INNOVATION AND CHAPTER 11 BANKRUPTCY OUTCOME

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Abstract

The purpose of this thesis is to explore the relationship between a firm's innovation and Chapter 11 bankruptcy outcome. Innovation is measured as R&D expenditure, the number of patents and the number of citations to capture both input and output of a firm's innovative activity. We find no significant relationship between innovation and bankruptcy outcome when we relate recent innovation to bankruptcy outcome. However, the relationship between innovation and bankruptcy outcome becomes significant when we consider the entire accumulated innovation prior to the bankruptcy, indicating older patents matter more in bankruptcy. We demonstrate that firms investing more in R&D expenditure and generating a higher number of patents before bankruptcy are more likely to reorganize than be liquidated or acquired. On the other hand, bankrupt firms with highly cited patents are more likely to be acquired than reorganize. Similar to other studies, our empirical results show that larger, more levered and liquid firms are positively associated with successful reorganizations. Finally, firms that file for prepackaged Chapter 11 bankruptcy and receive debtor-in-possession (DIP) financing during bankruptcy are more likely to reorganize than liquidate or be acquired. Firms file for bankruptcy during the 2008 economic crisis are prone to liquidation. Industry factor only matters for firms in the manufacturing industry, where firms with more innovation are more likely to reorganize than liquidated.

Keywords: Innovation, Chapter 11, Bankruptcy, Reorganization, Liquidation, Acquisition, DIP Financing

JEL Classification: G33, G34, O31, O34

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1. Introduction

Innovation and creativity are the two main elements in the knowledge-based economy. Every firm must maintain a coherent innovative strategy in order to keep their competitive advantage. In the meantime, a lack of innovation can cause a big threat to firms' survival. Economists, such as Schumpeter, suggest that innovation is one of the most important drivers for long-term economic growth, especially during the economic downturn. Numerous articles study the benefits of innovation and how innovation is linked to economic growth since Schumpeter innovation theory. Apart from bringing economic growth, innovation has been proved to be the main factor that enhances firms' performance. Morbey (1989) reports that there is a significant positive relationship between R&D expenditure and future growth in sales. Lev and Sougiannis (1996) find that R&D can generate future earnings. Chan et al. (1990) demonstrate that investors positively react to the firms' R&D announcement. Farre-Mensa et al. (2016) document that the approved patents by the USPTO help innovative startups to create more jobs, grow quickly, innovate and bring economic success.

Rosenbusch et al. (2011) show that innovation has a positive effect on the performance of small and medium size enterprises. They also suggest that SMEs should manage their innovative activities diligently in order to compete with larger and older firms. Innovation also decides firms' survival. Hall (1987) argues that the technological activities contribute hugely to the increases of the firm market value and therefore firm survival. Fontana and Nesta (2009) test how product innovation affects firm's form of exit by either liquidation or acquisition. They find a positive relationship between R&D and probability of surviving. They conclude that firms with products near the technological frontier are more likely to be acquired than be liquidated if they cannot stand as an independent entity in the market. Apart from increasing firms' performance or survival,

innovation selling plays critical role during assets reallocation bankruptcy process. Ma et al. (2019) find that 40% of the bankrupt firms sell their core innovation during bankruptcy for imminent financing needs as compared to healthy or non-financially constrained firms. The market becomes more active in evaluating innovation assets (Barniv et al., 2002; Bereskin et al., 2018) as the development and the recovery of the firms are largely relying on the novelty and technologies. According to Corrado and Hulten (2010), innovation assets are approximately accounted for 34% of firm's total capital. Innovative firms also use their patents as collateral to reach their debt financing purpose, indicating the huge contribution of intangible assets has on the financing process. Mann (2018) documents that innovative firms tend to use their patents as collateral to finance through debt, and this phenomenon is even truer for firms that are financially constrained. Chava et al. (2017) find that banks consider the value of patent when pricing loans and innovative firms with valuable patents get loans with lower rates as compared to firms with less innovation. Dahiya et al. (2003) document that debtor-in-possession financing during Chapter 11 process enables the filed firms to emerge from Chapter 11 more quickly than non-DIP financed filed firms. However, debtors may bear high interest and constraints from DIP lenders in the restructuring process (Li and Wang, 2016). Ma et al. (2019) show that bankrupt firms with higher amount of DIP financing are more likely to sell core patents during bankruptcy. Therefore, we hypothesize that the more innovative a firm is the higher possibility it has to emerge from Chapter 11 bankruptcy. In other words, we believe there is a positive relationship between innovation and successful reorganization. The rationale behind this hypothesis is the ability to achieve financing needs by utilizing innovation in Chapter 11 bankruptcy process makes bankrupt firms to acquire imminent financing and therefore increases the likelihood of successful reorganization.

Our research extends the current literature by studying the relationship between innovation and Chapter 11 bankruptcy outcome. Specifically, we examine if innovation is a significant determinant of the decision to reorganize or be acquired or liquidate. In this thesis, we collect all the U.S. firms that file for Chapter 11 bankruptcy from 1980 to 2018 and document factors that influence the bankruptcy outcomes. Our main explanatory variable of bankruptcy outcome is innovation. Firms that are in financial distress typically suffer from poor operating performance both related to firm and industry specific. Thus, we also analyze factors related to firms' assets, liability, profitability and liquidity for a sample of 842 Chapter 11 filings and for which we are able to determine the outcome of Chapter 11 (reorganized as an independent entity, acquired and operate under the control of the acquirer and liquidated and completely exit from the market). We decide to use firm's R&D expenditure, the number of patents and the number of citations as a proxy for firms' innovation in order to capture both innovation input and output.

We use logistic and multinomial regressions to examine the innovation and bankruptcy outcome relationship. Our result shows that the recently developed innovation (defined as the accumulated number of patents, the number of citations each patent received and R&D expenditure) is not significantly related to firm's decision to reorganize, liquidate or get acquired. However, we find that the accumulation of innovation (in terms of the number of patents) prior to bankruptcy is positively related to the likelihood a firm is reorganized than liquidated or acquired. This result indicates that the firms' entire intellectual stock matters more than the most recent one. On the contrary, the number of citations is negatively related to the decision to reorganize than acquired or liquidated, indicating bankrupt firms with highly cited patents tend to exit from bankruptcy via acquisition or liquidation. R&D expenditure has no impact on the bankruptcy outcome. Rationales regarding why such a discrepancy has occurred between the two

measurements of innovation could be because the acquisition is more favorable and less costly for bankrupt firms. Barniv et al. (1997) state that the acquisition is the best state as compared to other bankruptcy outcomes, reorganization and liquidation. They file that acquired firms generated the highest cumulative abnormal return and lowest lost to investors from 60 days prior to bankruptcy filing and one day after filing[1]. Gilson et al. (2016) report that M&A in bankruptcy is increasing and it is possible that firms that are viable for reorganization are actually being acquired. Among the several factors affecting M&A in bankruptcy, the exit financing for supporting firms' future operation is much higher than the financing required by the acquisition activity, leading to more M&A in bankruptcy.

We also demonstrate that firms that are larger, liquid and highly levered have a higher chance to emerge from Chapter 11 bankruptcy process as independent entity. Working capital and sales, scaled by firm assets, are the significant determinants of the bankruptcy outcome, but the results are inconsistent among different logistic regression models. To make our results more robust to different effects, we consider if the firms apply for bankruptcy during the economic crisis in 2008, if the bankruptcy petitions are pre-negotiated, if the bankrupt firms file for bankruptcy for non-financial reasons (eg. fraud) and if the insolvent debtors receive DIP financing during bankruptcy. The results show that firms that file for bankruptcy in year 2008 have higher possibility to liquidate than reorganize. The bankrupt firms that receive DIP financing during bankruptcy are more likely to reorganize as compared to non-DIP receivers. Tort cause has no impact on the bankruptcy outcome. Industry factor is relevant for firms belong to Manufacturing sectors. Firms in the Manufacturing sector with more innovation are more likely to be reorganized than liquidated. This result further validates the importance of innovation in the Manufacturing

[1] The second-best state is reorganization, and liquidation is the worst state according to Barniv et al. (2002).

sector. We also conclude that the positive relationship between the high number of patents and the high probability of reorganization is quite robust when we consider the above five dummies. One thing to notice is that the estimate on the number of citations becomes significantly negative in considering dummy variables when we compare reorganized firms with liquidated and acquired firms. We then conclude that filing for pre-packaged bankruptcy petition and receiving DIP financing make highly cited patent holders to liquidate or get acquired more often than reorganize.

This thesis makes several contributions. Firstly, it gives a different perspective on the examination of the predictors of Chapter 11 bankruptcy outcome. Mostly accounting and financial factors, industry and market variables and corporate governance related aspects are taken into consideration when we predict financial distress, bankruptcy regime choice and bankruptcy outcome. To the best of our knowledge, no research has ever attempted to explore the effect of innovation on Chapter 11 bankruptcy outcome except for a few papers examining how innovation decides a firm's survival (Siegfried and Evans, 1994; Wagner and Cockburn, 2010; Fontana and Nesta, 2009).

Secondly, this research advances our understanding about the role of innovation on t bankrupt firms. Great attention has been given to the impact of innovation on the performance or the survival of healthy firms. However, lack of empirical tests on the financially distressed firms holds us back from fully uncovering the importance of innovation. We expect our research will contribute to fill this gap.

Lastly, this thesis relates the intangible assets restructuring during bankruptcy to the bankruptcy outcome, addressing the importance of intangible assets selling and utilization in the bankruptcy.

The remainder of this thesis is organized as follows. In the next section, we present a comprehensive literature review and develop our main hypothesis. In Section 3, we briefly discuss Chapter 11 bankruptcy procedure in the United States. Research design, including data collection, variables construction and several descriptive statistics, are presented in Section 4. Section 5 shows the empirical results based on the logistic and multinomial regressions. In Section 6, we conclude the main findings and state future empirical research avenues.

2. Literature Review and Hypothesis Development

We do not deny the fact that a firm's financial and accounting characteristics are important analytical technique in assessing the performance of the business enterprise nor are that financial features, market factors and corporate governance combined play crucial roles in determining the form of a firm's existence in the market. However, some of these factors have been showing less accuracy because of the current upward trends in research and development activity. Every firm must maintain a coherent innovative strategy in order to stay ahead of fierce competitions. Lack of innovation can cause a big threat to a firm's performance and survival. Numerous academic articles have motivated to examine the relationship between firms' innovative efforts and firms' performance and survival. Morbey (1989) reports that there is a significant positive relationship between R&D expenditure and future growth in sales. Lev and Sougiannis (1996) find that R&D has an ability to generate future earnings. Chan et al. (1990) show that investors positively react to firms' R&D announcements. Rosenbusch et al. (2011) do not obtain any significant correlation between R&D intensity and future profitability. However, they document that innovation, measured as the number of patents, has a significantly positive effect on the performance of small and medium sized companies. In Hall and Bagchi-Sen (2002), the authors only find a positive

relationship between innovation measured in terms of new products introduction and performance, but not the performance measured in total revenues for the biotechnology industry in Canada. Hall et al. (1987) report that the technological activities, measured in R&D expenditures and patents, contribute hugely to the increase of knowledge that bring up the firm's market value and therefore to firm survival. Cefis and Marsili (2005) test how different types of innovation affect firm survival. They conclude that innovation increases firm's survival by 11% overall and process innovation (the innovation in the process of producing a product) itself increases the likelihood of firm survival by 25%. For product innovation, it has an impact on firms' survival only when combined with process innovation.

Very few articles have documented the relationship between innovation activity and mode of exit. Fontana and Nesta's (2009) test how product innovation affects a firm's form of exit by either liquidation or acquisition if the firms cannot survive. They conclude that firms with products near the technological frontier are more likely to be acquired than be liquidated if they cannot stand as an independent entity in the market. Wagner and Cockburn (2010) analyze the survival of 356 internet-based and software firms that made an initial offering of equity (IPO) during 1990 dot.com bubble and how their survivals are affected by the patents seeking endeavor before the collapse of the internet bubble in 2001. They show that patenting behavior is positively related to survival, and those firms with a high concentration of patent citations are more likely to be acquired than delisted from the NASDAQ if they encounter business failures.

Apart from increasing firms' performance or survival, innovation also plays a critical role in bankruptcy outcome and assets reallocation process. Innovative firms can sell their patents or use their patents as collateral to reach different financing purposes, indicating the huge contribution of intangible assets in corporate financing. Mann (2018) documents that innovative

firms using their patents as collateral tend to finance through debt, and this phenomenon is even truer for firms that are financially constrained. Chava et al. (2017) find that banks consider a patent's value when pricing loans and innovative firms with valuable patents get loans with lower rates as compared to firms with less innovation. Dahiya et al. (2003) show that debtor-in-possession financing during the Chapter 11 process enables the filed firms to emerge from Chapter 11 more quickly than non-DIP financed filed firms, and the bankruptcy duration is even shorter when the filed firms are able to get DIP financing from their previous lenders. Ma et al. (2019) reports that 40% of the bankrupt firms sell 18% of their intangible asset. They find that bankrupt firms with higher amount of DIP financing are more likely to sell core patents in assets selling process. However, debtors may bear high interest and constraints from DIP lenders in the restructuring process (Li and Wang, 2016). Hence, we believe that the ability to achieve financing needs through innovation selling in the Chapter 11 bankruptcy process can increase the likelihood of successful reorganization.

Most of the studies that test the relationship between innovation and firms' performance, or survival consider all firms in the market. In this thesis, we consider firms that are already in Chapter 11 bankruptcy process as it is reasonable to test if the bankrupt firms also benefit from innovation. According to the above literature review, we conjecture that bankrupt but innovative firms have a higher possibility to emerge from bankruptcy as an independent firm and firms with valuable patents (in terms of having highly cited patents) are more likely to be acquired than liquidated if they have to exit from the market. Therefore, our main hypothesis follows below:

Hypothesis: Innovative firms are more likely to reorganize than liquidate or get acquired. If the bankrupt firms have to exit from the market via acquisition or liquidation, those that are innovative have higher possibility of exiting the market via acquisition than liquidation.

3. Chapter 11 Bankruptcy Process in the United States

A business or an individual, which cannot fully pay its debt out of its current assets, can file for bankruptcy in the United Sates. There are different types of bankruptcies that are referred to by their chapter in the U.S. Bankruptcy code. Businesses or individuals can seek protection under Chapter 7, which is knowns as an immediate liquidation, or Chapter 11, which permits bankrupt firms to reorganize. The U.S. bankruptcy Reform Act took effect in 1980. This was the first time Chapter 11 was constructed. A Chapter 11 bankruptcy case starts with filing a petition with a bankruptcy court where the filer (a business or an individual) operates or resides. A bankruptcy petition can be brought upon by the insolvent debtor, which is called as a voluntary petition. Alternatively, firm's creditors can file bankruptcy petition, which is called involuntary bankruptcy. The main objective of Chapter 11 is to protect the insolvent debtors from their creditors while allowing them to operate and give them an appropriate amount of time to pay back their debts later.

There are several important dates during Chapter 11 bankruptcy. The first important date is the filing date. The filing date refers to the date that the insolvent debtor files for Chapter 11 bankruptcy. Usually, it is required by the bankruptcy court to disclose the current assets and current liabilities at the time of filing. The confirmation date is the date on which the submission of reorganization or liquidation plan gets confirmed by the court overseeing the case. There is a hearing by the court and a final vote from creditors and other investors and disclosure statements before court confirms the plan. The court confirms the reorganization or the liquidation plan when the debtor got approval from its Creditors' Committees and the bankruptcy court. However, before confirmation of a plan, several things could happen. If debtor's plan was rejected either by its creditors or by the bankruptcy court, the bankruptcy judge can convert the Chapter 11 case to

Chapter 7, which is known as an immediate liquidation. Usually a trustee will be assigned by the court to distribute the money by liquidating the debtor's remaining assets. However, the insolvent debtor has to submit the amended plan of reorganization if it wants to continue with a Chapter 11 reorganization plan. Apart from conversion to Chapter 7 process, the case can be dismissed by the court if a party of interest file a motion to dismiss the case, but the dismissal has to happen before the confirmation of a plan. A graphic illustration of the Chapter bankruptcy process is provided in Figure 1.

[Please insert Figure 1 about here]

Bankrupt firms are allowed to sell their assets under §363 bankruptcy code. The §363 sales preserves assets better to allow for higher bids and creditors to recover more, resulting in bankrupt firms prefer to liquidate under Chapter 11 process than under Chapter 7 liquidation outside bankruptcy court. Additionally, debtors' can sell their assets without getting approval from their creditors as long as the debtor itself and judge approve the sale. Debtors are also given large amount of freedom in deciding which assets to sell. The sales process usually starts when the debtor files for a sales motion to the bankruptcy court. A stalking horse, which is the first bidder interested in buying the debtor's asset, will be identified by the debtor and bankruptcy court. Usually, a public hearing will be held, and the secured and unsecured creditors can file a formal objection during the hearing. If judge approves the sales motion, debtors will conduct an auction and identify potential buyer. The whole process usually takes several weeks to accomplish.

4. Research Design

4.1 Sample Selection

We first obtain both public and private firms filing for Chapter 11 bankruptcy from 1980 to 2018 separately from Bloomberg, Audit Analytics and S&P Capital IQ. We focus on collecting bankruptcy information, such as company name and identifiers and bankruptcy file date. We first use Bloomberg terminal to collect Chapter 11 bankruptcy filers. We select all the industries except financial sector (the SIC code that ranges from 6000 to 6799 according to SIC classification) because bankruptcies are handled differently in this industry sector. We have 1,879 Chapter 11 filers with non-missing CIK (since we used CIK as the unique identifier to merge three datasets) from 1980 until 2018. Audit analytics is the second available data source we used for collecting bankruptcy information. Unfortunately, it only covers bankruptcy data from 2000 until 2018. We collect 1,928 Chapter 11 filers that are not in the financial industry with no missing CIKs. The last available data source is S&P Capital IQ. We collect 732 Chapter 11 bankruptcy filers using same criteria above. As a second step, we check for companies that file for bankruptcy more than once. We take the very first filing if the firm files for bankruptcy more than once. We find 40 multiple filers (some companies file bankruptcy more than two times) in Audit Analytics, one from Bloomberg terminal, and zero from S&P Capital IQ. However, we find out that Bloomberg tends to report oldest cases as opposed to S&P Capital provides the most recent cases when we merge three data sets. Therefore, we manually check companies with same merged names but with different bankruptcy file dates. We allow for 15 to 30 days deviation on the filing date. We manually check some of the companies that exceeds 30 days range (such as one year) and leave the earliest date as a bankruptcy file date.

We use CIK as a merging identifier to merge these three data sets. In total, we have 2,866 companies seek protection under Chapter 11 bankruptcy from 1980 until 2018. We conduct a visual inspection by writing a simple name matching code to compare company names among these three data sets since we only have CIK as the merging identifier. This process enables us to identify any wrongly merged companies. The visual inspection reveals that 85% of the companies merged perfectly with the same company name. The remaining 15% of the firms have different names. We search companies in EDGAR and find that some data sources use filer's new name, while others use the original name.

We decide to use only public companies in order to get complete financial and bankruptcy information. We consider a company "public" if it has average stock price of three years (36 months) prior to bankruptcy file date. We have 1,617 companies with three years average stock price and 1,249 companies with no average stock price. Therefore, we categorize these 1,617 companies as "public" and the remaining 1,249 as "private" companies in this thesis. We use header information from Compustat to supplement missing CUSIP, GVKEY and SIC to the existing merged data set. We have 1,492 firms out of 1,617 with full header information (including CUSIP, GVKEY, CIK and SIC code). Therefore, we deleted the remaining companies that are not covered by Compustat.

We also use Lynn M. LoPucki's Bankruptcy Research Database[2] as it provides complete information about Chapter 11 for large and "public" companies. The WebBRD database includes all Chapter 11 and Chapter 7 bankruptcy cases filed by or against a company since 1980. It has bankrupt companies that have assets worth $100 million or more at the time of filing (measured in 1980 dollars) and is required to file 10-Ks with the US Securities and Exchange Commission (SEC)

[2] http://lopucki.law.ucla.edu/

for a year ending not less than three years prior to the bankruptcy file date. The database collects information from a variety of sources, including the bankruptcy courts' files on the Public Access to Court Electronic Records (PACER) service and the company's filings with the SEC. PACER provides the full-text source for bankruptcy documents. The last date we have considered for UCLA's data is October 31, 2018, and any cases after that are not included. We construct the final sample using the same criteria : (1) We excluded 24 Chapter 7 cases; (2) We excluded 136 firms belong to financial industry (using the SIC division labeled with letter "H" in BRD's data set, the SIC code ranges from 6000 to 6799); (3) We deleted 25 cases that are pending and with unknown outcomes until the end of year 2018 as they are non-representative cases in many aspects; (4) We remove 71 second or third time bankruptcy filings for the same company, and we only keep the first filing. As a result, we have 868 cases with complete information. We merged the 1,492-case bankrupt list we have with UCLA's 868-case bankrupt list. In total, we have obtained a preliminary sample of 1,887 Chapter 11 filers over the period from 1980 until 2018.

Most of the efforts have been dedicated to identifying the bankruptcy resolutions for 1,886 companies. We mainly use Factiva (owned by Dow Jones & Company). We also outsource other search engines (e.g., Google) for companies that are not covered by Factiva or have a lot less bankruptcy information. For each bankrupt company, we first check if the bankruptcy file date from Factiva is the same to the date in the merged date set. If not, we correct the file date based on Factiva's information. We define bankruptcy end date as the date companies' reorganization plan is confirmed by the bankruptcy judge overseeing the case. We have the following steps to decide the bankruptcy end date for firms that go liquidated. We consider the case has ended if the judge approved the sales of all or substantially of debtor's assets or the sale that is more than half of the business. If no sales exceed half of the business, we take the date on which the last largest sale was

approved by the court. We do not have end dates for cases that are dismissed and converted before the confirmation of plan or the sale under the Chapter 11 bankruptcy's 363 code. We delete eight companies that are identified as Chapter 11 cases in our list but turn out to be Chapter 7 cases in Factiva.

We categorize the resolutions of Chapter 11 bankruptcy as reorganized, liquidated, acquired, merged, converted, dismissed, unknown, pending and private. We consider a firm is reorganized if the reorganization plan got confirmed by the bankruptcy court and the firm emerges from Chapter 11 as independent publicly traded firm and have the intention to operate indefinitely. We consider a firm is acquired if a firm exits from bankruptcy because of acquisition and operates under the control of the acquirers without any layoffs and ceasing its original operations. We consider a firm is liquidated if a firm sells all or substantially of its assets and operates only for the liquidation purpose. We consider a final resolution as converted if a company files a motion to convert its Chapter 11 case to Chapter 7 liquidation, and the conversion motion is approved by the judge who oversees the case. Usually, it would not take a long time to finish liquidating all of company's assets. Therefore, we consider conversion as liquidation. A case is considered dismissed if judge approves the dismissal of the case before the reorganization plan or the 363-sales confirmations. The reasons for a company's case to be dismissed can be based on a failure to file in good faith or the judge thinks companies have no prospect of any distribution to creditors and equity holders. We put unknown and pending as bankruptcy resolutions if we cannot decide the bankruptcy outcome or the case is still in bankruptcy process until the end of February 2019. There are several companies that went private (4 cases) or merged (8 cases) after exiting from bankruptcy. We classify companies that went private as reorganized since bankruptcy companies only decide to go private after the bankruptcy court approved their reorganization plans. The

merged cases are considered as acquired. We also collect other information on bankruptcy filing features, such as if the filing is pre-packaged or pre-negotiated, if the debtors receive DIP financing during the bankruptcy, and if the bankruptcy petition is filed for non-financial reason[3]. We label these non-financial variables as prepack, DIP and Tort for simplification.

Table 1 summarizes the sample selection process. We first delete 47 dismissed bankruptcy cases and 271 bankruptcy cases for which we are unable to determine the outcome of the Chapter 11 process. We only consider companies that have latest annual financial data within three years prior to bankruptcy to reflect debtors' pre-bankruptcy condition. As a result, 231 companies were eliminated because they did not have latest annual report within three years prior to bankruptcy. The patent dataset provided by Kogan, Papanikolaou, Seru and Stoffman (2017) contains all the patents granted to the public firms from 1926 to 2010. Therefore, we only consider public firms that filed for bankruptcy until the year of 2010. We are unable to match 228 bankrupt companies to the Stoffman's database. This 228 companies are not covered by CRSP, therefore not covered by Stoffman's database. Our final bankruptcy sample consists of 842 bankrupt firms with complete information.

[Please insert Table 1 about here]

Table 2 classifies the number of firms that filed for Chapter 11 bankruptcy protection from 1980 to 2010 according to their two digits SIC code. We divide the whole sample by industry sectors so we can have an understanding about the bankruptcy filing concentration in each industry. A sample of 842 publicly traded firms with complete court related, financial and patent data are used. According to SIC classification, the first three sectors with SIC code ranging from 0100-

[3] non-financial reason includes claims such as product liability, fraud, pension, environmental claims and patent infringement etc.

1999 are combined together and presented as a first sector. We also combine Wholesale and Retail sectors as a group. Other sectors are separately presented. Table 2 shows that the majority of the bankrupt companies belong to Manufacturing (334) and Services (162) sectors or Wholesale and Retail (161) sector combined, which comprise 40% and 19% of the sample, respectively. We observe that most of the bankruptcy filing is concentrated in the Manufacturing sector, indicating firms in the Manufacturing are more prone to business failures than the firms in the remaining sectors. This may be caused by the fact that firms in the Manufacturing sector need to make continuous alteration and creation, which lead to volatility and therefore causing firms to go bankrupt more often. The 842 bankruptcy filing firms include 358 (43%) reorganized firms, 79 (9%) acquired firms and 405 (48%) liquidated firms. We are not surprised that we have more liquidated firms than reorganized firms as we include all the bankrupt firms without considering the size. However, smaller bankrupt firms, compare to larger bankrupt companies, are economically less viable and therefore more likely to exit market.

[Please insert Table 2 about here]

4.2 Independent Variables and Data Collection

4.2.1 Innovation

R&D intensity and innovation experience are proved to be the direct antecedents of firm innovativeness (Brav et al., 2018). R&D expenditure have been used as a proxy for firm innovative efforts as it is a well-accepted measurement for innovation. Jermias (2007) uses firm's R&D expenditures to capture firm's innovation. It is arguable that the output of R&D process is stochastic, some of the R&D activity creates more value while some of them are not. Firms vary by the amount of money, time and efforts they put into the innovation process. Nevertheless, the higher level of dedication into the innovation process may not necessarily guarantee a successful

outcome as the innovation process is very complicated. If a firm devoted a substantial amount of their resources to the innovation process, but do not have the ability to leverage their resources efficiently, their research development can be hindered. Some firms, on the other hand, have the ability to allocate R&D resources efficiently and produce corresponding innovation outcome. Rosenbusch et al. (2011) test the relationship between innovation and the performance of SME. The results show that dedicating more resources to innovation output (e.g., the number of patents) leads greater increase in SME performance compared to innovation input (e.g., R&D expenditure).

Some researchers argue that patent and citation are the suitable proxy for innovation. Balsmeier et al. (2017) claim that innovative efforts cannot be fully captured by R&D expenditure and simple patent count. Hall and Bagchi-Sen (2002) measure innovation by including patent data consist of domestic and international applications and approvals, as they believe patent data has higher representative power than R&D expenditure. Almost all of the recently published papers studying firm's innovation use the number of patents and number of citations as a main proxy for innovation. For exemple, Chen et al. (2016), Kogan et al. (2017), Chemmanur and Tian (2018), and Bereskin et al. (2018) construct the innovation as the number of patents and the number of citations each patent receives in the subsequent years. Other variables are also developed to capture the different aspects of firms' innovation. Jia et al. (2017) add four innovation strategy variables, such as patent originality score, patent generality score, patent exploration intensity, and patent exploitation intensity, on top of R&D expenditure, the number of patents and the number of citations.

Referring to Hall et al. (2005), they state that knowledge creation process is a continuum concern, where it starts from investing in R&D expenditure and follows by generating patents and receiving citations. In this thesis, we decide to use firm's R&D expenditure, the number of patents

and the number of citations as a proxy for innovation to capture different aspects of innovation. The existing literature state that the average lag between the R&D expenditure and patent application is less than one year, indicating firms tend to apply for patents nearly at the same time as R&D expenditure (i.e., Hall et al., 1984; Lerner & Wulf, 2007). The applied patents start to receive citations after the patents are granted by USPTO and the lag between patent application date and patent grant date is two years in average (i.e., Hall et al., 2001; Chemmanur and Tian, 2018). However, not all the patents will necessarily be granted in the end. Hence, it is reasonable to treat R&D expenditure as an indicator of innovation input to capture innovation intensity, meanwhile treat the number of patents and the number of citations as indicator of innovation output to capture the economic significance and quality.

As we mentioned before, firms tend to file for patents right after the R&D activities (the lag is one year on average) and the filed patents usually get granted within two years on average. Therefore, it might be reasonable to relate firm's bankruptcy in the current year to innovation three years ahead. But one could argue that bankrupt firms usually cut R&D expenditure when the firms are experiencing some financial difficulties. From the perspective of agency theory, we believe that managers are risk averse and self-interest seeking (Jensen and Meckling, 1976), managers tend to cut R&D expenditure since the benefits of R&D investment is distant and the risk is high especially during the financial difficulties. Because of the above reasons, to account for the long-term nature of innovation process, our empirical tests relate firm bankruptcy in the current year to patent-related variables five years ahead. Ma et al. (2019) show that bankrupt firms tend to sell their core innovation during the bankruptcy and those core innovations could be developed much earlier than the bankruptcy filing. For example, the famous patent selling of Eastman Kodak. Eastman Kodak filed for bankruptcy in 2012 and sold around 1,110 patents that are developed in

2002. Different from healthy firms, bankrupt firms tend to sell valuable patents in order to achieve their imminent financing needs. Therefore, we also take the accumulated number of patents before bankruptcy as a different way of measuring the innovation for bankrupt firms in order to study if the older patents matter or not. According to the NBER innovation literature (Hall, Jaffe, & Trajtenberg, 2001), we decide to use application year as it is closer to the completion of the innovation (application date can reflect the occurrence of the R&D activities as well). Hall et al. (2001) present that the average lag between patent application date and patent grant date is 2 years. It is because the inventors have strong intentions to apply for a patent following the completion of the innovation. However, the patent grant date depends on the Patent Office, which inventors have no control over. We define the number of patents as the natural logarithm of one plus the accumulated number of patents applied within 5 years or all the patents accumulated prior to bankruptcy and the number of citations is the accumulated citations each patent received within 5 years or the entire history of each patents before bankruptcy. We calculate the R&D expenditure by taking the summation of 5 years R&D investment scaled by firm's book value of total assets.

We collect firm's R&D expenditure from Compustat. The NBER and the USPTO provide patent related data. The latest version of the National Bureau of Economic Research (NBER) database, which constructed by Hall et al. (2001), has patent and citation data from 1976 to 2006. NBER includes annual data regarding the number of total patents, the total received citations by each patent, the unique assignee's identifiers, such as GVKEY and CUSIP, to link to outside databases, such as Compustat. The USPTO database provides data on patent and citations from 1976 until the end of 2017. The USPTO includes patent application date, grant date, patent assignee name (the entity that owns the patent), and citations that all the patents receive until the end of 2017 (Marco et al., 2015). However, USPTO does not include a unique company identifier

that we can link to outside databases, such as Compustat. Researchers, who used the USPTO data, successfully matched assignees to the corresponding corporations using name-matching algorithm (Chen et al., 2016; Kogan et al., 2017; Bereskin et al., 2018). We go through the online Appendix given by Kogan et al.'s paper for matching assignees to Compustat firms and an online document from NBER website[4]. Considering the limited time and resources given, we decide to use Stoffman's dataset[5] for this thesis to test the hypothesis[6]. Stoffman's database provides all the patents granted from 1926 until 2010. It has data on the patent number, the patent application date, the number of citations each patent received by the end of 2010 and the permanent number from CRSP (permno). We match each patent to the corresponding bankrupt firms by permanent number. We do have some unmatched bankrupt firms that are not covered by CRSP, therefore not covered by Stoffman.

4.2.2 Control Variables

We mainly use variables that developed in Altman (1968) Z-score 5-factor and Ohlson (1980) O-score 9-factor bankruptcy prediction models to construct our control variables. Intuitively, these factors are useful for predicting the bankruptcy outcome. The widely used firm related factors for predicting firm survival are size, leverage, profitability, liquidity, and growth. We collect all the data from Compustat from 1970 to 2018. Financial variables are matched to the latest annual report within three years prior to bankruptcy to make sure the data accurately describes the firm's conditions at the time of bankruptcy filing. We define the control variables as follows:

[4] Online Appendix: https://users.nber.org/~jbessen/matchdoc.pdf
[5] Link the Stoffman's website: https://iu.app.box.com/v/patents
[6] See Appendix for detailed description on how to match patent assignees to firms in Compustat.

Size: We measure size as the natural logarithm of total assets. The amount of total assets is corrected for inflation by taking a base value of 82.4 for 1980. We use the Consumer Price Index-All Urban Consumers, base period from 1982-1984. We retrieved CPI index from FRED.

Leverage: The leverage of the firm is defined by the ratio of total liabilities to total assets. This ratio can reflect firm's capital solvency and financial structure. Most of the bankrupt companies should display a leverage that is higher than one. One could argue that higher leverage leads firms to become bankrupt more quickly and maybe less financially distressed pre-bankruptcy, and therefore, more likely to be reorganized than the lower leverage firms that accumulated operating loss for years before forced to file bankruptcy. We expect firms with a larger leverage ratio are likely to reorganize.

Working Capital: We define this ratio as Working Capital/Total Assets. Among three liquidity ratios, the working capital over total assets proved to be the most valuable one in both univariate and multivariate analyses in Altman's (1968) study. Altman (1968) find that the significance level is slightly higher for the ratio of working capital over total assets when the ratio of current liabilities over current assets is deleted from the logit model. In our thesis, we label it as WC/TA for the regression model. We expect the higher the WC/TA, the higher the probability of reorganization.

Retained Earnings: We define this ratio as Retained Earnings/Total Asset. Altman (1968) uses retained earnings over total assets to measure the cumulative profitability over time of a company. Retained earnings can also be interpreted as earned surplus. Usually young firms have lower RE/TA ratio as they need more time to cumulate their earnings. Higher RE/TA means companies were doing great in the past and less likely for them to liquidate. In other words, firms that have higher RE/TA ratio have more time to negotiate and wait for a better option. We label this variable as RE/TA in the regression model.

Net Income: We scale firm's net income by its total assets. We label it as NI/TA in the regression model. This variable is used by Ohlson (1980) and Barniv et al. (2002) to represent firm's profitability. A higher net income (profit) usually implies a better performance pre-bankruptcy.

IAROA: Adjusted return on asset ratio that represents firm's profitability. Following Denis and Rodgers (2007) and Maksimovic and Phillips (1998), IAROA is calculated by subtracting the industry median ROA from sample firm's ROA. We define ROA as Earnings before Interest, Tax, Depreciation and Amortization (EBITDA) divided by Total Asset. We posit that firms which perform better than their industrial benchmark have higher possibility to reorganize.

Liquidity: We use current ratio to proxy firm's liquidity. Current ratio is a ratio between current assets divided by current liabilities. Both the ratio of working capital over total assets and the ratio of current liabilities over current assets are used in Ohlson's (1980) nine variable model for predicting corporate bankruptcy failure. We label this variable as Liquidity in the logit regression model. Liquid firms tend to possess more liquid assets than the non-liquid firms and therefore can quickly sell assets without making dramatic changes to the assets' price and firms' financial condition.

Table 3 reports the descriptive statistics for bankruptcy sample firms. Panel A of Table 3 presents the statistics for the full sample. Outliers are present in our sample, as the kurtosis of most of the variables are high, except variables sales and liquidity. Griliches et al. (1987) show that the distribution of patent is very skewed. This is true in our sample as well. The number of patents is extremely skewed to the right as we have zero patents for around 50% of the companies. This is also true for RD5, which is the sum of firm's R&D expenditure within five years prior to bankruptcy, and the number of citations. For example, Texaco owns 794 patents within 5 years prior to bankruptcy filing and its patents generate the highest number of citations, which is 3,5900,

in our sample. Therefore, we take natural logarithm of one plus the number of patents (citations) in our regression models to take care of the skewness. TA is the firms' total assets (measured in million U.S dollars) that we use to measure firm size. We did not report the adjusted amount of total assets, which is corrected for inflation by taking a base value of 82.4 for 1980. The average sample firm has total assets of $1,122.790 million and median is $246.333 million. The distribution of total assets is extremely skewed as the median firm has total assets of $246.333 million. The mean of leverage ratio of full sample, which is defined as total liabilities divided by total assets, is greater than one as firms that enter into bankruptcy have fewer amount of assets to cover larger amount of debt. The means of RE/TA, NI/TA and ROA are -39.30%, 54.30% and -17.20%, respectively, indicating that full sample firms performed poorly before their bankruptcies. The mean of WC/TA is -28.10%, suggesting mean sample firms have severe internal liquidity problems with negative working capital. We also can arrive to the same conclusion if we define liquidity ratio as current assets divided by current liabilities. The median of liquidity for full sample 0.974, indicating that half of the bankrupt firms have no ability to cover their short-term liabilities with their current assets. We further compare the variables among three groups that we classified according to bankruptcy outcome. We observe that reorganized firms tend to invest more on R&D expenditure and produce and receive more patent and citations as compared to acquired or liquidated firms. The means of size between reorganized and acquired or liquidated firms indicate that reorganized firms seem to hold more assets than other firms do. Reorganized firms tend to borrow more by having the highest leverage ratio. Firms that are reorganized and liquidated have higher leverage ratio than acquired firms. We also notice that liquidated firms are the worst performer in the market by having RE/TA ratio of -43.413% compare to acquired and reorganized

firms. On the other hand, liquidated firms have higher sale ratio, indicating they might have faced with some fire sale of their products to alter the bad financial situation before the bankruptcy filing.

[Please insert Table 3 about here]

Table 4 reports correlation matrix for the explanatory variables. We observe that the number of citations, the size of the firm and liquidity are positively correlated to the number of patents. This indicates that firms with a higher number of patents are larger, liquid and the patents are highly cited. Sales is negatively related to the number of patents. We should note that the number of patents and the number of citations have a high absolute magnitude at 0.896. Other variables are not significantly related to the number of patents. Size is negatively related to R&D expenditure scaled by total assets. This negative correlation indicates that smaller firms are willing to spend more on R&D activities to compete with relatively big companies. The positive correlations between size and NI/TA, ROA and IAROA show that larger firms tent to be more profitable and grow faster compare to the smaller firms. The negative relationship between Leverage and RE/TA, NI/TA, IAROA and liquidity indicates that levered firms show lower profit, less growth and lower liquidity. Sales/TA is positively related to firms' RE/TA, NI/TA and IAROA, indicating higher sales usually leads to higher profit and higher growth.

[Please insert Table 4 about here]

We compare the explanatory variables among three subsamples based on bankruptcy outcome (reorganized vs. acquired, reorganized vs. liquidated, and acquired vs. liquidated). The mean and median difference test statistics are reported in Table5. Panel A of Table 5 compares the mean and median difference between the three groups. We use Fisher and Kruskal-Wallis

tests for equality of means and medians for the full sample. Only the mean of the number of patents within five years prior to bankruptcy is significantly different when we jointly compare the three groups. However, other main variables, such as the number of citations and R&D expenditure, show no significant mean or median difference. Both parametric and nonparametric tests from Table 5 fail to reject the equality of innovation between subsamples for most of the cases. Variables size, leverage, working capital ratio, industry adjusted ROA and liquidity ratio measured as current assets over current liabilities show at least one difference either in mean or median when we jointly compare the three groups.

For the subsamples, we use Student's t-test for the equality of means between two groups and Wilcoxon Mann-Whitney test for the equality of medians between two groups. The mean of the number of patents is significantly different at 5% confidence level where we compare the recognized firms to the acquired firms. Both parametric and non-parametric statistical tests fail to reject the equality of means or medians of the number of citations when we compare the two groups. This result is contradictory to the results from Table 4, where we observe that the number of citations for the reorganized firms is higher than that of the acquired or liquidated firms. We can state that the mean and median of the number of citations are not statistically different when we compare both the full sample and the sub-samples. The mean R&D for the acquired firms is higher than that for the liquidated firms and the test statistic is significant. Other variables present quite significant difference in mean and median when we compare the two groups. For example, the differences of the mean and median size are significantly different at the 1% confidence level for each pair of three groups. We find similar result from Table 4, where the reorganized firms are larger than the acquired and the liquidated firms. The mean (median) leverage is significantly different at the 1% confidence level when we

compare reorganized firms to acquired firms (liquidated firms). According to Panel B from Table 5, the differences of mean and median working capital ratio, adjusted ROA and liquidity are statistically significant when we compare between reorganized firms and liquidated firms. Similar results can be drawn from Panels C and D from Table 5.

[Please insert Table 5 about here]

4.3 Logistic Regression Model

The models developed for predicting corporate bankruptcy include multiple discriminant analysis by Altman (1968) and Ohlson's (1980) nine variables logistic regression model. Tam and Kiang (1990) introduce the artificial Neutural networks to predict financial distress. Other financial distress prediction models include the Probit model of Zmijewski (1984) and the Mixed Logit Model of Jones and Hensher (2004). In this thesis, we use logistic regression model to test the relationship between innovation and bankruptcy outcome. Conditional probability models, like Probit and Logit, derive the probability of a dichotomous (or polytomous) dependent variable by using coefficients on the independent variables.

The simple logit model is:

$$P(x) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\cdots+\beta_N X_N)}} \quad (1)$$

The P(x) represents the probability of a specific outcome. X_i (i=1, 2, 3, …, N) is the explanatory variable in the logistic regression model. In a logistic model, we assume that each group is mutually exclusive and the errors are logistically distributed. We split the full sample into three different pairs, where we have reorganized firms and liquidated firms, acquired firms and

liquidated firms, and reorganized firms and acquired firms. We label outcome as the latent variable, where it only takes two values. For example, if we compare reorganized firms to liquidated firms, the outcome takes one if a firm is reorganized, otherwise it takes zero. LnNumpat is calculated as the natural logarithm of one plus the accumulated number of patents applied five years prior to bankruptcy filing date. Size is defined as the natural log of firm's total assets (in million dollars). Firm size is corrected for inflation by taking a base value of 82.4 for 1980. Leverage is measured as the total liabilities divided by total assets. WC/TA refers to the ratio between working capital and total assets. RE/TA is retained earnings over total assets. NI/TA is gross net income over total assets. IAROA is the industrial adjusted ROA by subtracting industry's ROA from firms' ROA. Return on asset (ROA) is defined as EBITDA over total assets. Sales/TA is defined as sales over total assets. Liquidity is a ratio of current assets and current liabilities.

The following are the main logistic regression models used to test the relationship between innovation and the bankruptcy outcome.

Model 1:

$$Outcome = \beta_0 + \beta_1\, LnNumpat + \beta_2 LnNumcit + \beta_3 RD5 + \beta_4 LnSize + \beta_5\, Leverage + \beta_6\, WC/TA + \beta_7\, RE/TA + \beta_8\, NI/TA + \beta_9\, IAROA + \beta_{10}\, Sales/TA + \beta_{11} Liquidity + \varepsilon \quad (2)$$

Model 2:

$$Outcome = \beta_0 + \beta_1\, lnNumpat + \beta_2 LnNumcit + \beta_3 RD5 + \beta_4 LnSize + \beta_5\, Leverage + \beta_5\, Sales/TA + \beta_7\, Liquidity + \beta_8\, Prepack + \beta_9\, Tort + \beta_{10}\, DIP + \varepsilon \quad (3)$$

We use the above two models to fully capture the relationship between innovation and Chapter 11 bankruptcy outcomes. Model 1 includes both input and output indicators of innovation

and all the control variable that could impact a firm's bankruptcy decision. Model 1 is mainly used in regressions 1, 2, and 3 from Table 6. In the first regression from Table 6, the innovation is measured 5 years prior to bankruptcy, while the entire accumulation of innovation is considered in the second regression. We do this to test if the older innovation compares to recent one matters or not. The third regression of Table 6 is a subsample where we only include companies that have non-zero R&D expenditure and generate non-zero patents. We also use model 2 (slightly different from Model 1) to study the relationship more in details. We consider several dummy variables, such as Crisis, Prepack, DIP, Tort and Industry dummy, that could affect bankruptcy outcome. Some debtors negotiate with their creditors and main shareholders and come to an agreement before the filings, indicating a fixed outcome regardless of other factors. Therefore, we create a dummy variable called Prepack. to test the impact of pre-packed bankruptcy petitions. We examine if the insolvent debtors received DIP financing during bankruptcy or not. According to Ma et al. (2019), bankrupt firms tend to sell core innovation to get external financing. Also, firms with DIP financing during bankruptcy are more likely to emerge from bankruptcy than firms do not (Dahiya et al., 2003). Most of the bankruptcy firms file for bankruptcy as they occur with serious financial problems. But there is still some bankrupt firms file for bankruptcy for non-financial reasons, such as frauds and any type of claims. Industry factors could impact both the choice of going reorganization or liquidation and the innovation intensity. Such as, firms in manufacturing sector maybe tend to be more innovative than other industries.

We report both coefficients of the logistic regression and p-values for complete explanation. The coefficients of the logit regression interpret the log odds of changes in the dependent variables between two outcomes, while the odds ratio shows the exponentiated change. The disappearing of log odds in the dependent variable can be shown as: If $\beta(X) = \log Y$, then $e^{\beta}X=Y$. Therefore, it is

more intuitive to study the odds ratio. We have odds ratio greater than 1 if we have a positive coefficient in the logit regression, and we have odds ratio smaller than 1 if we have a negative coefficient in the logit model.

The likelihood ratio test provides a definitive test of the strength of the logit model. The null hypothesis is that the entire model is insignificant, or that all the coefficients are insignificantly different from zero between any pair of outcome. Let $L(\theta^*)$ be the likelihood estimate for the original model. $L(\theta)$ do the value of likelihood estimate with the restriction imposed that all the coefficients are zero. The likelihood ratio is defined as:

$$\lambda = \frac{L(\theta^*)}{L(\theta)}$$

Define the test statistic as -2 Log(λ), which is asymptotically distributed as Chi square with degrees of freedom equal to the number of independent restrictions imposed.

5. Regression Analysis

5.1 Logistic Regression

Table 6 reports logistic regression of Chapter 11 bankruptcy outcome on innovation and pre-filing financial features. We compare bankruptcy outcomes in pairs across three possible outcomes as we defined earlier. We compare reorganized firms against liquidated firms and acquired firms against liquidated firms, and finally reorganized firms against acquired firms in each regression using the regression models.

We measure innovation within five years prior to bankruptcy for regression 1 of Table 6 to test if the relationship between recent innovation and bankruptcy outcome is related or not. The second column of regression 1 indicates only variable LnNumpat is a significant determinant of the decision to be acquired rather than to be liquidated. The first and third columns of regression

1 show that innovation is not significantly related to the likelihood that a firm is reorganized compare to be acquired or liquidated. In addition, this result is not consistent with the result presented in Table 5, where the mean of variable Numpat between reorganized and acquired firms is statistically significant. The number of citations is not significantly related to any of the three outcomes.

The coefficient estimates on Size, leverage, WC/TA, Sales/TA, IROA and liquidity in the first columns of regression 1 are statistically significant when we compare the decision to reorganize to the decision to liquidate. For other pairs of groups in regression 1 from Table 6, we do not find any significant coefficient except size continues to be the significant determinant. This is probably because larger firms are economically viable and less prone to dramatic changes, such as bankruptcy. The positive coefficient on the leverage of regression 1 (column 1) indicates that firms with higher liability prior to the bankruptcy are more likely to reorganize than to liquidated or to be acquired. Firms become bankrupt because of suboptimal capital structure. Higher leverage leads firms to become bankrupt more quickly compare to smaller leverage that accumulated over time. Therefore, smaller levered firms might in the financially distressed status for a longer time than highly levered firms did. WC/TA represents how efficient a firm in paying back its short-term debt. Positive regression coefficient on WC/TA indicates that the higher the liquidity, the higher possibility for a firm to reorganize. Sales/TA is also a significant factor to determine the final bankruptcy outcome. Higher sales before bankruptcy lowers the possibility that a firm is reorganized than liquidated. Bankruptcy firms usually face with decline in sales before bankruptcy. Firms that are more viable may choose not to fire sale their products in the first place in order to alter declining financial status. They may seek for other alternatives, such as borrow money from banks or their creditors, etc. On the other hand, the less viable firms tend to sell their products

immediately with lower price and generate cash flow to mitigate firm's status. It is worthy to notice that other variables do not determine the bankruptcy outcome. For example, RE/TA, NI/TA and IAROA. As a conclusion, we compare reorganized and liquidated firms, we find that firms with larger size, more levered and higher sales tend to reorganize than be acquired or liquidate.

Regression 2 from Table 6 tests whether the relatively older (the entire accumulated innovation prior to bankruptcy) innovation matters. There are two reasons why we choose to do this. Firstly, for the long-term nature of innovation process, regression 2 and other remaining regressions relate the firm bankruptcy in the current year to all the accumulated patent-related variables prior to bankruptcy. Secondly, according to Ma et al. (2019), they state that bankrupt firms sell their most liquid and re-deployable assets. Hence, the recently developed innovation may not play more important roles than the older patents. We still consider the five years accumulated R&D expenditure for the remaining regressions. The estimates of LnNumpat on the first and third columns show that the number of patent is a significant determinant of the decision to reorganize than to liquidated or be acquired. The variable R&D expenditure significantly determines the three outcomes. However, the number of citations is positively related to acquisition or liquidation, indicating firms with higher quality of patents are more likely to get acquired than reorganized. This is contradictory to our hypothesis, where we state that the greater innovation increases the likelihood of emerging from bankruptcy. Barniv et al. (2002) order the three states bankruptcy outcome as they are economically distinguishable. They state that the acquisition outcome is the best state as it generates the highest cumulative abnormal return and lowest lost to the investors from 60 days prior to filing and one day post filing. The second-best state is reorganization while liquidation ranked as the worst state. It is usually very costly for bankrupt firms, which planning to reorganize, to get exit financing (for supporting future operation

or to pay back their creditors) as they possess lower credit compare to non-distressed acquirer. Gilson et al. (2016) argue that the greater M&A in recent years is caused by the unavailable or costly exit financing while acquisition financing is much less costly for bankrupt firms, leading economical viable companies to sell all of their assets as ongoing concerns rather than reorganize. It can be interpreted as bankrupt firms hope to operate as ongoing concerns but with tight budget choose to be acquired even if they are qualified for reorganization. The last column of third regression from Table 6 compares firms that are emerged as an independent entity and firms that did not. The result shows that the more you invest R&D expenditure and generate a high number of patents, the more likely you emerge successfully. But bankrupt firms with highly cited patents are less likely to emerge from bankruptcy.

Regression 3 from Table 6 is a complementary test. In the previous regressions, we notice that the pre-bankruptcy industry adjusted ROA, Sales/TA and RETA do not affect the decision to reorganize, liquidate or be acquired. In regression 3, we excluded WC/TA, Liquidity and the above three variables. We create a subsample by choosing bankrupt firms that both have non-zero R&D expenditure and non-zero patent. The subsample only includes companies that invest in R&D expenditure and generate patents as a result. The first thing to note is that the coefficients on LnNumpat is still statistically significant when we compare reorganized firms to liquidated firms and reorganized firms to acquired firms. This indicates that firms spend R&D expenditure efficiently by producing a higher number of patents are more likely to reorganize than be acquired or liquidate. The estimates on the number of citations is not significant.

[Please insert Table 6 about here]

We run regression 1 from Table 7 to test whether economic crisis impact the decision to reorganize, liquidate or be acquired while controlling for other important determinants of the bankruptcy outcome. The coefficient on the crisis shows that firms file for bankruptcy results more in liquidation than reorganization when we compare reorganized firms to liquidated firms, indicating the negative effect of economic crisis on firm's reorganization. The positive relationship between innovation (in terms of the number of patent) and the likelihood to reorganize than liquidate or get acquired is robust even during the economic downturn. Therefore, we conclude that the financial and economic crisis of 2008 did not affect the innovation and bankruptcy outcome relationship and innovative firms still could reorganize than other non-innovative firms during economic crisis.

Some additional issues need to be considered. Regression 2 from Table 7 includes several special features of bankruptcy. We consider several binary variables, such as if the bankruptcy case in pre-packaged or pre-negotiated, if the debtor file for bankruptcy for non-financial reasons (e.g. fraud), and if the debtor receives any Debtor-in-Possession (DIP) financing during bankruptcy. The variables, Prepack, Tort and DIP, takes 1 if the debtor negotiated with its creditors before the filing, file for bankruptcy for non-financial reasons, and receives DIP financing during bankruptcy. A prepackaged bankruptcy is when the insolvent debtor negotiates with its creditors about the reorganization plan that will take effect once the company enters Chapter 11. If a company has insufficient time or ability to complete a fully prepackaged Chapter 11 bankruptcy case, an alternative is a pre-negotiated plan which is quite similar to a prepackaged plan. All these require an agreement from the main creditors upon specific reorganization plan. Usually, the outcomes are fixed, and it is very less likely that any variables can exert an impact on those pre-agreed decision.

Consistent with our hypothesis, the estimates on prepack is significantly positive when we compare reorganized and liquidated firms or reorganized and acquired firms, indicating that the final bankruptcy outcome is reorganized if the debtors file for pre-packaged or pre-negotiated petitions. The positive relationship between innovation (in terms of patent measurement) and the likelihood to reorganize than liquidate or get acquired is robust when petitions are pre-packaged or pre-negotiated. A prepackaged filing is almost always accompanied by a plan of reorganization that has been accepted by all existing claim classes. This process generally ensures that such firms will emerge from the reorganization process. Dahiya et al. (2013) show that if the firms with DIP financing during bankruptcy have higher possibility to reorganize than non-DIP receivers. Our result is consistent by showing a significantly positive relationship between DIP and reorganization. One thing to notice is that the estimate on the number of citations becomes significantly negative when we compare the reorganized firms to the liquidated or acquired firms, indicating filing for pre-packaged petition bankruptcy or receiving DIP financing during bankruptcy make highly cited patent holders to exit from market via liquidation or acquisition than reorganization. The final regression 3 from Table 7 provide information if any of three most frequent industries in our sample influence bankruptcy outcome. Most of the firms in our sample belong to Manufacturing. After controlling the main determinants from Table 6, only firms in the Manufacturing are less prone to liquidation.

[Please insert Table 7 about here]

5.2 Robustness Test

In this thesis, we use a multinomial logistic regression model for robustness test in which all three outcomes, reorganization, acquisition and liquidation, are compared in one regression. In the multinomial logistic regression model, latent variable is the outcome and takes the value of 1 if the firm is reorganized, 2 if the firm is acquired, and 3 if the firm is liquidated.

Table 8 reports the estimates of the multinomial logistic regression model. We report both coefficients estimate and p-values in the parentheses for each variable. We also report the number of observations, the Log-Likelihood Ratio test and ratio's p-values for each regression.

The conclusions that can be drawn from Table 8 are almost the same to those drawn from Table 6. Regression 1 of Table 8 still shows no significance for the coefficients of LnNumpat, LnNumcit and R&D if we relate firm bankruptcy in the current year to patent-related variables five years ahead. However, from Regression 2 to Regression 3 of Table 8, innovation has a significantly positive relationship (in terms of the number of patents) with a likelihood that a firm is reorganized than to be acquired or liquidated. The number of citations is still negatively correlated to the likelihood of reorganization. Larger firms are more likely to survive in the Chapter 11 process and emerge as independent firms. Firms that have higher leverage ratio and more liquid prior to bankruptcy are significantly more likely to reorganize than liquidated.

[Please insert Table 8 about here]

6. Conclusion

In this thesis, we argue that innovation plays a deterministic role for not only the survival of the healthy firms but also the bankrupt firms. We study the relationship between firm's innovation efforts and Chapter 11 bankruptcy outcome using logistic regression models. Specifically, we

examine if innovation is highly related to the likelihood that a firm is reorganized, acquired or liquidated. We firstly collect Chapter 11 bankruptcy information about 842 U.S companies for which we are able to determine the bankruptcy resolutions over the period from 1980 to 2010. We use the number of patents, the number of citations and R&D expenditure as a proxy for firm's innovation to capture both innovative input and output. We also consider factors related to firms' assets, liability, profitability and liquidity as bankrupt firms typically suffer from poor financial performance before bankruptcy filings.

Our results show that innovation is not significantly related to the likelihood that a firm is reorganized than to be acquired or liquidate if we relate firm bankruptcy in the current year to patent-related variables five years ahead. However, when we consider all the accumulated patents and citations each patent received prior to bankruptcy, the innovation (in terms of the number of patents and R&D) and reorganization relationship becomes strong and significant. This result suggests that the bankrupt firms' whole knowledge stocks or the older patents matter more than the recently developed innovation five years before bankruptcy. We also find that the highly cited patent is positively related to firm's acquisition. This is contradictory to our hypothesis, where we state that valuable innovation (by having highly cited patents) increases the likelihood of emerging from bankruptcy. Barniv et al. (2002) order the three states bankruptcy outcome as they are economically distinguishable. They state that the acquisition outcome is the best state as it generates the highest cumulative abnormal return and lowest lost to the investors from 60 days prior to filing and one day post filing. The second-best state is reorganization while liquidation ranked as the worst state. It is usually very costly for bankrupt firms, which planning to reorganize, to get exit financing (for supporting future operation or to pay back their creditors) as they possess lower credit compare to non-distressed acquirer. Gilson et al. (2016) argue that the greater M&A

in recent years is caused by the unavailable or costly exit financing while acquisition financing is much less costly for bankrupt firms, leading economical viable companies to sell all of their assets as ongoing concerns rather than reorganize. It can be interpreted as bankrupt firms hope to operate as ongoing concerns but with tight budget choose to be acquired even if they are qualified for reorganization. Also, firms with R&D expenditure and a decent number of patents are more likely to reorganize than liquidate or be acquired. This result indicates that the firms' ability to efficiently spend and allocate R&D expenditure and produce related patents is very vital for the survival of the bankrupt firms.

Similar to other articles, our results confirm that firms larger, highly levered and liquid firms possess a higher chance to emerge from Chapter 11 bankruptcy process as an independent entity. We find evidence that working capital and sales, both scaled by firm assets, are the significant determinants for bankruptcy outcome, but the results are inconsistent among different logistic regression models. Variables represent firm's profitability have no significant power on the decision to reorganize than be acquired or liquidated. To make our results more robust to different scenarios, we consider the economic crisis in 2008, if the bankruptcy petitions are pre-negotiated, if the bankrupt firms file for bankruptcy for non-financial reasons (ed. fraud), if the insolvent debtors receive DIP financing during bankruptcy and industrial factor. The results show that firms that file for bankruptcy in year 2008 have higher possibility to liquidate than reorganize. Firms with prepacked/prepackaged bankruptcy fillings can emerge from bankruptcy or get acquired instead of being liquidated. The bankrupt firms that receive DIP financing during bankruptcy are more likely to reorganize as compared to non-DIP receivers. Tort cause has no impact on the bankruptcy outcome. Industry factor is relevant for firms belong to the Manufacturing sector where firms are more likely to be liquidated than reorganize. We conclude

that the positive relationship between the high number of patents and the high probability of reorganization is quite robust when we consider the above five dummies. The negative relationship between the number of citations and reorganization still holds for all the regressions from Table 7. However, one thing to notice is that the estimate on the number of citations becomes significantly negative in considering these dummy variables (regression 2 and 3 from Table 7) when we compare reorganized firms with liquidated firms. We can conclude that filing for pre-packaged bankruptcy petition and receiving DIP financing make highly cited patent holders to liquidate than reorganize.

Our empirical results can partially validate the positive relationship between innovation and firms' reorganization process. Innovation is positively related to firms' reorganization when we define innovation as the combination of the accumulated number of patents and accumulated R&D expenditure before bankruptcy. However, the high number of citations is linked to acquisition, giving us a hint that highly cited patents maybe an attractive asset for potential acquirers. Therefore, valuable innovation may not help bankrupt firms to emerge from bankruptcy, but increases the possibility of being acquired instead of completely exiting from the market. Again, we still think that acquisition is much a much healthier status than liquidation as it saves jobs and avoids economic downturns.

We may have questions about how innovation is actually helping the bankrupt firms. In other words, what is behind this relationship. Bankrupt firms are financially constrained and have lower credit compared to other healthy firms in the market. From our perspective, having the ability to acquire both internal and external financing during bankruptcy is a deterministic factor to the decision of reorganization. If bankrupt firms can get enough financing to pay back their debt and dedicate the remaining to the post reorganization related activity, they are almost ready for

emerging from bankruptcy. We understand that financing is critical for bankrupt firms, and the next question is how do firms, especially bankrupt firms, get financing? The answer to this is through patent. What is really happening is that bankrupt firms sell patents or take patents as collateral to achieve their imminent financing needs. In a nutshell, bankrupt firms desperately need financing, and one efficient way to get financing is to utilize innovation. However, in order to testify the channel, we need to create a variable, such as the percentage of the intangible assets sold (particularly sold patents) and, if available, prices paid for patents, or the percentage of patents taken as collateral for financing purpose and run this variable against bankruptcy outcome to see if we have any association or not. Other factors that could be considered in the future research are the secured creditor ratio, economic factors, boardroom independence and diversity, and regulatory factors in patent selling process, etc. We also can extend the innovation and bankruptcy relationship into innovation and duration relationship or innovation and post-reorganization performance relationship. To sum up, the bankruptcy and innovation relationship study needs more empirical research in the future as it has not been fully explored and we need to further understand the true value of innovation to the operation of bankrupt firms.

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Appendix A

Matching Patent Assignees to Firms in Compustat

The USPTO provides patent data until the end of 2017. The first step is to create a dataset that links each assignee to the corresponding patents and to the corresponding citations accumulated until the end of 2017 as the patent and citation datasets are separately given in the USPTO. We can use real frame id (rf_id) given in USPTO as a unique identifier to merge among different datasets. As a final dataset, we will have assignees, patents, patent application date, patent grant date, citations, conveyance type[7], assignors (the inventors) and transaction date.

Next step is to identify who is the initial assignees of each patent by looking at conveyance type. This task to match initial assignees to corporations is more difficult than it might initially seem as we have limited information about patent's initial ownership. We need to gather information about patent transactions between parties (or employee and employer) to track down who owns the patent or who is the initial assignees. The detailed information about patent reassignment is described in Graham et al. (2018). Graham et al. (2018) state that the legal ownership of a patent will not change if the patent is pledged as collateral and it only changes when the lending party defaults. In other situations, where there is a reassignment between parties or between employer and employees[8], and merger, the legal ownership will transfer. Moreover, if the subsidiaries are the assignor of the patent, the ownership of that patent goes to their parent companies. Therefore, we need to identify corporations' family tress to figure out who owns whom. Then we can match the initial assignees to the list of corporate names from Compustat and their subsidiaries after figuring out who is the initial assignee of each patent.

[7] For different conveyance type refer to Graham et al. (2018).

[8] Employees usually transfer the ownership of patent to the firms that employ them. The employer assignments appear to be the most common conveyance type in USPTO records.

We need to clean the “noise” appeared in initial assignees’ names before the name matching process. This step should let us be able to match most of the assignees to the firms and their subsidiaries. The remaining assignees, where we could not carry an exact name matching, will be matched to likely corporations by word frequency algorithm. This will generate a score for each potential match and the one with higher score represent a potential match between assignees and corporations. But still, the last step will not guarantee all the assignees with matched corporations.

Table 1: Sample selection for Chapter 11 bankruptcy filers from 1980 to 2018

We collect all the Chapter 11 bankruptcy filers from 1980 to 2018. We delete 47 dismissed bankruptcy cases. We also eliminate 271 bankruptcy cases for which we are unable to determine the outcome of the Chapter 11 process. We only consider companies that have latest annual financial data within three years year prior to bankruptcy to reflect debtors' pre-bankruptcy condition. As a result, 231 companies were excluded because they did not have latest annual report. As Stoffman's data only available until 2010, we excluded bankruptcy filings after 2010.We are unable to match 228 bankrupt companies to the Stoffman's database since these firms are not covered by CRSP. Our final sample consists of 842 bankrupt firms.

Selection of firms	
Total number of bankrupt firms collected from 1980 to 2018	1,887
Less:	
Bankruptcy cases that are dismissed by the court	47
Firms that bankruptcy resolutions are unknown	271
Firms do not have latest financial data within three years prior to bankruptcy	231
Firms file for bankruptcy after 2010	268
Firms that cannot be matched to Stoffman's database	228
Complete data for regression analysis	**842**

Table 2: The sample of bankrupt firms from 1980 to 2010

This table reports the final bankruptcy outcomes by SIC industry classification. Firms' bankruptcy resolutions are manually collected from Factiva. We consider a firm is reorganized if its reorganization plan is confirmed by the court and emerged as an independent publicly traded firm. We consider a firm is liquidated if a firm sells all or substantially all of its assets during the bankruptcy. We consider a firm is acquired if a firm exits from bankruptcy because of acquisition and operates under the full control of the acquirer. Party of interest (debtor or the creditors) have the right to ask for court to convert a Chapter 11 case to Chapter 7 case. We consider conversion same as liquidation as conversion usually does not take very long time to liquidate the firm's assets. We classify companies that went private after the confirmation of the reorganization plan as reorganized firms. We classify merger cases into acquired group. We delete the dismissed cases and cases that we are unable to determine the final bankruptcy outcome. The SIC code ranges from 40-49 is the Transportation, Communications. Electric. Gas and Sanitary services. The SIC code ranges from 91-99 includes Public Admiration and other Non-classified industries.

Industry (two-digit SIC code)	**Bankruptcy Resolutions**			
	Reorganized	**Acquired**	**Liquidated**	**All Firms**
Agriculture, Mining and Construction (01-19)	30	6	19	55 (6%)
Manufacturing (20-39)	150	32	152	334 (40%)
Trans., Comm., Elec., Gas and Sani. Service (40-49)	56	10	59	125 (15%)
Wholesale and Retail Trade (50-59)	56	15	90	161 (19%)
Services (70-89)	65	16	81	162 (19%)
Other (91-99)	1	0	4	5 (1%)
Total Firms	**358 (43%)**	**79 (9%)**	**405 (48%)**	**842 (100%)**

Table 3: Descriptive statistics for sample bankrupt firms from 1980 to 2010

This table reports summary statistics for U.S firms that filed Chapter 11 bankruptcy for the period 1980-2010. The firm specific financial data is collected from Compustat. We take the latest financial annual report within three years prior to bankruptcy. We collected the patent and citations data from USPTO. The Numpat5 is calculated as the accumulated number of patents applied within five years prior to bankruptcy filing. Numcit5 is the accumulated number of citations each patent received within 5 years prior to bankruptcy. Numpat (Numcit) is the entire accumulated number of patents (number of citations each patent received) prior to bankruptcy. RD5 refers to the sum of R&D expenditure during 5 years prior to firm's bankruptcy filing. TA is firm's total assets, in million dollars. Leverage is measured as the total liabilities divided by total assets. WC/TA refers to the ratio between working capital and total assets. RE/TA is calculated as retained earnings over total assets. NI/TA is defined as gross net income over total assets. Return on asset (ROA) is defined as EBITDA over total assets. Sales/TA is defined as sales over total assets. Liquidity is measured by the ratio of current assets over current liabilities.

Variable	Numpat5	Numcit5	Numpat	Numcit	RD5	TA	Leverage	WC/TA	RE/TA	NI/TA	ROA	Sales/TA	Liquidity
Panel A: Full Sample													
Mean	4.871	38.276	38.759	389.850	86.578	1122.790	1.147	-0.281	-3.900	-0.543	-0.172	1.294	1.324
Std. Dev	34.943	304.045	359.820	4143.590	1284.460	5212.540	2.263	2.216	30.527	1.747	0.828	1.137	1.364
Min.	0.000	0.000	0.000	0.000	0.000	0.106	0.060	-50.331	-740.065	-32.932	-12.420	0.000	0.003
25%	0.000	0.000	0.000	0.000	0.000	70.798	0.680	-0.328	-1.389	-0.479	-0.131	0.560	0.495
Median	0.000	0.000	0.000	0.000	0.000	246.333	0.863	-0.007	-0.392	-0.185	0.011	1.089	0.974
75%	1.000	0.000	3.000	18.000	8.869	652.400	1.117	0.190	-0.068	-0.042	0.079	1.688	1.655
Max.	794.000	7819.000	6366.000	101269.000	35900.000	91901.000	51.252	0.835	1.942	4.515	1.126	12.838	14.874
Skew.	16.861	20.814	14.731	19.673	26.271	13.623	16.101	-17.064	-19.597	-11.357	-9.700	3.045	3.616
Kurt.	341.708	514.614	238.749	441.582	723.724	219.885	318.227	348.634	438.184	173.016	125.307	18.757	21.621
Panel B: Reorganized Firms													
Mean	7.687	66.701	56.112	456.863	156.762	2054.600	1.277	-0.404	-3.937	-0.392	-0.087	1.225	1.096
Std. Dev.	47.436	457.983	426.401	3336.350	1909.050	7840.950	1.946	1.825	40.027	1.059	0.780	1.007	1.089
Min.	0.000	0.000	0.000	0.000	0.000	0.443	0.117	-25.867	-740.065	-13.948	-12.420	0.013	0.036
25%	0.000	0.000	0.000	0.000	0.000	175.899	0.804	-0.537	-1.136	-0.388	-0.039	0.528	0.382
Median	0.000	0.000	0.000	0.000	0.000	415.331	0.967	-0.066	-0.376	-0.172	0.049	1.058	0.797
75%	1.000	0.000	3.000	15.000	15.557	1251.420	1.201	0.114	-0.069	-0.039	0.097	1.560	1.389
Max.	794.000	7819.000	6366.000	46161.000	35900.000	91901.000	28.883	0.770	0.923	4.515	1.120	7.838	9.081
Skew.	13.509	14.180	11.703	10.996	18.503	9.096	10.476	-10.595	-17.870	-7.131	-11.917	2.269	2.920
Kurt.	214.550	232.526	153.569	130.738	347.055	96.062	131.817	132.264	328.573	81.914	178.688	8.823	13.680

Table 3 (Cont.):

Variable	Numpat5	Numcit5	Numpat	Numcit	RD5	TA	Leverage	WC/TA	RE/TA	NI/TA	ROA	Sales/TA	Liquidity
Panel C: Acquired Firms													
Mean	0.975	12.329	7.468	92.975	12.218	635.566	0.973	-0.067	-1.141	-0.408	-0.055	1.216	1.370
Std. Dev.	2.557	48.824	24.156	305.074	36.797	1032.400	0.698	0.667	2.230	0.726	0.293	0.837	1.206
Min.	0.000	0.000	0.000	0.000	0.000	6.892	0.060	-4.756	-12.138	-5.045	-1.388	0.078	0.101
25%	0.000	0.000	0.000	0.000	0.000	108.706	0.651	-0.080	-1.022	-0.416	-0.090	0.617	0.737
Median	0.000	0.000	0.000	0.000	0.000	272.987	0.850	0.049	-0.339	-0.177	0.008	1.170	1.139
75%	0.000	0.000	3.000	19.000	0.137	671.150	1.052	0.203	-0.039	-0.052	0.090	1.624	1.550
Max.	15.000	388.000	167.000	1762.000	251.200	6537.600	5.678	0.545	0.821	0.101	0.701	4.115	8.859
Skew.	3.574	6.308	4.945	4.451	4.512	3.545	4.393	-5.323	-3.370	-4.136	-2.074	1.236	3.833
Kurt.	14.232	46.061	27.616	20.123	24.210	15.338	26.942	35.420	13.036	22.144	6.803	1.829	21.339
Panel D: Liquidated Firms													
Mean	3.141	18.210	29.523	388.523	39.043	394.159	1.066	-0.213	-4.413	-0.704	-0.270	1.372	1.514
Std. Dev.	23.220	73.347	328.929	5085.830	453.887	823.810	2.680	2.658	22.920	2.283	0.927	1.284	1.563
Min.	0.000	0.000	0.000	0.000	0.000	0.106	0.064	-50.331	-383.877	-32.932	-12.403	0.000	0.003
25%	0.000	0.000	0.000	0.000	0.000	36.094	0.594	-0.205	-2.048	-0.618	-0.266	0.553	0.608
Median	0.000	0.000	0.000	0.000	0.000	139.596	0.798	0.038	-0.421	-0.197	-0.036	1.123	1.106
75%	1.000	0.000	2.000	19.000	6.722	360.503	0.996	0.237	-0.076	-0.050	0.049	1.822	1.863
Max.	442.000	771.000	6302.000	101269.000	9112.000	8837.000	51.252	0.835	1.942	0.415	1.126	12.838	14.874
Skew.	17.090	6.127	17.579	19.449	19.871	5.124	16.675	-17.337	-12.732	-9.799	-8.067	3.306	3.585
Kurt.	318.659	44.570	330.376	385.952	398.098	36.051	307.364	322.667	195.162	117.444	87.606	20.334	20.177

Table 4: Pearson correlation matrix for explanatory variables

This table reports the correlation matrix for the independent variables. The whole sample contains 842 companies that filed for Chapter 11 bankruptcy during 1980 until 2010. The LnNumpat is calculated as the natural logarithm of one plus the accumulated number of patents applied within five years prior to bankruptcy. The LnNumcit is calculated as the natural logarithm of one plus the accumulated number of citations each patent received within five years prior bankruptcy. RD5/TA refers to the sum of R&D expenditure during 5 years prior to bankruptcy scaled by total assets. LnSize is the natural logarithm of firm's total assets (in million dollars). Total assets is corrected for inflation by taking a base value of 82.4 for 1980. Leverage is measured as the total liabilities divided by total assets. WC/TA refers to the ratio of working capital over total assets. RE/TA is defined as retained earnings over total assets. NI/TA is gross net income over total assets. IAROA calculated by subtracting the median of each industry's ROA from firm's ROA. Return on asset (ROA) is defined as EBITDA over total assets. Sales/TA is defined as sales over total assets. Liquidity is measured by the ratio of current assets over current liabilities. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10%, respectively.

Variable	LnNumpat	LnNumcit	RD5/TA	Size	Leverage	WC/TA	RE/TA	NI/TA	IAROA	Sales/TA	Liquidity
LnNumpat	1.000										
LnNumcit	0.896***	1.000									
RD5/TA	0.048	0.052	1.000								
LnSize	0.098***	0.059**	-0.232***	1.000							
Leverage	-0.030	-0.036	0.455***	-0.237***	1.000						
WC/TA	0.053	0.053	-0.414***	0.229***	-0.969***	1.000					
RE/TA	0.012	0.008	-0.831***	0.275***	-0.584***	0.565***	1.000				
NI/TA	-0.001	0.000	-0.399***	0.300***	-0.458***	0.441***	0.383***	1.000			
IAROA	0.016	-0.013	-0.653***	0.428***	-0.696***	0.697***	0.626***	0.652***	1.000		
Sales/TA	-0.102***	-0.090***	-0.069**	-0.141***	0.038	0.017	0.035	0.037	0.080**	1.000	
Liquidity	0.107***	0.131***	-0.024	-0.024	-0.157***	0.207***	0.061**	0.037	0.026	-0.106***	1.000

Table 5: Multivariate analysis for bankruptcy sample firms

This table reports statistical tests for full sample and between two groups based on the final bankruptcy outcome. The whole sample contains 842 companies that filed for Chapter 11 bankruptcy. We have 358 reorganized firms, 79 acquired firms and 405 liquidated firms. The LnNumpat calculated as the natural log of one plus the accumulated number of patents applied within five years prior to bankruptcy. The LnNumcit calculated as the natural logarithm of one plus the accumulated number of citations each patent received within five years prior bankruptcy. We define Size as the natural log of firm's total assets (in million dollars). RD5/TA refers to the sum of R&D expenditure scaled by total assets during five years prior to bankruptcy. Leverage is measured as the total liabilities divided by total assets. WC/TA refers to the ratio of working capital over total assets. RE/TA is defined as retained earnings over total assets. NI/TA is gross net income over total assets. IAROA is calculated by subtracting the median of each industry's ROA from firm's ROA. Return on asset (ROA) is defined as EBITDA over total assets. Sales/TA is the ratio of sales over total assets. Liquidity is measured by the ratio of current assets over current liabilities. We conducted parametric and non-parametric test for each variable. Panel A reports F test for the equality of the means of the three groups. K-W stat is the Kruskal-Wallis test for equality of the medians of the three groups. Panels B, C, and D report t test and Wilcoxon Mann-Whitney test results for different pair of groups. T-test is the Student's t test for the equality of the mean between two groups and the Wilcoxon tests the equality of medians between two groups. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10%, respectively.

Statistic	LnNumpat	LnNumcit	RD5/TA	Size	Leverage	WC/TA	RE/TA	NI/TA	IAROA	Sales/TA	Liquidity
Panel A: Full Sample											
F-Stat	2.510*	1.650	0.360	52.320***	1.080	1.050	0.380	3.220**	5.590***	1.790	0.210
P-value	0.082	0.193	0.695	<0.0001	0.341	0.351	0.685	0.040	0.004	0.167	0.814
K-W Stat	0.466	1.609	4.000	57.580***	40.879***	19.170***	2.537	4.224	55.673***	2.723	18.995***
P-value	0.792	0.447	0.1352	<0.0001	<0.0001	<0.0001	0.281	0.121	<0.0001	0.256	<0.0001
Panel B: Reorganized Firms vs. Acquired Firms											
t-test	2.430**	1.550	1.360	2.340**	2.340**	-2.670***	-1.300	0.170	-0.620**	0.090*	-1.800*
p-value	0.016	0.124	0.176	0.021	0.020	0.008	0.194	0.866	0.535	0.932	0.061
Wilcoxon	-0.822	-1.180	-1.772**	-1.342***	-1.975**	3.017***	0.893	-0.102	-1.615*	0.643	3.667***
p-value	0.206	0.119	0.038	0.009	0.024	0.001	0.186	0.450	0.053	0.260	0.000

Table 5 (Cont.):

Statistic	LnNumpat5	LnNumcit5	RD5/TA	LnSize	Leverage	WC/TA	RE/TA	NI/TA	IAROA	Sales/TA	Liquidity
Panel C: Reorganized Firms vs. Liquidated Firms											
t-test	1.640	1.490	0.080	9.790***	1.250	-1.150	0.200	2.460**	2.940***	-1.760*	-4.270
p-value	0.102	0.136	0.937	<0.0001	0.211	0.251	0.844	0.014	0.003	0.078	<0.0001
Wilcoxon	-0.346	0.905	-0.367	7.574***	6.318***	-4.088***	1.204	2.031**	7.528***	-1.596**	-4.235***
p-value	0.365	0.183	0.357	<0.0001	<0.0001	<0.0001	0.114	0.021	<0.0001	0.055	<0.0001
Panel D: Acquired Firms vs. Liquidated Firms											
t-test	-1.280	-0.570	-3.070***	4.330**	-0.600	0.950	2.790***	2.110**	3.810***	-1.370	-0.880
p-value	0.202	0.570	0.002	<0.0001	0.547	0.344	0.006	0.035	0.000	0.172	0.381
Wilcoxon	-0.659	-0.610	-1.884**	2.580***	0.761	0.644	1.353*	0.635	2.111**	0.3889	0.278
p-value	0.255	0.271	0.023	0.005	0.223	0.251	0.088	0.263	0.017	0.349	0.390

Table 6: Logistic regression 1

This table shows the results of the logistic regression model for the three paired outcomes. The LnNumpat5 (LnNumcit5) calculated as the natural log of one plus the accumulated number of patents (citations) within five years prior to bankruptcy for regression 1. Other regressions in table 6 consider the entire accumulation of patents and citations prior to bankruptcy. R&D5 is the sum of R&D expenditure within five years prior to the bankruptcy for all the regression in table 6. We define LnSize as the natural log of firm's total assets (in million dollars). Leverage is measured as the total liabilities divided by total assets. WC/TA refers to the ratio of working capital over total assets. RE/TA is defined as retained earnings over total assets. NI/TA is defined as gross net income over total assets. IAROA is calculated by subtracting the median of each industry's ROA from firm's ROA. Return on asset (ROA) is defined as EBITDA over total assets. Sales/TA is defined as sales over total assets. Liquidity is measured by the ratio of current assets over current liabilities. Regression 1 takes the five-year innovation prior to bankruptcy into account, while regressions 2 and 3 consider the entire accumulation of innovation prior bankruptcy. Regression 3 is a subsample where it only includes firms that have non-zero R&D expenditure and generate non-zero patents. LL is the log likelihood. P-values are in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10%, respectively.

	(1) Innovation five years prior to bankruptcy			**(2) Entire innovation prior to bankruptcy**				**(3) Nonzero R&D expenditure and patent**		
	Reo vs. Liq Reo=1	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**	**Reo vs. Liq Reo=1**	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**	**Reo vs. Acq. or Liq Reo=1**	**Reo vs. Liq Reo=1**	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**
Intercept	-2.3704***	-2.6208***	-0.3551	-2.4861***	-2.5723***	-0.3002	-2.4524***	-2.8547***	-2.1988	-0.8666
	(<0.0001)	(0.0005)	(0.6607)	(<.0001)	(0.0006)	(0.7166)	(<.0001)	(0.0021)	(0.0636)	(0.5476)
LnNumpat5	0.0976	-0.5412*	0.4674	0.3129**	-0.2730	0.5955**	0.3599**	0.4166**	-0.1629	0.5851*
	(0.6006)	(0.0967)	(0.1857)	(0.00825)	(0.3126)	(0.0421)	(0.0360)	(0.0366)	(0.5967)	(0.0777)
LnNumcit5	0.1337	0.2831	-0.1605	-0.1708	0.2076	-0.3783**	-0.2059*	-0.1830	0.0534	-0.2078
	(0.2380)	(0.1082)	(0.4104)	(0.1262)	(0.1992)	(0.0343)	(0.0545)	(0.1715)	(0.7957)	(0.3538)
RD5/TA	0.2385**	0.0983	0.1165	0.3938***	0.1703*	0.2594**	0.3631***	0.0923	0.0817	0.0319
	(0.0154)	(0.6903)	(0.7863)	(<.0001)	(0.0939)	(0.0145)	(<.0001)	(0.2566)	(0.5489)	(0.7860)
LnSize	0.3736***	0.1915*	0.2483**	0.5496***	(0.2661)	0.1962	0.4553***	0.2624**	0.1199***	0.2268**
	(<0.0001)	(0.0604)	(0.0174)	(0.0015)	0.2948	(0.6047)	(0.0040)	(0.0193)	(0.0015)	(0.0271)
Leverage	0.5347***	0.1446	0.2146	0.3529**	0.2365	-0.7021	0.2777*	0.5184*	0.2372	0.0382
	(0.0027)	(0.5508)	(0.5657)	(0.0399)	(0.5235)	(0.1227)	(0.0776)	(0.0582)	(0.4340)	(0.9321)
WC/TA	0.1478***	0.1840	-0.7027	-2.4861***	-2.5723***	-0.3002	-2.4524***			
	(0.0020)	(0.4963)	(0.1213)	(<.0001)	0.0006	(0.7166)	(<.0001)			

Table 6 (Cont.):

	(1) Innovation five years prior to bankruptcy			(2) Entire innovation prior to bankruptcy				(3) Firms with nonzero R&D expenditure and patent		
	Reo vs. Liq Reo=1	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**	**Reo vs. Liq Reo=1**	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**	**Reo vs. Acq or Liq Reo=1**	**Reo vs. Liq Reo=1**	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**
RE/TA	0.0109	0.0304	-0.0110	-0.00497	0.0323	-0.0442	-0.0048			
	(0.2529)	(0.5901)	(0.8941)	(0.1400)	(0.5477)	(0.6095)	(0.1527)			
NI/TA	0.1489	-0.0645	0.4837*	0.0675	-0.0731	0.5305*	0.0828	0.4683	0.6363	0.4724*
	(0.3721)	(0.5344)	(0.0890)	(0.5746)	(0.4832)	(0.0664)	(0.5209)	(0.1075)	(0.1921)	(0.0955)
IAROA	1.0361***	0.9282	-0.7953	0.5213**	0.8684	-0.9128	0.4165*			
	(0.0025)	(0.1317)	(0.2619)	(0.0366)	(0.1283)	(0.2041)	(0.0954)			
Sales/TA	-0.1498*	-0.1250	-0.0007	-0.1317*	-0.1071	-0.0295	-0.1097			
	(0.0673)	(0.1317)	(0.9614)	(0.0986)	(0.4140)	(0.8386)	(0.1540)			
Liquidity	-0.2471***	-0.1315	0.0228	-0.2666***	-0.1402	0.0633	-0.2471***			
	(0.0019)	(0.3134)	(0.8799)	(0.0009)	(0.2868)	(0.6839)	(0.0014)			
Nb of Obs	763	483	437	763	483	437	842	200	137	103
LL	168.6691	14.4839	26.9984	39.3761	0.7532	15.1226	129.375	37.7384	5.4062	8.3460
P-value	<0.0001	0.1520	0.0026	<0.0001	0.6744	0.1277	<0.0001	<0.0001	0.4929	0.2138

Table 7: Logistic regression 2

This table shows the results of the logistic regression model for the three paired outcomes. LnNumpat (LnNumcit) calculated as the natural log of one plus the accumulated number of patents (citations) prior to bankruptcy for all regressions in table 7. RD5 is the sum of R&D expenditure within 5 years prior to the bankruptcy for regression 1. We define LnSize as the natural log of firm's total assets (in million dollars). Leverage is measured as the total liabilities divided by total assets. WC/TA refers to the ratio of working capital over total assets. RE/TA is retained earnings over total assets. NI/TA is defined as gross net income over total assets. IAROA is calculated by subtracting the median of each industry's ROA from firm's ROA. Return on asset (ROA) is defined as EBITDA over total assets. Sales/TA is calculated as sales over total assets. Liquidity is a ratio between current assets and current liabilities. Crisis is a dummy variable that takes value of one if the bankrupt firms file for bankruptcy in 2008. Prepack takes one if the bankruptcy filing is pre-packaged or pre-negotiated and zero otherwise. Tort takes the value of one if bankrupt firms file for bankruptcy for non-financial reasons and zero otherwise. DIP takes one if the bankrupt firm received DIP financing during bankruptcy and zero otherwise. Manufact., Trans., and Service are dummy variables that equal to one if the bankrupt firm belongs respectively to the Manufacturing,Ttransportation, Communications, Electric, Gas and Sanitary Service, and Services sectors and zero otherwise. LL is the log likelihood. P-values are in the parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10%, respectively.

	(1) Financial crisis as a dummy			(2) Prepack, DIP and Tort as dummies			(3) Industry as a dummy		
	Reo. vs. Liq. Reo.=1	**Acq. vs. Liq. Acq.=1**	**Reo. vs. Acq. Reo.=1**	**Reo. vs. Liq. Reo.=1**	**Acq vs. Liq. Acq.=1**	**Reo. vs. Acq. Reo.=1**	**Reo. vs. Liq. Reo.=1**	**Acq. vs. Liq. Acq.=1**	**Reo. vs. Acq. Reo.=1**
Intercept	-2.4491***	-2.5555***	-0.4466	-0.1275	2.4880*	-3.4473***	-3.3925***	-2.7872***	-0.1296
	(<0.0001)	(0.0006)	(0.5941)	(-0.9270)	(0.0738)	(<0.0001)	(<.0001)	(0.0003)	(0.8691)
LnNumpat	0.3058*	-0.2793	0.5442**	0.9885***	-0.3306	0.4699**	0.3028*	-0.2897	0.5899**
	(0.0895)	(0.3106)	(0.0454)	(0.0077)	(0.3354)	(0.0421)	(0.0955)	(0.2833)	(0.0464)
LnNumcit	0.3356	0.2069	-0.3452*	-0.5907***	-0.1860	-0.3144**	-0.2047*	0.1716	-0.3637**
	(0.9078)	(0.2001)	(0.0560)	(0.0093)	(0.3704)	(0.0411)	(0.0704)	(0.2862)	(0.0412)
RD5	-0.0030	-0.0556	0.1154	0.0005*	0.0006*	0.0001	0.0078	-0.0033	0.0001
	(0.6813)	(0.5753)	(0.2786)	(0.0980)	(0.0908)	(0.2657)	(0.987)	(0.4980)	(0.0076)
LnSize	0.3916***	0.1709*	0.2694**	0.0567*	-0.1268	0.4260***	0.4305***	0.2218**	0.2429**
	(<0.0001)	(0.0911)	(0.0118)	(0.0897)	(0.4589)	(0.0011)	(<.0001)	(0.0318)	(0.0130)
Leverage	0.5686***	0.2773	0.2376	0.4298	-0.5485	1.1664	0.5301***	0.2684	0.1619
	(0.0010)	(0.2781)	(0.5313)	(0.4665)	(0.1037)	(0.0010)	(0.0019)	(0.2828)	(0.6108)
WC/TA	0.3730**	0.1840	-0.7412				0.3384**	0.3193	-0.4743
	(0.0302)	(0.4963)	(0.1076)				(0.0494)	(0.3726)	(0.2889)

Table 7 (Cont.):

	(1) Financial crisis as a dummy			(2) Prepack, DIP and Tort as dummies			(3) Industry as a dummy		
	Reo vs. Liq Reo=1	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**	**Reo vs. Liq Reo=1**	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**	**Reo vs. Liq Reo=1**	**Acq vs. Liq Acq=1**	**Reo vs. Acq Reo=1**
IAROA	0.5090**	0.8584	-1.0133	0.7023	1.9518	0.2917	0.4360**	0.9023*	-0.3859
	(0.0420)	(0.1291)	(0.1617)	(0.4498)	(0.2293)	(0.6698)	(0.0298)	(0.0994)	(0.4571)
Sales/TA	-0.1304**	-0.1050	-0.0156	0.0004	0.0003	0.0000	-0.0742	-0.1222	0.0310
	(0.1029)	(0.4233)	(0.9152)	(0.0626)	(0.1412)	(0.5644)	(0.3832)	(0.4384)	(0.8498)
Liquidity	-0.2720***	-0.1406	0.0699				-0.2692***	-0.1803	0.0292
	（<0.0001）	（0.2851）	（0.6553）				(0.0008)	(0.1800)	(0.8482)
Crisis	-0.8344**	-0.1274	-0.9819						
	(0.0422)	(0.8288)	(0.1337)						
Prepack				1.6734***	0.0926	1.5946***			
				(<0.0001）	(0.8049)	(<0.0001)			
Tort				0.3376	-0.2921	0.9448			
				(0.5759)	(0.6567)	(0.0362)			
DIP				0.7393**	-0.4117	-0.2351			
				(0.0192)	(0.2086)	(0.2672)			
Manufact.							0.4232*	-0.2703	0.0926
							(0.0620)	(0.4654)	(0.8039)
Trans.							-0.2366	0.5199	0.2268
							(0.3792)	(0.2841)	(0.6433)
Services							0.2970	0.0511	0.3586
							(0.2487)	(0.9091)	(0.4311)
Nb of Obs	763	484	437	763	484	437	763	484	437
LL	135.8242	17.7893	27.1839	51.7764	17.0002	106.8199	141.2524	23.2552	21.3036
P-value	<0.0001	0.0937	0.0073	<0.0001	0.0744	<0.0001	<0.0001	0.0256	0.0461

Table 8: Multinomial regression

The table 8 shows the result of the multinomial logistic regression model. We consider the three regressions presented in Table 6 to test if the results are robust when we change the logistic regression to a multinomial regression. The dependent variable outcome equals to 1 if the firm is reorganized, 2 if the firm is acquired and 3 if the firm is liquidated. The LnNumpat (LnNumcit) is calculated as the natural log of one plus the accumulated number of patents (citations) within 5 years prior to bankruptcy for regression 1. Other regressions consider the accumulation of patents and citations prior to bankruptcy. We define LnSize as the natural log of firm's total assets (in million dollars). RD5 is the sum of R&D expenditure within 5 years prior to bankruptcy for regression 1. Leverage is measured as the total liabilities divided by total assets. WC/TA refers to the ratio of working capital over total assets. RE/TA is defined as retained earnings over total assets. NI/TA is defined as gross net income over total assets. IAROA is calculated by subtracting the median of each industry's ROA from firm's ROA. Return on asset (ROA) is defined as EBITDA over total assets. Sales/TA is defined as sales over total assets. Liquidity is a ratio between current assets and current liabilities. LL is the log likelihood. P-values are in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5% and 10%, respectively.

	(1) Innovation 5 year prior to bankruptcy			**(2) Entire innovation prior to bankruptcy**			**(3) Firms with nonzero R&D expenditure and patent**		
	Reo vs. Liq	**Acq vs. Liq**	**Reo vs. Acq**	**Reo vs. Liq**	**Acq vs. Liq**	**Reo vs. Acq**	**Reo vs. Liq**	**Acq vs. Liq**	**Reo vs. Acq**
Intercept	-2.7337***	-2.9869***	0.2532	-2.3694**	0.9605	-3.2336	-3.0126***	-3.1512***	0.1387
	(<0.0001)	(<0.0001)	(0.6973)	(0.0470)	(0.6840)	(0.1814)	(<0.0001)	(<0.0001)	(0.8406)
LnNumpat	0.0780	-0.0817	0.1485	0.4350***	-0.2804	0.4528**	0.6547**	0.3222	0.3326***
	(0.4108)	(0.5938)	(0.3219)	(0.0041)	(0.4964)	(0.0434)	(0.0265)	(0.5732)	(0.0083)
LnNumcit	0.2348	-0.2652	0.0390	-0.1297	0.2076	-0.3678**	-0.1678	0.0556	-0.0988
	(0.9080)	(0.8721)	(0.4512)	(0.8623)	(0.1992)	(0.0378)	(0.1723)	(0.7857)	(0.4456)
RD5	-0.0003	-0.0020	0.0018	-0.0005	-0.0008	0.0003	-0.0001	-0.0002	0.0098
	(0.4831)	(0.3097)	(0.3855)	(0.1014)	(0.8273)	(0.9262)	(0.5282)	(0.3768)	(1.2370)
LnSize	0.4678***	0.2396***	0.2184***	0.0589	-0.2352	0.2905	0.5003***	0.2662***	0.2341***
	(<0.001)	(0.0031)	(0.0074)	(0.7150)	(0.4369)	(0.3554)	(<0.0001)	(0.0023)	(0.0079)
Leverage	0.4491***	0.1600	0.2891	1.1158***	0.2968	0.8191	0.4456***	0.1586	0.2870
	(0.0026)	(0.5443)	(0.2613)	(0.0041)	(0.7485)	(0.3798)	(0.0032)	(0.5490)	(0.2657)
WC/TA	0.3363**	0.4314	-0.0951	0.4378	1.5153	-1.0774			
	(0.0267)	(0.2190)	(0.7841)	(0.3856)	(0.3543)	(0.5123)			

Table 8 (Cont.):

	(1) Innovation 5 year prior to bankruptcy			(2) Entire innovation prior to bankruptcy			(3) Firms with nonzero R&D expenditure and patent		
	Reo vs. Liq	**Acq vs. Liq**	**Reo vs. Acq**	**Reo vs. Liq**	**Acq vs. Liq**	**Reo vs. Acq**	**Reo vs. Liq**	**Acq vs. Liq**	**Reo vs. Acq**
RE/TA	-0.00246	0.998	0.00277	0.0241	0.0880	-0.0639			
	(0.5296)	(0.7095)	(0.8456)	(0.4553)	(0.3834)	(0.5394)			
NI/TA	0.0577	0.00289	0.0548	0.2135	-0.5895	0.8030	0.0570*	0.0010	0.0676*
	(0.5731)	(0.9742)	(0.6723)	(0.6997)	(0.3061)	(0.3033)	(0.0842)	(0.9066)	(0.0327)
IAROA	0.0411	0.00134	0.0398	0.6856	0.4581***	-1.0593			
	(0.7765)	(0.9946)	(0.8553)	(0.3993)	(0.0023)	(0.5179)			
Sales/TA	-0.1611**	-0.0136	-0.1474	0.1436	0.0482	0.0954			
	(0.0241)	(0.8994)	(0.1968)	(0.5411)	(0.8971)	(0.7969)			
Liquidity	-0.2944***	-0.1781	-0.1163	-0.0293	-0.1219*	0.5826			
	(<0.0001)	(0.1647)	(0.3932)	(0.8123)	(0.0705)	(0.2967)			
Nb of Obs	842			842			220		
LL	145.9566			34.7658			135.0029		
P-value	(<0.0001)			(<0.0001)			(<0.0001)		

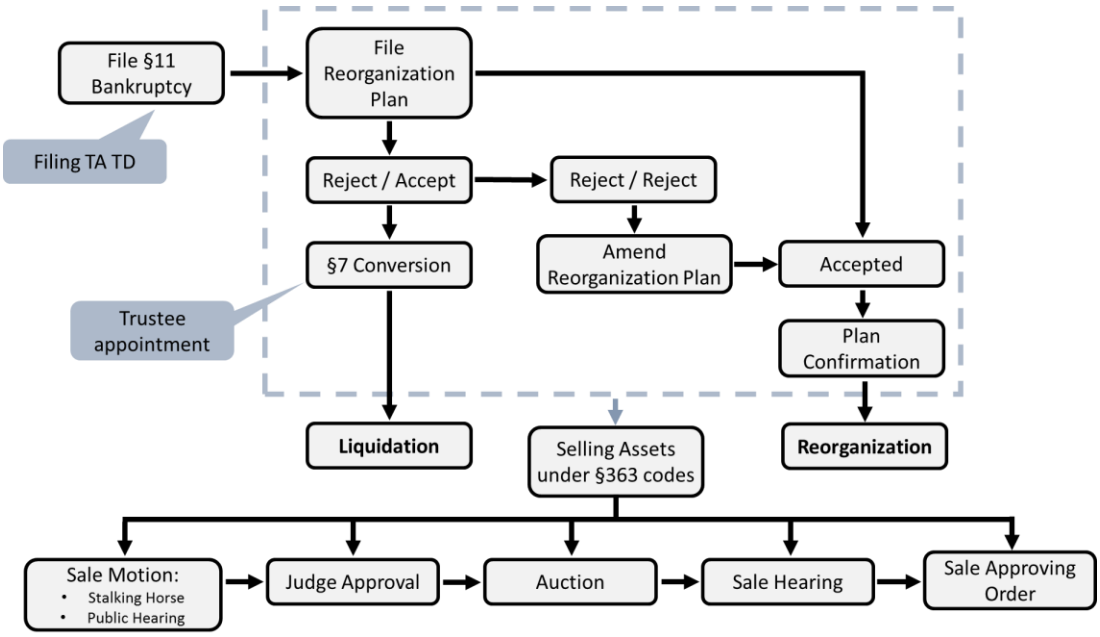

Figure 1: Chapter 11 process

This figure illustrates the Chapter 11 process. The starting point is when the debtor file for bankruptcy and the ending point is when the bankruptcy outcome is identified.