financing, instead of redeploying under-exploited innovation.

To further explore the rationale of selling innovation for financing under heterogeneous conditions, we conduct three additional tests. First, we compare the innovation selling decisions of bankrupt firms that likely experience financial (but not economic) distress versus those firms that experience economic distress. We find that trading frictions appear to be the dominating concern for financially distress firms, which are economically viable and file bankruptcy to resolve liquidity and capital structure problems. These firms are more likely to deploy liquid innovation but not more likely to sell core assets. Interestingly, economically distressed firms also tend to redeploy under-utilized core assets, suggesting that these firms also utilize bankruptcy to restructure their business via asset restructuring.

Second, we examine whether firm's tendency of selling innovation for financing is affected by its access to alternative sources of external financing. Specifically, we compare firms with and without debtor-in-possession (DIP) financing. DIP financing allows the debtor to raise

capital immediately after bankruptcy filing to meet working capital needs during restructuring (Dahiya, John, Puri, and Ramırez, 2003; Li and Wang, 2016). With DIP financing in place, firms are given more time to market innovation for potential sale. Therefore, the incentive to raise financing through selling innovation is weaker for firms with DIP finance. We find consistent evidence that the effect of trading frictions on selling decisions is weaker for firms with DIP financing.

Third, motivated by the fire-sale logic (Shleifer and Vishny, 1992), we study whether weak financial conditions of industry peers further exacerbate bankrupt firms' needs to sell more liquid innovation to raise financing. Following prior literature, we capture industry conditions using abnormally low industry stock returns and sales growth, and find that the sensitivity of selling innovation to trading frictions is stronger when the firm's industry is distressed. Overall, these heterogeneity analysis provides further support to the view that selling innovation in bankruptcy is largely for raising financing.

To confirm that such strategies indeed allow bankrupt firms to easily redeploy assets, we briefly turn to examine whether trading frictions affect the outcomes of bankruptcy auctions of innovation sales. To collect detailed information on the process of auctioning innovation in bankruptcy, we develop an algorithm to parse bankruptcy filings related to bankruptcy asset sales and manually code information on auctions conducted.[2] Our results confirm that more liquid assets attract more bidders to participate in auctions, and are sold with a larger increase in price from the initial biding price.[3]

At last, we provide several suggestive evidence that further supports the view of selling innovation for financing. We explore human capital reallocation decisions around patent sales. In normal times, inventors of sold innovation are likely to depart from the firm. However, we show some evidence that bankrupt firms try to retain inventors of their sold patents after patent deployment. In other words, firms sell patents for financial reasons but retain talents associated with them. Additionally, those bankrupt firms keep citing sold patents, further justifying that those innovations are of importance for the business of the firm.

[2]As far as we know, this is one of the few papers to investigate the auction process of asset allocation in bankruptcy (Eckbo and Thorburn, 2008; Gilson, Hotchkiss, and Osborn, 2016).

[3]One limitation of the data, however, it that as opposed to settings of real assets such as airplanes, it is hard to determine fair value of patents and therefore calculate the potential discount in asset sales (Kogan et al., 2014).

To sum up, our empirical findings are more consistent with the view that innovation sales in bankruptcy are driven by financing needs, as opposed to asset restructuring motives. Specifically, with imminent financing needs, firms tend to sell innovation that can be easily redeployed. In this process, firms may lose innovation that is deemed important to the firm. However, firms try to minimize human capital costs of bankruptcy by retaining inventors as the property rights of innovation are transferred.

This paper contributes to two strands of literature. It is related to studies of asset allocation in bankruptcy. Maksimovic and Phillips (1998), Pulvino (1998, 1999), and Ramey and Shapiro (2001) study how trading frictions affect the costs of allocating capital. Benmelech and Bergman (2011), Bernstein, Colonnelli, and Iverson (2015) and Meier and Servaes (2016) show that those costs could not only affect the bankrupt firms themselves but also spill over to other firms. Gilson, Hotchkiss, and Osborn (2016) document that asset sales are favored by secured creditors and show their effects on debt recovery. This paper complements this literature in several ways. First, in terms of methodologies, as opposed to investigating the ex post costs of reallocation, our analysis focuses on the ex ante motivation and decision to sell or retain individual assets. Second, conceptually, we try to draw inferences on the asset restructuring view versus the view of financing through asset sales in bankruptcy. Lastly, we examine the reallocation of intangible assets, while existing research largely studies tangible assets in a specific industry.

This paper is also related to the literature on the market for technologies, and how it interacts with financial markets. A growing empirical literature studies how firms use market for technologies to reallocate innovation and create value for a firm (Hoetker and Agarwal, 2007; Serrano, 2010; Akcigit, Celik, and Greenwood, 2016; Brav, Jiang, Ma, and Tian, 2017), and the growth of innovation into a unique asset class in financial markets (Hochberg, Serrano, and Ziedonis, 2014; Mann, 2015; Farre-Mensa, Hegde, and Ljungqvist, 2016). We provide empirical evidence that the liquidity of patents is a key determinant of innovation allocation during bankruptcy, and this mechanism may distort the functioning of the MFT to allocate and facilitate diffusion of knowledge. Our findings also have implications regarding the type of innovation that firms are incentivized to produce in the first place (Ederer and Manso, 2011; Manso, 2011).

The remainder of the paper is organized as follows. Section 2 discusses sample construction and measurements. Section 3 establishes facts for innovation reallocation in bankruptcy. Section 4 presents the main results and discussions. Section 5 concludes.

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. The initial screening draws 2,926 total filings. We manually match our sample firms with Compustat using firm names and company information and remove 630 firms that do not have a valid identifier in Compustat. We then remove cases that were dismissed (154 cases), pending as of the mid of 2016 (22 cases), merged into another leading case (2 cases), have unknown outcomes (232 cases), and financial firms (160 cases) as they are not typical cases to study innovation. This process leaves us with a sample of 1,623 cases.[4]

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

We determine whether a Chapter 11 firm obtains debtor-in-possession (DIP) financing, using court dockets retrieved from the Public Access to Court Electronic Records (PACER). We search the following key phrases: "debtor-in-possession financing," "DIP financing," "post-petition financing," "secured financing", and other similar key words to identify whether a motion on DIP financing was filed by the debtor and whether the judge approved it. For cases with incomplete dockets we search bankruptcy plans and news via LexisNexis and Factiva to verify whether DIP financing was granted by bankruptcy courts.

[4]Our dataset is the largest bankruptcy datasets for public firms with detailed case information. The number of Chapter 11 filings by public US firms in our sample is twice as large as that covered in the widely used UCLA-LoPucki Bankruptcy Research Database (BRD), which covers Chapter 11 filings by US public firms with $100 million assets in constant 1980 dollars for the sample period. The ability to cover smaller firms is particularly important considering that many smaller entrepreneurial firms own many innovation assets.

We use Compustat for financial statement data reported as of the last fiscal year prior to 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 current year minus sale of the previous year, and scaled by 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 the prior literature, industry conditions are measured based on how distressed the industry (3-digit SIC) is as a whole in the year that the firm files for bankruptcy. Following Gilson, John, and Lang (1990) and Acharya, Bharath, and Srinivasan (2007), we label an industry to be "distressed" if the median annual stock return for the industry in a year is less than or equal to -20%. We also measure industry distress based on the product market performance of the industry, specifically defined by being in the bottom decile of sales growth of a year (Gilson, Hotchkiss, and Osborn, 2016) among all 3-digit SIC industries. Detailed variable definitions are described in the Appendix.

2.2 Patent Profiles and Patent Transactions

2.2.1 USPTO Patent Information

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 United States Patent and Trademark Office (USPTO). The combined data are linked to the whole 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 the 430 technology classes based on the underlying fundamental feature of the innovation. It also records the number of citations received by each patent and the source of those citations, which help to identify the utilization of each specific patent and potential users.

2.2.2 USPTO Patent Reassignment

When owners sell their patents, they are required to file patent reassignment documents with USPTO (Graham, Marco, and Myers, 2017). The original USPTO patent reassignment

database provides useful information for the purpose of identifying patent transactions: the assignment date, the participating parties, including the assignee (the "buyer") and the assignor (the "seller") in a transaction, and comments on the reason for the assignment. We merge the raw assignment data with the USPTO patent database so as to gather additional information on the original assignees and patent technology classes, and with the HBS inventor database.

We then follow a procedure, similar to that used by Ma (2016) and Brav, Jiang, Ma, and Tian (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 a patent transfer from an inventor to his/her employer, or that between two subsidiaries of a firm. This step is important for our study because bankrupt firms are more likely to undergo organizational changes in this period. For example, we make sure that cases like "General Motors Corporation" reassigning its patents to "General Motors Global Technology Operations" are not counted as real patent transactions. We provide a more detailed description of the data and methodology in the Internet Appendix.

2.3 Manual Coding of §363 Sale Motions and Orders

We examine the detailed process of patent sales via §363 through manual reading of motions and orders that are retrieve from court dockets on Public Access to Court Electronic Records (PACER) and Bloomberg Law.[5] We manually collect key variables of §363 sales such as motion date of the sale, the nature of the assets to be sold, identity of the stalking horse, number of bidders in auction, identity of competitive bidders and winning bidder, initial bidding price, final price, date of sale order, patent numbers of patents sold, and prices paid for patents if available.[6]

2.4 Key Variables

Four patent-specific measures, *Redeployability*, *MFT Liquidity*, *Patent Utilization*, and *Tech Closeness*, are constructed to capture the economic forces behind the decisions of retaining or selling a specific patent. The first two measures capture trading frictions,

[5] Appendix Section A3 provides a detailed description on patent sales via §363 sale.

[6] A detailed description of data retrieval and coding is provided in Appendix Section A4.

or liquidity, associated with a particular patent while the last two measures capture the utilization and strategic importance of the patents to the possessing firm.

2.4.1 Innovation 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 real asset market (Benmelech and Bergman, 2008; Benmelech, 2009; Bernstein, Colonnelli, and Iverson, 2015), substantial adjustment costs are associated with exploiting a new type of innovation, which 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 "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 this same company (i.e., 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, which was shown to be relevant in measuring such concepts. A higher self-cite ratio is assumed to correlate with more limited redeployability in the market for technology, in the same spirit as Hoetker and Agarwal (2007) and Marx, Strumsky, and Fleming (2009). Therefore, we define patent-level $Redeployability_p$ as $1-$ self-cite ratio.

2.4.2 Market for Technology (MFT) Liquidity

$MFT\ Liquidity_{pt}$ is 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. in decentralized markets such as the patent markets, buyers and sellers face fixed costs to search for the right trading partner (Hagiu and Yoffie, 2013; Akcigit et al., 2016). Market thickness reduces search costs for the right trading partner and facilitates reallocation to efficient users, thus increasing the liquidity of capital. The thickness of the market and the liquidity of the capital can be reflected by the activeness of trading in this market (Gavazza, 2011).

We follow Hochberg et al. (2014) to compute this *MFT Liquidity* measure using the

trading activities in the market for technologies (MFT). We first exploit the USPTO patent assignment and reassignment data to identify the number of patents that are transacted each year in each technology class. Patent transactions are defined to include sales of patents as standalone assets as well as transfers bundled through corporate acquisitions (similar to Serrano (2010) and Galasso, Schankerman, and Serrano (2013)). The constructed dataset is merged to the population of tradable patents in each technology class-year cell. The ratio of transacted patents over the patent population provides us with the *MFT Liquidity* measure for each technology class and issue year, which then can be uniquely mapped to each patent p.

2.4.3 Patent Utilization

We use citation-based measures to capture the utilization of a patent in the owning firm. In specific, we construct *Patent Utilization* as of patent p in year t as the total number of citations received by p in the three years preceding bankruptcy filing, i.e., $t-3$ 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, plausibly because it better fits the overall innovation profile of the owner or is commercialized more successfully by the ownership.

2.4.4 Technological Closeness

We follow Akcigit, Celik, and Greenwood (2016) to construct the *Tech Closeness* 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 each 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, Jiang, Ma, and Tian (2017) both show that patents with higher *Tech Closeness* are of higher 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. Appendix Section A2 provides a detailed illustration on the construction of the

measure.

3 Basic Facts: Selling Innovation in Bankruptcy

Given the novelty of the setting, we start by providing an overview of the phenomenon of selling innovation in bankruptcy. These stylized facts will also provide guidance for our main analysis.

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

We first investigate how often and how much firms sell innovation during the bankruptcy reorganization process, that is, from the bankruptcy filing to the confirmation of the reorganization/liquidation plan. Table 1 presents bankrupt firms' intensity of selling innovation, tabulated based on firms' industries defined by Fama-French 12 Industry categorization (Panel A), and based on the year a case is filed (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 any patents during bankruptcy periods, and the percentage of patents that were sold.[7]

[Insert Table 1 Here.]

Selling innovation during bankruptcy is a surprisingly pervasive phenomenon. 40% of bankrupt innovative firms sell at least one patent in the reorganization process, and patents transacted account for about 18% of their total patent stock. Cross-sectional comparison in Panel A suggests that the intensity of selling innovation in bankruptcy varies across industries. Healthcare, drug, and medical device companies sell their innovation assets more than any other industries, with 56% of firms conducting such activities and 30% of their patent portfolios being sold. But even the industries that are least likely to sell patents in bankruptcy (Wholesale and Retail, Consumer non-durables) witness nearly 25% of their bankrupt firms sell more than 15% of patent holdings. Time-series analysis in Panel B suggests that selling innovation, even though largely overlooked in academic studies, is not a new phenomenon. The proportion of firms that sold patents and the percentage of patents that were transacted remained at a fairly stable level since the early 1980s.

[7]Naturally, the ratio of sold patents is defined as zero for firms that did not sell any patents.

[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 USPTO (that is, a firm's initial inclusion in the sample is after its first patent is issued). The key independent variable is first a dummy variable, *I(In Bankruptcy)*, indicating whether the firm is undergoing a bankruptcy reorganization process in that quarter.[8] 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. Those firms are predicted to sell approximately 2.2% more of their patent portfolios every quarter during bankruptcy reorganizations. Overall, we find that innovation, as a unique asset class, is actively traded in bankruptcy.

Stylized Fact 2: *Selling innovation concentrates within a short time-window after the bankruptcy filing.*

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

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

where the key difference is that the independent variables of interests are now the set of dummies, $d[t-4], ..., d[t+4]$, indicating if 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 overall 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 of selling increases by more than sixfold. The F-test suggests that the six times increase in probability is statistically significant at the 1% level. At the intensive margin (column (4)), the increase is even more dramatic.

[8] We categorize the dummy as one for cases when part of the quarter was in the firm's bankruptcy process.

[Insert Figure 2 Here.]

The increase of innovation sale concentrates at the first two quarters subsequent to the filing of the bankruptcy case, 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 selling innovation is conducted within a very short time-window after the filing of bankruptcy.

Stylized Fact 3: *Innovation sales in bankruptcy are dis-proportionally front-loaded in the whole asset reallocation process.*

We analyze sales of innovation compared to those of other asset sales using manually collected US court records. We code each of the collected §363 sales as "innovation" and "no innovation." Figure 3 plots both the total number of these 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.

[Insert Figure 3 Here.]

We find a similar immediateness of asset sales. But more interestingly, innovation-related sales have higher intensity of occurrence immediately after bankruptcy filings. Nearly 60% of §363 sales in the quarter of filing are innovation-related. By the fourth quarter, the ratio of innovation-related sales drops to 17%. Overall, it appears that innovation assets are dis-proportionally sold immediately after the bankruptcy filing.

4 Main Results

The intensity and speed of selling innovation after bankruptcy filing is consistent with two different views on asset reallocation in bankruptcy. On the one hand, bankrupt firms have imminent liquidity needs for working capital at the outset of bankruptcy filing and thus sell assets immediately for financing. On the other hand, firms sell innovation promptly after bankruptcy filing for the purpose of restructuring assets in a timely manner. In this section,

we empirically examine firms' decision for innovation sale, through the lens of the selling decision of individual patents.

4.1 Baseline Results

The baseline analysis is performed on a patent-level cross-sectional dataset. Each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing. We estimate the following OLS regression,

$$Sold_{ip} = \beta \cdot TradingFriction_{ip} + \gamma \cdot PatentUtilization + \lambda \times Control_p + \alpha_i + \varepsilon_{ip}. \quad (2)$$

$Sold_{ip}$ is a dummy variable indicating whether patent p was sold during the bankruptcy restructuring process by its owning firm i. $TradingFrictions_{ip}$ capture capital liquidity sourced specific reployability of the patent (*Redeployability*), and from frictions in market for technology (*MFT Liquidity*). $PatentUtilization$ capture the utilization and technological closeness of patent p in firm i. We also control for patent characteristics such as number of total citations and patent age, and firm-specific patent transaction intensities using firm-level fixed effects.

[Insert Table 3 Here.]

We first report summary statistics of this patent-level dataset in Table 3 Panel A. This dataset covers all patents owned by 518 innovative bankrupt firms that have nonmissing values of key patent-level variables. The average value of redeployability is 0.790. This suggests that on average 79% of citations received by a patent are in fact made by other firms. 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 0.022 at the 25th percentile to 0.039 at the 75th percentile. The average utilization rate suggests the number of citations of each patent received within three years is only at two. The technological closeness measure between a patent and the whole patent portfolio owned by the firm is 0.590.

Panel B of Table 3 describes the 518 innovative firms in the sample. About 20% of the cases are pre-packaged filings. More than half of our sample firms receive DIP financing. The bankruptcy cases, on average, stay for 546 days in the restructuring process. The case outcomes are: 12% acquired, 12% converted to Chapter 7, 51% emerged, and 24% liquidated in Chapter 11. Our sample firms on average own 172 patents at the time of bankruptcy filings with the median patent holding at 12, 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.

Table 4 presents the regression results of Eq. (2). In column (1), trading frictions are measured using the extent to which a specific patent could be redeployed by other firms; in column (2), we focus on *MFT Liquidity*. Patent utilization and the technological closeness between the patent and the firm are analyzed in column (3) and (4), respectively.

Column (1) shows that *Redeployability* is a strong determinant of whether a patent is likely to be reallocated during the bankruptcy restructuring. The coefficient of 0.030 in column (1) translates a one standard deviation change to a 0.82% (0.025×0.327) increase in probability of selling, which is a 9.19% jump based on the unconditional probability (8.9%). In column (2), *MTF Liquidity* of a patent is positively and significantly associated with a higher probability of it being sold during the bankruptcy period. The estimate in column (2), 0.193, 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% (0.193×0.022). This economic magnitude equates to a 4.71% increase based on the unconditional probability that a patent is sold in bankruptcy (8.9%).

[Insert Table 4 Here.]

In terms of *PatentUtilization* and *Tech Closeness*, we do not find supporting evidence that firms systematically sell under-exploited patents or those that are strategically less valuable to the firm. If anything, firms seem to sell those patents that perform well recently and that are in their core business. Specifically, patent utilization is positive and significantly associated with the decision to sell a patent. Similarly, *Tech Closeness* predicts a higher probability of selling, which is very different from the finding in Akcigit, Celik, and Greenwood

(2016) who show that firms sell more technologically distant patents in normal times, and Brav et al. (2017) who show the same patterns of selling distant patents in corporate restructuring initiated by hedge fund activists.

In column (5), we find that the estimations are qualitatively and quantitatively similar when all four measures are included in the regressions. Note that Table 4 includes firm fixed effects in all analyses. Therefore, the relationship between capital liquidity and the probability of being 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 capital liquidity and bankruptcy behaviors at the same time.

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 of innovation sale is most likely made by the debtor after bankruptcy filing, rather than via a prepackaged agreement between the debtor firm and the buyer before filing for bankruptcy.[9] The results are both qualitatively and quantitatively similar to the full sample presented in columns (1) to (5).

4.2 Heterogeneities

The empirical evidence thus far is more consistent with the view in which firms sell more liquid innovation to meet imminent financing needs for either working capital or repayment of debt in bankruptcy. In this section, we further investigate the heterogeneities of the result among firms with different financing needs—namely, firms that suffer financial versus economic distress, firms that successfully arrange direct financing from lenders versus those

[9] A bankruptcy case is defined as prepackaged if the debtor drafted the plan, submitted 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 less than all classes or obtains the acceptance of less than all classes necessary to confirm before the bankruptcy case is filed, then the case is regarded as pre-negotiated. We exclude both prepackaged and pre-negotiated cases for our analysis.

that do not, and firms whose industry peers suffer distress versus those not.

4.2.1 Financial vs. Non-Financial Distress

Firms file for bankruptcy due to various causes. They generally suffer either financial distress or economic distress, or a combination of the two. Firms suffering financial distress are economically viable and try to utilize the bankruptcy process to resolve liquidity and capital structure issues, whereas firms in economic distress tend to use bankruptcy to restructure their business, potentially via asset restructuring. Thus, the motive to sell more liquid assets to meet financing needs is expected to be stronger in financially distressed firms.

Empirically, it is challenging to distinguish firms in financial distress with those in economic distress (Gertner and Scharfstein, 1991). Prior empirical studies use a combination of financial leverage and operating performance to do the categorization (Asquith 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. We divide our sample of Chapter 11 firms into terciles using leverage ratio and then within each leverage tercels we create tercels using ROA. Thus we have a total of nine buckets of sample firms. We treat firms in the three buckets that are in both top tercel of leverage and top tercel of ROA, in top tercel of ROA and middle tercel of leverage, and in top tercel of leverage and middle tercel of ROA as financially distressed firms (Lemmon et al., 2009).

[Insert Table 5 Here.]

Table 5 presents the regression results for the two samples of bankrupt firms that suffer financial distress (columns (1) to (3)) and non-financial distress (columns (4) to (6)), respectively. The estimates for the two subsamples exhibit striking differences. The probability of selling innovation for firms suffering financial distress is much more sensitive to patent redeployability and market liquidity, suggesting that the pressure for financing is stronger during financial distress. The coefficient of *Tech Closeness* is no longer statistically significant for firms suffering financial distress.

In contrast, the evidence shows firms that are likely to suffer economic distress tend to sell patents that are close to firm's core of innovation and under-utilized patents. The evidence is

intuitive as economically distressed firms tend to suffer bad operating performance, potentially due to non-performing core assets. These firms redeploy such assets for restructuring purpose. Yet to be clear, even in those firms, the pressure to sell liquid assets is still pronounced.

4.2.2 Access to Finance and Liquidity Provision

Instead of financing through asset sales, bankrupt firms can obtain financing through debtor-in-possession (DIP) financing in bankruptcy. Prior studies on DIP financing document that bankrupt firms can approach either pre-petition bank lenders or alternative investors for post-petition financing (Dahiya, John, Puri, and Ramırez, 2003; Li and Wang, 2016). However, DIP can be costly to the borrower such as carrying high interest rates, and stringent requirements on collateral, covenants, and default triggers.[10] Firms that choose not to or are unable to obtain post-petition financing have a short window to sell assets for financing and/or paying off debt, and thus the incentive for avoiding trading frictions may be stronger for those firms (Ayotte and Skeel, 2013).[11]

[Insert Table 6 Here.]

Table 6 shows how trading frictions determine the innovation reallocation decision in subsample of firms with and without DIP financing. In firms with DIP financing, the sensitivity of selling patents to *Redeployability* is 0.029, and the R^2 is 0.14; the sensitivity jumps by more than 50% to 0.043 in the subsample without DIP financing and the R^2 increases to 0.56. This shows that trading frictions have a stronger effect on innovation reallocation decisions in firms with more financing needs (the No DIP sample). The results are similar in columns (4) to (6) when *MFT Liquidity* is used as a proxy for the trading friction. In the Online Appendix we show that firms without DIP financing are in general more likely to conduct patent sales than firms with DIP financing. This confirms that firms with DIP financing have a weaker incentive to raise financing via asset sales. Overall, our

[10] See, for example, "Chapter 11: Debtor-in-Possession Lending Report," Debtwire Analytics, 2014; Skeel (2003); Roe and Tung (2013).

[11] We acknowledge that firm's decision to obtain DIP financing may be beyond the financing concern. For example, pre-petition lenders may pressure the firm to obtain DIP financing in order to enforce their debt priority (Skeel, 2003) or governance changes (Li and Wang, 2016). However, since new money is always provided in DIP financing packages (Moody's, 2008) firms with DIP financing have the capital available for short-term liquidity needs and therefore have more time to market assets for sale.

finding suggests that the financing constraint induces the bankrupt firms to sell liquid assets to avoid market frictions for raising financing.

4.2.3 Industry Conditions and Avoidance of Fire-sale

In Shleifer and Vishny (1992), poor industry conditions exacerbate trading frictions and the liquidation value of assets. The idea is intuitive—when a firm needs to sell assets in bankruptcy, its industry peers that potentially could be efficient users and bidders of those assets are likely to experience distress themselves, resulting in "fire sales".[12] Following this logic, we investigates whether the intention to sell liquid innovation for financing is aggravated by financial constraints of industry peers.

Table 7 presents the subsample results by splitting firms using industry condition. In 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 being sold during bankruptcy increases with its redeployability, in both distress and non-distress industries. However, the effect is more than 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 nearly five times stronger than that in a non-distressed industry. In columns (3) and (6), we report t-tests that show the statistical significance between the estimated coefficients in distressed industry and non-distressed industry subsamples.

[Insert Table 7 Here.]

In Panel B, we split the sample based on whether the industry was at the bottom decile of sales growth in that year among all industries. The role of trading frictions again is much stronger for firms in poorer industrial environments. Overall, Table 7 shows that firms'

[12] On the empirical side, Asquith, Gertner, and Scharfstein (1994) document that workout is more likely than a liquidation when industry conditions are poor; Maksimovic and Phillips (1998) show that incentives to reorganize depend on industry conditions; Granja et al. (2016) show that industry conditions are in fact a great proportion of costs in the process of selling failed banks. Schlingemann, Stulz, and Walkling (2002) show in a more general setting that industry conditions determine the allocation in corporate divesting. Bernstein et al. (2015) show that market thickness and local economic conditions jointly determine the ex post efficiency of allocation in bankruptcy.

incentives to avoid trading frictions in reallocating assets are amplified in distressed industries, which is consistent with the financing motives of asset sale.

4.3 Evidence from the §363 Sale Auction Process

To confirm that liquid innovations help facilitate the sale and achieve the financing objective, we briefly turn to examine whether trading frictions affect 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 via PACER for cases that are filed after 2002, when court dockets went electronic at most U.S. bankruptcy courts. We are particularly interested in the number of bidders that participated in each auction and the incremental change from the initial bidding price by the "stalking horse" to the final price paid by the winning bidder. The presumptive intuition is that both a larger number of bidders and a larger initial-final price jump signal competitive auction process and 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 initial to final price. We find that more liquid assets attract more bidders to auctions, and their final selling prices have larger increases from the starting price. This is consistent with findings in the real asset market that liquid assets are sold more efficiently. To our best knowledge, this is one of the first papers to investigate the auction process of asset allocation in US bankruptcies (see also Gilson et al. (2016)).[13]

4.4 Further Evidence

Our analysis by far provides supporting evidence to the view that firms sell innovation primarily to satisfy financial needs rather than to reallocate inefficiently utilized assets. In this section, we provide additional evidence to understand how this view of selling innovation

[13]Prior work on bankruptcy auctions is mainly based on the Scandinavian style of mandatory auctions. See, for example, Thorburn (2000); Hotchkiss and Moodraian (2003); Eckbo and Thorburn (2008, 2009).

in bankruptcy links to broader innovation-related activities, including the pecking order of selling innovation, inventor reallocation, patent utilization, and patent litigation.

4.4.1 The Liquidity Pecking-Order

If firms sell liquid innovation assets as a way to raise financing during the bankruptcy reorganization process, then there can be a dynamic pecking order of the selling sequence based on the liquidity of each patent. In specific, in the time series, firms can choose to sell the more liquid assets before the less liquid ones. To examine this implication, we focus on the patents that are eventually sold, and plot the average liquidity of those patents sorted by the quarter of selling, ranging from quarter zero (the quarter of filing), to one year after the filing (if the reorganization plan had not been 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 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 that bankrupt firms dynamically manage the innovation reallocation decision based on the liquidity of the patent.

4.4.2 Retention of Human Capital

Examining the human capital reallocation decision can also help us further distinguish whether selling innovation is primarily for financing. Conceptually, if the motive to sell innovation is to terminate the operation of under-exploited assets, we would observe the departure of labor working on these assets as well. In contrast, if the intellectual property rights are sold for financing needs, we would expect connected human capital being retained in the firm.

The analysis is conducted using an inventor-firm-year-level dataset extracted from the HBS Patent Database, and each observation is an inventor i in a firm j for a particular year

t. We estimate the following specification,

$$\begin{aligned} InventorMobility_{ijt} = \beta_1 \cdot PatentBeingSold_{ijt} \times InBankruptcy_{jt} \\ \beta_2 \cdot \ PatentBeingSold_{ijt} + \beta_3 \cdot \ InBankruptcy_{jt} \\ + \lambda \times Control_i t + \alpha_i + \varepsilon_{ijt}. \end{aligned} \tag{3}$$

$InventorMobility_{ijt}$ is a dummy variable indicating if inventor i at year t moves to another firm in the next 3 (or 5) years. $I(PatentBeingSold)$ equals to one if the inventor has one or more patents sold in year t to a firm that the inventor is not currently working at. $I(InBankruptcy)$ indicates whether year t is the year that firm j files bankruptcy.

[Insert Table 9 Here.]

In Panel A, we study whether inventor's patent being sold and inventor's firm being in bankruptcy affect inventor's reallocation decision. In normal times, inventors of sold innovation depart from the firm with a much higher intensity. Inventors also tend to leave a company after it files for bankruptcy, that is, there is loss of talents and human capital (Graham, Kim, Li, and Qiu, 2016; Baghai, Silver, Thell, and Vig, 2017). Interestingly, coefficients associated with $PatentBeingSold_{ijt} \times InBankruptcy_{jt}$ are negative and marginally significant. This evidence suggests that bankrupt firms retain inventors of their sold patents after patent deployment. This is inline with the interpretation that firms sell patents for financial reasons but keep talents associated with them.

In Panel B, we further look at whether firm's adoption of Key Employee Retention Plan (KERP) during bankruptcy affect inventor mobility. We find that the adoption of retention bonus plans turns out to be an important mechanism to retain critical employees (Goyal and Wang, 2016). Firms that adopt these plans are better able to retain inventors after patents are sold.

4.4.3 Utilization of Patents after Transactions

In addition to tracing human capital reallocation, we also document the pattern of utilization of those patents sold in bankruptcy. Figure 5 plots the coefficients β_k from the

following regression at the patent (i)-year (t) level:

$$Citation_{i,t} = \sum_{k=-3}^{+3} \beta_k \cdot d[t+k]_{i,t} + \gamma \cdot Controls_{i,t} + \alpha_i + \alpha_t + \varepsilon_{i,t}. \quad (4)$$

$Citation_{i,t}$ is the number of new citations a patent receives in a given year, and we separately estimate for the total citations received by the patent (Panel (a)) and those received from the bankrupt firm themselves (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 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_i. Standard errors are clustered at the firm level.

[Insert Figure 5 Here.]

We find that the overall utilization of the patents sold during the bankruptcy process experiences an "up and down" dynamic. One interpretation is that bankrupt firms sell better utilized hot patents (the "up" part) in order to raise financing, yet those patents do not necessarily better fit the buyer thus fall in total citations (the "down" part). Meanwhile, the flat pattern of citations made by the bankrupt firm to the patents suggest that those patents can be very useful to the firm and remain an important technology for the firm (though the property rights are transferred).

4.4.4 Patent Litigation

Lastly, we study how patent litigation contributes to explaining patent sales in bankruptcy. Patents provide owners the legal rights to sue for potential infringement. Patent litigation has become increasingly important in the past decades. Some patents are transacted for reasons surrounding litigation (Galasso et al., 2013; Akcigit et al., 2016). For example, a firm might buy a patent if it is sued by the firm owning this patent, to resolve uncertainty associated with the litigation process. This argument fits with the framework of trading frictions naturally—litigated patents are typically heavily used and redeployable by one or a few identifiable firms, therefore it is more likely to be reallocated if offered for sale.

[Insert Table 10 Here.]

To capture a patent's litigation status when its owning firm files for bankruptcy, we obtain data from Lex Machina, Derwent LitAlert, and 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 Table 4.

Table 10 presents the results. Even though patent litigation is uncommon in our sample (1% of patents are in litigation), it has strong explanatory power of allocating patent in bankruptcy. A litigated patent is about 4% more likely to be sold than other patents even after controlling for other liquidity measures.

4.5 Discussions

In this section, we open some discussions on the results documented in paper and intend to use these discussions to shed light on the broader asset reallocation decision in bankruptcy, implications for bankruptcy costs, and agency issues.

4.5.1 Sales of Innovation and Tangible Assets

The intensity of selling innovation we document in the paper is comparable to other types of assets as documented in prior studies. For instance, Maksimovic and Phillips (1998) document that manufacturing firms sell 44–59% of their plants during bankruptcy restructuring. Focusing on the deployment of real estate assets of bankrupt firms, Bernstein et al. (2015) show that 70% of Chapter 11 plants continue under original owner (and therefore 30% of plans are effectively sold) after one year of filing, compared to 54% of plants that continue to operate in cases converted to Chapter 7. Furthermore, Gilson et al. (2016) show that 53% of their sample firms involve a sale of some or all debtor's assets via §363 sale during reorganization with 21% of their firms selling substantially all assets as going concern business.

Are all assets sold to satisfy financing needs as opposed to restructuring assets? Indeed, it is beyond the scope of this paper to claim whether the argument of asset sales for financing can be generalized to all asset classes. In fact, there are several reasons to believe that

innovation is a unique asset class to best serve the financing role. First, patent reallocation involves minimal adjustment of physical assets and labor, which significantly lowers the adjustment cost; second, using certain innovation in production is mutually non-exclusive among firms, thus reallocating innovation does not necessary means that related production must be terminated in the selling firm.

4.5.2 Bankruptcy Costs

Financial distress and bankruptcy are costly to firms. These costs range from direct costs such as legal and professional fees (Altman, 1984; LoPucki and Doherty, 2004) to indirect costs arising from such as the loss of customers (Hortacsu, Shin, Syverson, and Venkataraman, 2013) and the loss of employees and human capital (Graham et al., 2016; Baghai et al., 2017). The "fire sale" discount associated with asset sales (Shleifer and Vishny, 1992; Pulvino, 1998) may further exacerbate the difficult financial situations faced by the firm. Therefore, firms in bankruptcy try to take all necessary actions to avoid such costs. What is the implication of our empirical evidence for firm's intention to avoid bankruptcy costs?

Our empirical findings suggest that bankrupt firms sell innovation mostly for meeting financing needs. To minimize the potential "fire sale" discount, firms sell innovations that are most tradable and redeployable. Similarly, the fast selling of innovation reflects firm's intension to avoid prolonged restructuring process to save on professional and legal fees. Furthermore, we find that firms try to retain inventors after innovation sale, reflecting their intention to minimize the human capital costs of bankruptcy. The evidence together suggests that a firm's imminent financing need interacts with the intension to avoid bankruptcy costs in shaping a firm's decision in innovation sale in bankruptcy. However, the overall value implication for the firm remains unclear.

4.5.3 Agency Issues

It is unclear whether innovation sale is due to managers' self-fulfilling incentives or managers' optimal response to financing needs and market frictions. Classical agency theories (Jensen and Meckling, 1976) suggest that managers engage in asset substitution in financial distress such as selling assets to raise financing in order to keep the firm as a going-concern—

the continuation bias (Hotchkiss, 1995; Weiss and Wruck, 1998). Such actions can be value destructive if efficiently employed innovation is redeployed to less efficient users. In contrast, managers' constrained optimal decision making suggests that when facing severe constraints in raising financing managers redeploy assets that are likely to experience the least trading frictions in order to maximize the estate value. It is extremely challenging to empirically test one hypothesis against the other in our context. Nevertheless, we intend to draw on recent literature on creditor control to shed light on this discussion.

Recent studies on enforcement of creditor rights document a rise in creditor control in financially distressed firms. Their effects on firms are manifested in high CEO turnover (Eckbo et al., 2016), reduction in risk-shifting (Gilje, 2016), and better incentive contract design (Goyal and Wang, 2016). The active involvement of activist investors as both secured (Li and Wang, 2016) and unsecured creditors (Jiang et al., 2012) ensure that creditors' recovery is preserved and enhanced in bankruptcy. Furthermore, since lenders often have security interest on assets sold via §363, such sales are closely monitored by lenders (and may be even consulted with the lenders before the sale). It is reasonable to conclude that managers are unlikely to sell assets to self-serve. However, we do not rule out the possibility that managers' selling decisions in response to market frictions may be related to senior lender's pressure in cashing out the collateral (Ayotte and Morrison, 2009). Under creditor pressure to sell assets within a short time window, managers facing trading frictions have even stronger incentives to avoid fire sale by selling liquid innovations.

5 Concluding Remarks

To sum up, this paper provides the first empirical study on innovation reallocation during corporate bankruptcies. We document stylized facts of selling innovation in bankruptcy—its pervasiveness, immediateness, and front-loading in asset reallocations. We then test two alternative economic rationales behind these activities, namely the asset restructuring view and the financing through asset sales view. We find that firms reallocate patents that are subject to less trading frictions—as opposed to selling peripheral or under-exploited 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 under-exploited assets. We also provide further evidence supporting this view using inventor mobility as patterns of citations post-sale.

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Figure 1. Legal Process of Selling Assets in via §363 Bankruptcy

This figure illustrates the process of selling assets via §363 in bankruptcy. The starting point is when §363 motions are filed and the ending point is judicial order approving the sale.

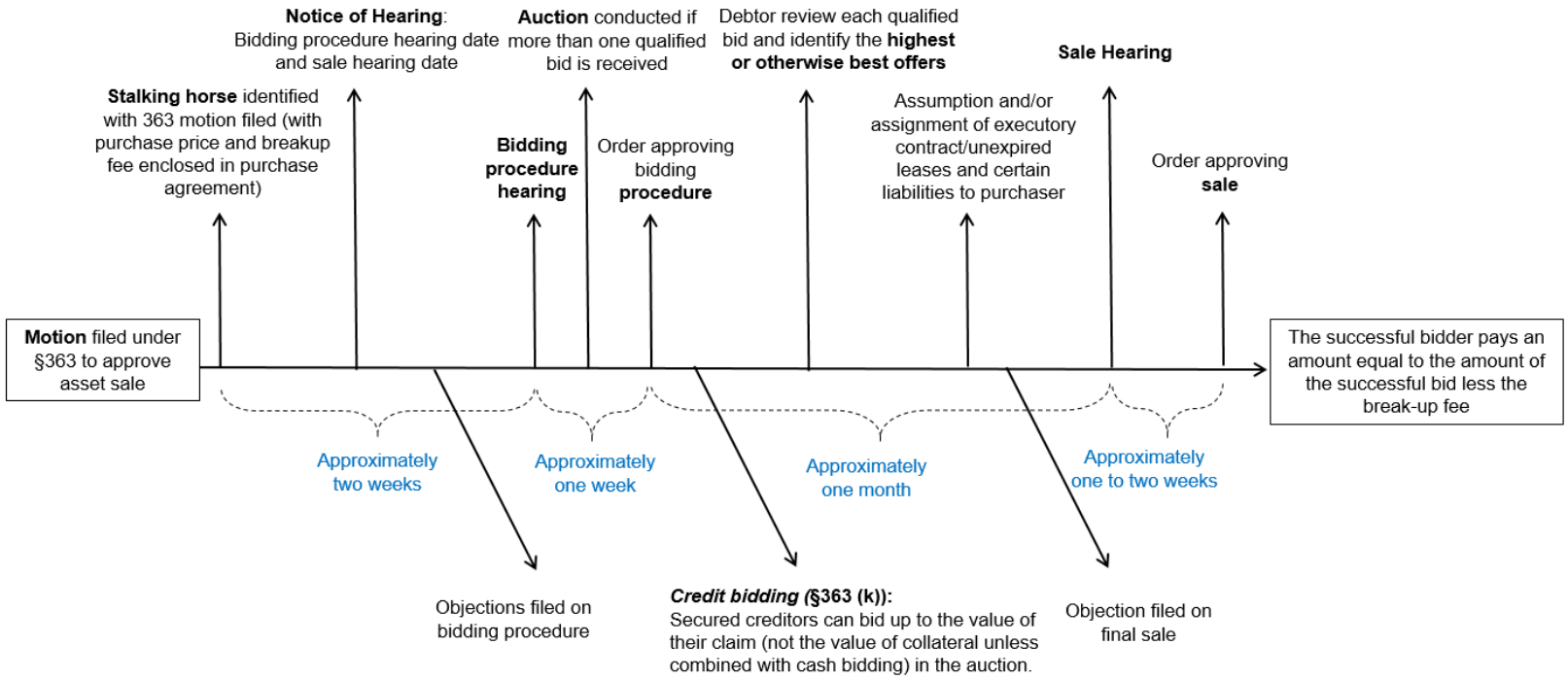
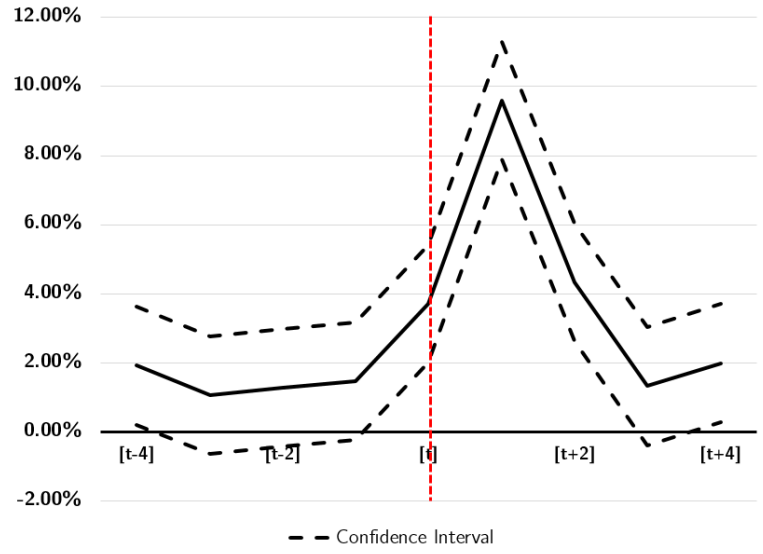


Figure 2. Selling Patents around Bankruptcy Filings

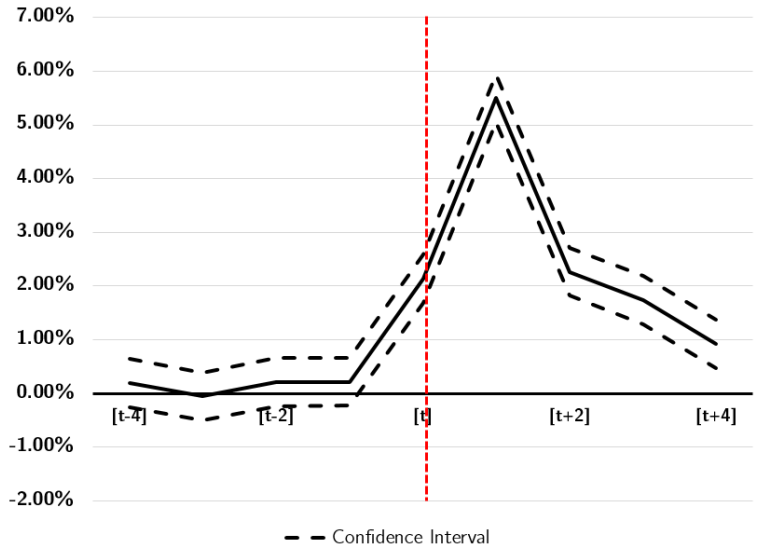
This figure presents the dynamics of the intensity of selling innovation from four quarters prior to the filing of bankruptcy to four quarters subsequent to the filing. We perform the analysis on a firm-quarter panel of all US public firms that have at least one valid patent grant from USPTO (that is, a firm starts to be included into the sample after its first patent is issued). Dependent variables are the dummy variable indicating whether the firm sold any patent 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, $d[t-4], ..., d[t+4]$, indicating if 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. Innovation-related Sale 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 as "innovation" and "no innovation" based on the motion and order of sales. The percentage of sales with innovation is presented in bars, and the total number of sales is presented in dots.

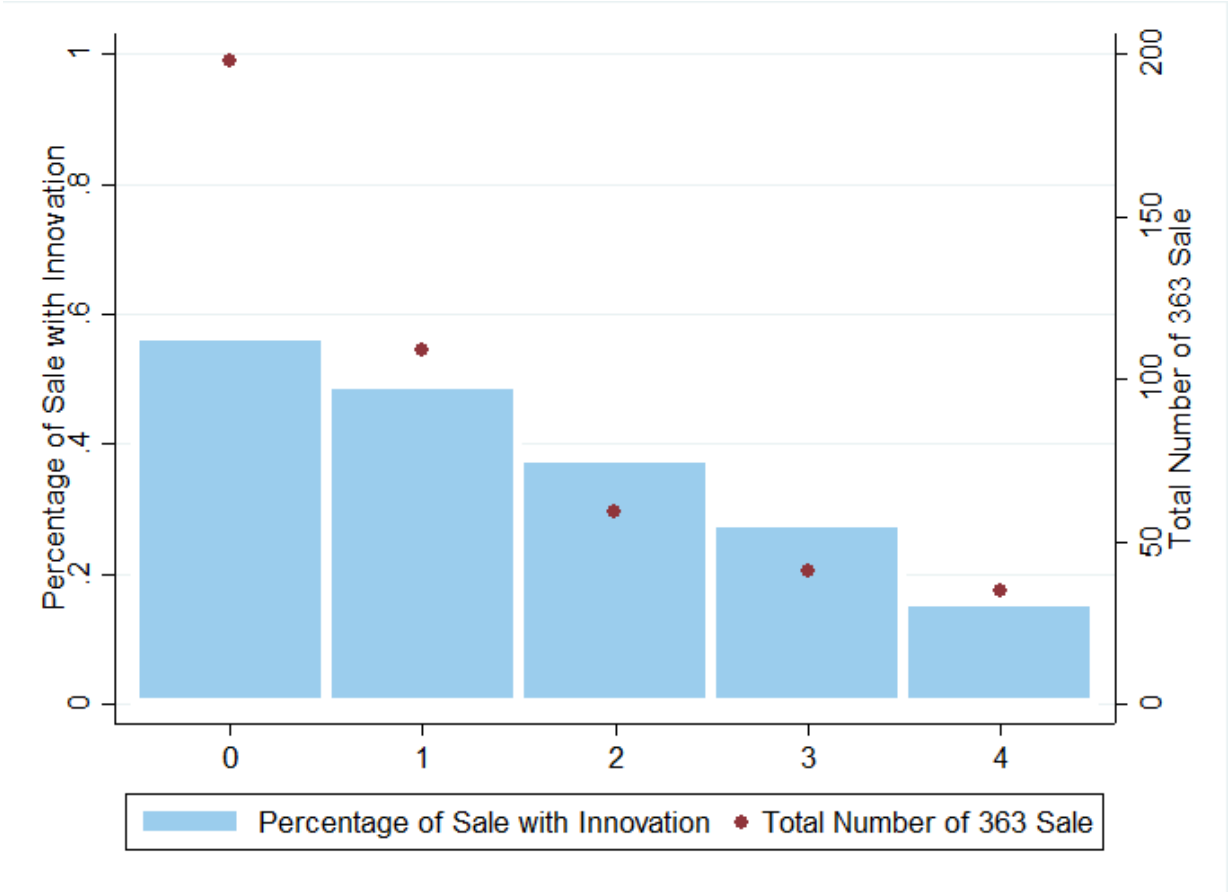
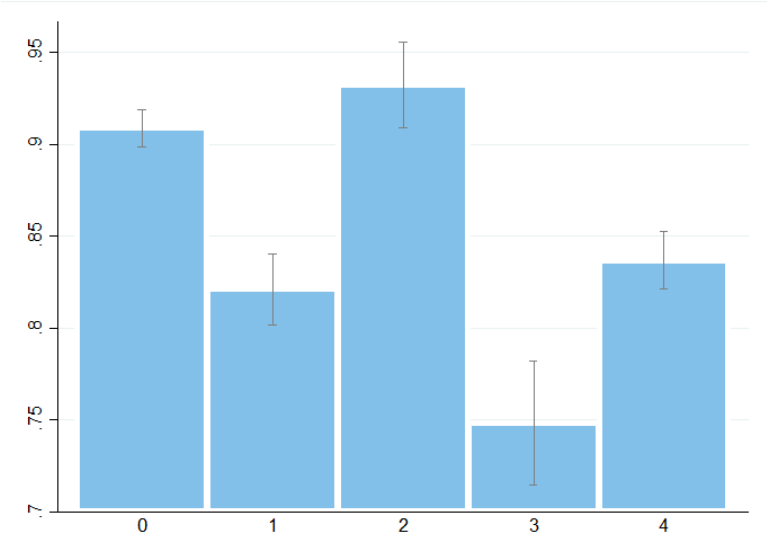
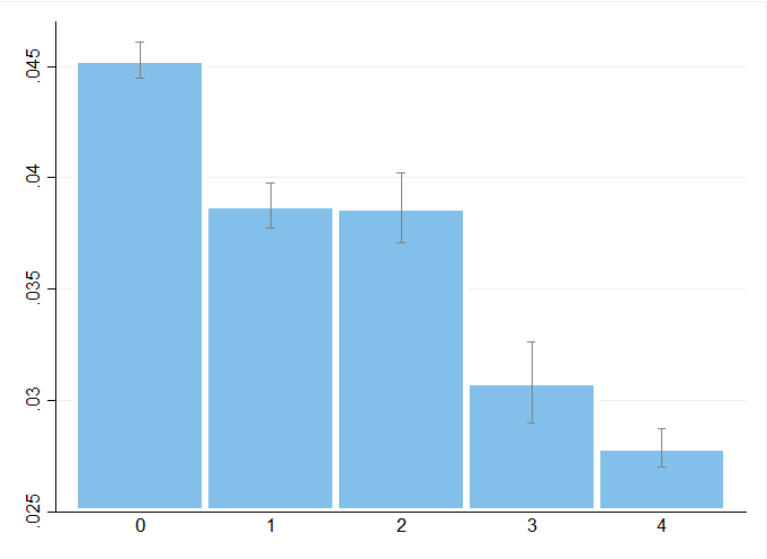


Figure 4. Patent Liquidity of Sold Patents during Bankruptcy

This figure studies the time-series trend of sold patents' liquidity during the bankruptcy restructuring process of its firm. Y-axis is the mean of liquidity measures for the patent sold in a particular quarter after its firm filed for bankruptcy; the liquidity measures are *Redeployability* in Panel (a) and *MFT Liquidity* in Panel (b). 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 over Time



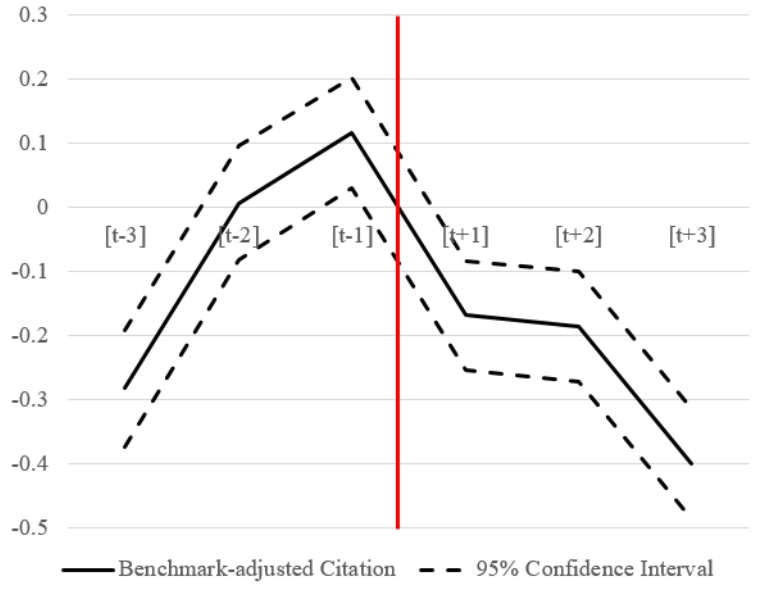
(b) MFT Liquidity over Time

Figure 5. Citation Dynamics around Patent Transactions of Bankrupt Firms

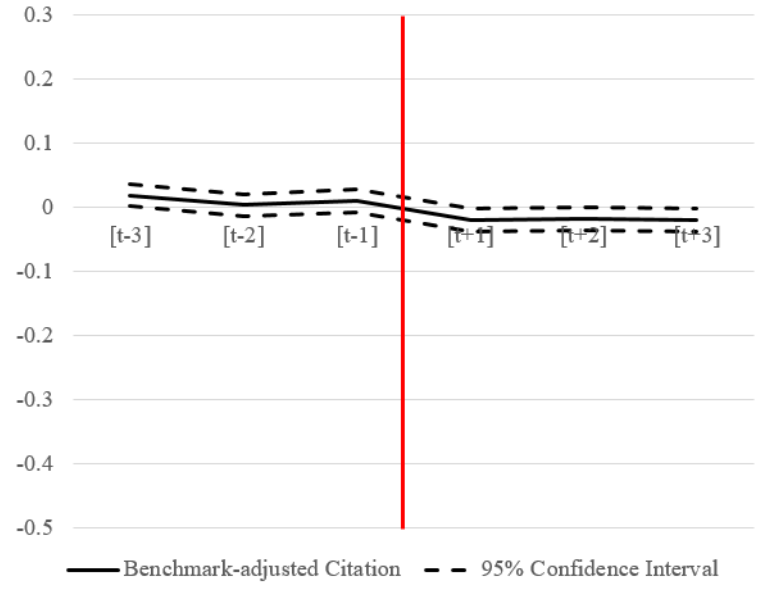
This figure plots the coefficients β_k from the following regression at the patent (i)-year (t) level:

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

$Citation_{i,t}$ is the number of new citations a patent receives in a given year, and we separately estimate for 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_i. Standard errors are clustered at the firm level.



(a) Total Citations Received by the Patent



(b) Citations Received from the Bankrupt Firm Itself

Table 1
Overview of the Bankrupt Firms and Their Innovation Transactions

This table provides an overview of the sample of bankrupt firms and their activities of selling innovation (patents) during the bankruptcy restructuring 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 of 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 Public Access to Court Electronic Records (PACER). Patent holding information of each firm from 1976 to 2006 is accessed using the National Bureau of Economic Research (NBER) patent database. We extend the NBER patent database to 2012 using Bhaven Sampat's United States Patent and Trademark Office (USPTO) patent and citation data. Patent transactions are obtained from 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, which are defined as 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 did not sell any patents). Patent selling activities are reported for two time windows—between bankruptcy filing date and the confirmation date of the reorganizing plan, and between bankruptcy filing date and 24 months after the confirmation date.

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

	Number of Obs		Selling [Filing, Confirmation]	
	Full Sample	Innovative Sample	% of Firms	% of Patents
Consumer NonDurables	131	48	29%	18%
Consumer Durables	77	44	52%	11%
Manufacturing	193	118	32%	10%
Oil	70	6	33%	33%
Chemicals	37	17	35%	6%
Business Equipment	230	126	46%	25%
Telecommunication	126	16	38%	31%
Utilities	24	9	44%	24%
Wholesale and Retail	303	32	25%	15%
Healthcare	128	48	56%	29%
Other Industries	304	54	35%	15%
Total	1,623	518	40%	18%

Panel B: Bankruptcy Cases and Patent Transactions by Filing Year

	Number of Obs		Selling [Filing, Confirmation]	
	Full Sample	Innovative Sample	% of Firms	% of Patents
1981	1	0	0%	0%
1982	3	1	0%	0%
1983	1	0	0%	0%
1985	5	2	0%	0%
1986	7	4	50%	17%
1987	6	2	100%	29%
1988	14	5	20%	10%
1989	19	5	60%	26%
1990	30	11	18%	9%
1991	39	11	18%	9%
1992	41	11	18%	1%
1993	49	13	31%	4%
1994	34	7	43%	30%
1995	44	6	67%	20%
1996	42	12	33%	15%
1997	42	7	57%	36%
1998	63	19	32%	19%
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 Time Dynamics of Innovation Sale in Bankruptcy

This table tests whether bankrupt firms are more likely to sell patents during bankruptcy, and the time dynamics of such transactions. We construct a firm-quarter panel of all US public firms that have at least one valid patent grant from USPTO (that is, a firm starts to be included into the sample after its first patent is issued). The dependent variable is the dummy variable indicating whether the firm sold any patent in that quarter (column (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 (column (3) and (4)). In columns (1) and (3) the key independent variable is a dummy variable, *I(In Bankruptcy)*, indicating if the firm is undergoing a bankruptcy process in that quarter (between 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:

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

Independent variables of interest are the set of dummies, $d[t-4], ..., d[t+4]$, indicating if the firm-quarter observation fits into the $[-4, +4]$ time-frame of the bankruptcy event. 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)
	Sell Innovation = 1		% 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 Innovation

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 of 2016, and is manually matched with Compustat. We remove cases of financial corporations. Patent holding information of each firm from 1976 to 2006 is accessed using the National Bureau of Economic Research (NBER) patent database. We extend the NBER patent database to 2012 using Bhaven Sampat's United States Patent and Trademark Office (USPTO) patent and citation data.Patent transactions are obtained from 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 Public Access to Court Electronic Records (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 prior to the bankruptcy filing. For each variable, we report the mean, standard deviation, 25th, 50th, and 75th percentiles.

Panel A: Summary Statistics of Patents Owned by Bankrupt Firms

	N=59,593				
	Mean	Std.Dev	p25	p50	p75
Redeployability	0.790	0.327	0.667	1.000	1.000
MFT Liquidity	0.033	0.022	0.022	0.031	0.039
Tech Closeness	0.590	0.303	0.334	0.567	0.864
Patent Utilization	1.955	5.100	0	0	2
Scaled Citations	1.373	2.023	0.458	0.880	1.652
Patent Age (Years)	14.100	8.500	7.000	13.000	20.000

Panel B: Summary Statistics of Bankrupt Innovative Firms

	Number of Cases=518				
	Mean	Std.Dev	p25	p50	p75
Prepack	0.196	0.397	0.000	0.000	1.000
DIP Financing	0.549	0.498	0.000	1.000	1.000
Duration (in days)	511	536	203	370	641
Outcome (Acquired)	0.127	0.333	0.000	0.000	0.000
Outcome (Converted)	0.121	0.326	0.000	0.000	0.000
Outcome (Emerged)	0.509	0.500	0.000	1.000	1.000
Outcome (Liquidated)	0.238	0.426	0.000	0.000	0.000
Assets (from bankruptcy filing)	965.311	5548.184	23.160	90.313	300.087
Leverage	0.589	0.499	0.232	0.512	0.809
Sales Growth	0.279	1.614	-0.198	-0.028	0.153
ROA	-0.304	0.562	-0.415	-0.141	0.001
R&D/Assets	0.114	0.201	0.004	0.028	0.133
Patent Stock	172.180	1273.629	3.000	12.000	39.000
Industry Distress (Stock Return)	0.288	0.453	0.000	0.000	1.000
Industry Distress (Sales)	0.157	0.364	0.000	0.000	0.000

Table 4
Innovation Redeployment in Bankruptcy

This table presents how the innovation reallocation decision of bankrupt firms is affected by patent-level characteristics associated with a specific asset using linear regressions. The analysis is conducted in a patent-level dataset, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model,

$$Sold_{ip} = \beta \cdot TradingFriction_{ip} + \gamma \cdot PatentUtilization + \lambda \times Control_p + \alpha_i + \varepsilon_{ip}.$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating if patent p was sold during the bankruptcy restructuring process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. Trading frictions are measured using *Redeployability*, capturing the extent the patents are utilized by firms other than the owning firm, and *MFT Liquidity*, capturing the liquidity of the market specific to the patent's technology class; patent utilization is measured using *Patent Utilization* which is the total citations received by the patents in the recent three years, and *Tech Closeness* which is the distance between the patent and the core technological expertise of the firm. For patent age, *I(Young Patent)* equals to one if the patent was granted no earlier than six years ago. 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 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 pre-packaged. 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						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Redeployability	0.025***				0.026***	0.023***	0.027***
	(8.636)				(8.848)	(8.093)	(8.335)
MFT Liquidity		0.193***			0.212***	0.086**	0.239***
		(4.421)			(4.806)	(2.038)	(5.148)
Patent Utilization			0.000*		0.000	0.000	0.001*
			(1.820)		(1.280)	(1.161)	(1.749)
Tech Closeness				0.018***	0.022***	0.014***	0.022***
				(5.472)	(6.547)	(4.194)	(6.081)
Young Patent	0.037***	0.037***	0.037***	0.037***	0.037***	0.021***	0.050***
	(11.582)	(11.554)	(11.692)	(11.710)	(11.528)	(6.609)	(13.297)
Scaled Citation	0.004***	0.004***	0.003***	0.004***	0.003***	0.003***	0.004***
	(6.034)	(6.126)	(4.697)	(6.259)	(5.002)	(4.977)	(5.057)
Observations	59,593	59,593	59,593	59,593	59,593	50,850	51,872
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 Only						Yes	
Exclude Pre-packed							Yes

Table 5
Financial (Not Economic) Distress

This table documents how the innovation reallocation decision of bankrupt firms is affected by patent-level characteristics associated with a specific asset, conditional on whether the bankruptcy is due to financial or non-financial distress. The analysis is conducted in a patent-level dataset, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model,

$$Sold_{ip} = \beta \cdot TradingFriction_{ip} + \gamma \cdot PatentUtilization + \lambda \times Control_p + \alpha_i + \varepsilon_{ip}.$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating if patent p was sold during the bankruptcy restructuring process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. Trading frictions are measured using *Redeployability*, capturing the extent the patents are utilized by firms other than the owning firm, and *MFT Liquidity*, capturing the liquidity of the market specific to the patent's technology class; patent utilization is measured using *Patent Utilization* which is the total citations received by the patents in the recent three years, and *Tech Closeness* which is the distance between the patent and the core technological expertise of the firm. We split the sample into *Financial Distress* sample in columns (1) to (3); and *Non-financial Distress* sample in columns (4) to (6). *Financial Distress* sample is defined as having top tercel in ROA and top tercel in book leverage, or having top tercel in ROA/book leverage and middle tercel in book leverage/ROA. We control for patent age and number of total citation 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					
	(1)	(2)	(3)	(4)	(5)	(6)
	Financial Distress			Non-financial 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
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.295	0.292	0.295	0.205	0.204	0.205
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 6
The Role of DIP Financing

This table documents how the asset reallocation decision of bankrupt firms is affected by the trading frictions associated with a specific asset, conditional on whether having DIP financing during bankruptcy. The analysis is conducted in a patent-level dataset, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model,

$$Sold_{ip} = \beta \cdot TradingFriction_{ip} + \gamma \cdot PatentUtilization + \lambda \times Control_p + \alpha_i + \varepsilon_{ip}.$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating if patent p was sold during the bankruptcy restructuring process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. Trading frictions are measured using *Redeployability*, capturing the extent the patents are utilized by firms other than the owning firm, and *MFT Liquidity*, capturing the liquidity of the market specific to the patent's technology class; patent utilization is measured using *Patent Utilization* which is the total citations received by the patents in the recent three years, and *Tech Closeness* which is the distance between the patent and the core technological expertise of the firm. The sample is split into "with DIP" and "No DIP" based on whether the bankrupt firm receives DIP financing during the bankruptcy restructuring process (from bankruptcy filing to the confirmation of the restructuring plan). We control for patent age and number of total citation 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					
	(1)	(2)	(3)	(4)	(5)	(6)
	With DIP	No DIP	T-Test	With DIP	No DIP	T-Test
Redeployability	0.029***	0.043***	0.014***			
	(9.218)	(5.052)	(2.601)			
MFT Liquidity				0.121***	1.601***	1.480***
				(2.668)	(9.308)	(8.851)
Observations	49,150	13,618		49,150	13,618	
R-squared	0.140	0.560		0.139	0.562	
Controls	Yes	Yes		Yes	Yes	
Firm FE	Yes	Yes		Yes	Yes	

Table 7
The Effect of Industry Conditions

This table documents how the asset reallocation decision of bankrupt firms is affected by the trading frictions associated with a specific asset, conditional on industry conditions. The analysis is conducted in a patent-level dataset, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model,

$$Sold_{ip} = \beta \cdot TradingFriction_{ip} + \gamma \cdot PatentUtilization + \lambda \times Control_p + \alpha_i + \varepsilon_{ip}.$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating if patent p was sold during the bankruptcy restructuring process (from bankruptcy filing to the confirmation of the reorganization plan) by its owning firm i. Trading frictions are measured using *Redeployability*, capturing the extent the patents are utilized by firms other than the owning firm, and *MFT Liquidity*, capturing the liquidity of the market specific to the patent's technology class; patent utilization is measured using *Patent Utilization* which is the total citations received by the patents in the recent three years, and *Tech Closeness* which is the distance between the patent and the core technological expertise of the firm. 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 was at the bottom decile of sales growth in that year (Gilson, Hotchkiss, and Osborn, 2016). We control for patent age and number of total citation 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					
	(1)	(2)	(3)	(4)	(5)	(6)
	Distress	Non-Distress	T-Test	Distress	Non-Distress	T-Test
Redeployability	0.082***	0.025***	0.057***			
	(6.316)	(8.352)	(4.348)			
MFT Liquidity				0.888***	0.183***	0.705**
				(3.032)	(4.144)	(2.464)
Observations	5,513	54,631		5,513	54,631	
R^2	0.371	0.277		0.367	0.277	
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	0.123***	0.026***	0.097***			
	(5.193)	(9.218)	(6.281)			
MFT Liquidity				4.001***	0.080*	3.921***
				(10.109)	(1.868)	(15.193)
Observations	4,300	55,846		4,300	55,846	
R^2	0.390	0.200		0.401	0.199	
Controls	Yes	Yes		Yes	Yes	
Firm FE	Yes	Yes		Yes	Yes	

Table 8
Evidence from §363 Asset Auctions

This table studies how the process of selling innovation by bankrupt firms is affected by the trading friction of its overall patent portfolio. The analysis is conducted in a setting of selling innovation by bankrupt firms using a transaction-deal dataset, and each observation is a transaction. We estimate the following model,

$$AuctionFeature = \beta \cdot \ TradingFriction_i + \lambda \times Control_i + \varepsilon_i.$$

The dependent variable, *AuctionFeature*, include 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. *TradingFrictions* are measures of capital liquidity as described in Section 2.4, which captures frictions sourced from specific redeployability of the patent (*Redeployability*, in columns (1) and (3)), and from market for technology (*MFT Liquidity*, in columns (2) and (4)). The t-statistics based on robust standard errors are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Numer 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^2	0.086	0.157	0.124	0.037

Table 9
Inventor Mobility and Innovation Reallocation Around Bankruptcy

This table documents how inventors reallocation decision of a firm is affected by reallocation of inventors' patent and the status of bankruptcy for the firm inventor is in. The analysis is conducted in a setting of tracking inventor mobility using an inventor-firm-year-level dataset, and each observation is an inventor i in a firm j for a particular year t. The sample includes inventors from all public firms between 1980 and 2010. We estimate the following specification,

$$\begin{aligned} InventorMobility_{ijt} = \beta_1 \cdot PatentBeingSold_{ijt} \times InBankruptcy_{jt} \\ \beta_2 \cdot \ PatentBeingSold_{ijt} + \beta_3 \cdot \ InBankruptcy_{jt} \\ + \lambda \times Control_i t + \alpha_i + \varepsilon_{ijt}. \end{aligned}$$

$InventorMobility_{ijt}$ is a dummy variable indicating if inventor i at year t moves to another firm in the next 3/5 years. $I(PatentBeingSold)$ equals to one if the inventor has one or more patents sold to a firm that the inventor is not currently working at. $I(InBankruptcy)$ indicates whether year t is the year that firm j files bankruptcy. In Panel A, we look at whether inventor's patent being sold and inventor's firm being in bankruptcy affect inventor's reallocation decision. In Panel B, we further look at whether giving Key Employee Retention Plan (KERP) during bankruptcy affect inventor mobility. We control for inventor's productivity by measuring their new patents granted and total number of citation in the last three years. More details regarding those variables are described in Section 2.4 and Appendix. 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)	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)
I(Patent Being Sold) × I(In Bankruptcy)			-0.035			-0.046*
			(-1.463)			(-1.807)
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

Table 10
Patent Litigation and the Reallocation of Innovation in Bankruptcy

This table documents how the asset reallocation decision of bankrupt firms is affected by the litigation status of the patent, in addition to its asset liquidity. The analysis is conducted in a patent-level dataset, and each observation is a patent p in a bankrupt firm i's patent portfolio in the year of filing, using the following model,

$$Sold_{ip} = \beta_L \cdot Litigation + \beta \cdot TradingFriction_{ip} + \gamma \cdot PatentUtilization + \lambda \times Control_p + \alpha_i + \varepsilon_{ip}.$$

The dependent variable $Sold_{ip}$ is a dummy variable indicating if patent p was sold during the bankruptcy restructuring 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 bankruptcy filing. Trading frictions are measured using *Redeployability*, capturing the extent the patents are utilized by firms other than the owning firm, and *MFT Liquidity*, capturing the liquidity of the market specific to the patent's technology class; patent utilization is measured using *Patent Utilization* which is the total citations received by the patents in the recent three years, and *Tech Closeness* which is the distance between the patent and the core technological expertise of the firm. 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				
	(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)
Young Patent	0.049***	0.049***	0.046***	0.042***	0.037***
	(17.595)	(17.624)	(15.406)	(14.482)	(11.532)
Scaled Citation	0.002***	0.002***	0.003***	0.003***	0.003***
	(5.407)	(5.481)	(4.649)	(6.067)	(4.825)
Observations	59,593	59,593	59,593	59,593	59,593
R-squared	0.296	0.295	0.287	0.293	0.287
Firm FE	YES	YES	YES	YES	YES

Appendix

A1 Key Variable Definitions

Variable	Definition and Construction
	a. Innovation and Its Liquidity
MFT Liquidity	A patent-year level variables, calculated as the ratio of transacted patents in the patent's technology class over the patent stock in that class.
Redeployability	Proxy for 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 cites).
Patent Utilization	Total citation 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 et al. (2016).
Young Patent	Equals one if the patent is granted no earlier than six years ago.
Scaled Citations	Citation 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, a case is prepackaged if the debtor drafted the plan, submitted 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 less than all groups or obtains the acceptance of less 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 top tercel in ROA and top tercel in leverage, or in top tercel in ROA/leverage and middle tercel 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)	Indicator variable on whether the median stock return for the 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)	Indicator variable on whether the industry (3-digit SIC) is at the bottom decile of sales growth in that year (Gilson, Hotchkiss, and Osborn, 2016).
	d. Firm Characteristics
Total Assets (Billion)	Total assets adjusted to 2007 US Dollars.
Size (Log of Assets)	The natural logarithm of total 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.

A2 Measure of Technological Closeness

The first measure *Tech Closeness* is adapted from Akcigit, Celik, and Greenwood (2016), which 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 prior to 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 class 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 The Process of Patent Sale via §363 of the Bankruptcy Code

In this appendix, we provide a general illustration on asset sale in bankruptcy with a particular focus on the patent sale via §363 of the 1978 Bankruptcy Code.

Firms typically obtain secured financing by pledging assets as collateral and lenders thus effectively have a security interest/lien on the assets pledged. Intellectual properties such as patents are becoming one of the frequently used collateralized assets for borrowing (Hochberg, Serrano, and Ziedonis, 2014; Mann, 2015). Upon bankruptcy filing, the automatic stay provision (§362) forbids lenders from exercising their rights to seize the collateral during the legal proceeding. A firm must seek approval from the bankruptcy court for the use or sale of the collateralized assets.

Typically, a firm can sell patents and other assets using either sale via §363 or a Chapter 11 reorganization/liquidation plan. The two selling mechanisms are not mutually exclusive, and both can be captured by United States Patent and Trademark Office (USPTO) patent reassignment database. For example, a firm that conducts §363 sales can still be liquidated later. One prominent difference between the two mechanisms is whether creditors' vote is required for the sale. Conducting a §363 sale is subject to debtor's discretion and judge's approval but not to creditors' vote.[14] In contrast, asset sales through a plan must be voted by each class of creditors and approved by the judge (§1121, §1126, §1129).[15] Furthermore, the "free and clear of liens and encumbrances" nature of the §363 sale makes it an attractive option for a debtor to deploy assets.[16] The provision for debtor to use or sell collateralized assets free and clear of liens is explicitly laid out in §363(f) with the following quote:

[14]For example, S363(b) allows sale of a debtor' 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."

[15]The debtor needs to receive the consent of each impaired class of claimants that account for half in number and 2/3 in value of the impaired class of claims in order for the judge to approve the (liquidation) plan. However, when such conditions are not satisfied the judge may "cram down" the plan if at least one impaired class of claimants approves the plan and the judge finds that (1) the plan does not "discriminate unfairly" and (2) the plan is "fair and equitable" (§1129(b)). Further, the judge may convert the Chapter 11 case to Chapter 7 liquidation, where assets are sold piecemeal by U.S. trustee with no plan confirmed.

[16]In contrast to selling assets outside of bankruptcy, where the lender may have a lien on both the collateral that is transferred to the new owner and the proceeds from the sale, §363 sale allows for free and clear of liens such that the lender will have the lien on the proceeds of the sale only after the sale (§552(b)), exempting the buyer from old lender's security interest (Ayotte and Skeel, 2013).

"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."

To sell assets via §363 in bankruptcy, the bankrupt firm needs to file a sale motion to the bankruptcy judge. A stalking horse, the initial interested buyer, is usually identified by the firm and notified to the judge. The sale motion illustrates the bidding and selling procedure, which are up to the judge's approval. A public hearing date on the sale procedure is specified in the sale motion. Key stakeholders of the bankrupt firm, including secured creditors, unsecured creditors, 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 or not to approve the bidding procedure so that other potential buyers may submit bids. Next, the bankrupt firm solicits other potential bids and conducts an auction for the sale. Once the successful bidder is identified by the bankrupt firm, a final sale hearing is held. The judge then approves the sale to the successful bidder. The transaction takes a few weeks to complete. A graphic illustration of the sale process is provided in Figure 1.

Assets sold via §363 range from small pieces of assets (i.e., De Minimis assets) to substantially all of the assets of the debtor. Intellectual properties such as patents have become one of frequently sold assets via §363. Buyers can be any parties, including industry competitors, financial institutions, and debtor's creditors.[17]

A final note, sale of intellectual properties is governed by not only §363 but also §365 of the Bankruptcy Code, which regulates the assumption, assignment, and rejection of executory

[17]§363(k) allows secured creditors to "credit bid" for assets using their allowed secured claims instead of cash to bid up to the value of their claim (not the value of collateral unless combined with cash bidding) in a §363 auction. The secured creditors submitting the bids can be either the "old and cold" creditors or new creditors who purchase debt claims right before or after Chapter 11 filing.

contracts and unexpired leases.[18] The main reason why §365 is quoted in many sale motions is that patent sale often triggers the transfer of a (non-exclusive) patent licensing agreement, which is generally regarded as an executory contract by the bankruptcy courts. The debtor can be a licensor or a licensee of a patent and needs to specify whether the licensing contract is transferred together with the sale. The debtor's decision and outcome on the assumption, assignment, and rejection of patent licensing contracts is beyond the scope of this study. However, while coding information on sale of patents we make notes on whether licensing agreements are part of the sale.[19]

[18]Trade secret, inventions, patents (regardless being granted or in application), and copyrights as treated as intellectual properties under the Bankruptcy Code while trademarks are not.

[19]As a licensee, the debtor may not assume or assign a patent license without the consent of the licensor because certain federal patent law may preclude it. As a licensor, the debtor may reject the licensing contract with a non-bankrupt licensee. However, §365(n), which was amended by the congress on October 18, 1998, grants the licensee specific rights to assume the contract if it continues to make royalty payments. But a non-debtor licensee may lose its rights in the event of a 363 sale. The decision to assume, assign, or reject an executory contract is generally regarded as an issue of the debtor's business judgement by bankruptcy courts. But judges may interpret it differently and make decisions accordingly.

A4 Manual Coding of of §363 Sale Motions and Orders

We started with public firms that own at least one patent at the time of bankruptcy filing. This leaves us 518 firms out of the 1,623 public bankrupt firms in our sample. A first step, we locate the case docket by searching docket number and company name on PACER. We find that the majority of cases that filed for Chapter 11 after 2002 have full case docket on PACER (case documents for most cases filed before 2002 are largely unavailable on PACER or any other platform). Each case docket contains basic descriptive information such as filing date, assigned judge, and legal counsel representing the debtor or creditors‘ committee. It also contains an index of court documents sorted by date, with an attached description summarizing the type and purpose of the document. In order to get the key variables, we download all related documents that contain the keyword "sale" in the description column as §363 Sale documents. We identified 240 court dockets that have one or more §363 Sale documents out of all court dockets available on PACER. [20]

After retrieving all the §363 Sale documents that are downloadable, we hand-collect information on the key variables listed above by reading through the sale documents. A bankrupt firm may have conducted multiple §363 Sales. We treat each sale independently. The beginning and end of a particular sale can be tracked by its motion and order files. Motion file usually contains information on assets to be sold and stalking horse's initial proposal of purchase. Patent sale details can usually be found in the Schedule exhibit attached to the motion file. Order file usually describes the bidding process, final winner, and the final price. Within these two types of files, we use keywords associated with each variable to obtain information. For example, we search for "initial bidder" for the identity of stalking horse in the motion file, and "purchaser" or "the successful bidder" for the winning bidder in the order file.

[20] We also use other variations of the keyword "sale" such as "sale\", "sale—" and "sale " to exclude plural form, since the plural form "sales" is commonly used in company naming and could yield unwanted documents such as creditor's claim. However, we still flag the documents with keywords "sales" and "363", and manually check to see if we need information from these documents.