Patents and the Survival of Internet-related IPOs

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Abstract

We examine the effect of patenting on the survival prospects of 356 internet-related firms that made an initial public offering on the NASDAQ at the height of the stock market bubble of the late 1990s. By March 2005, almost 2/3 of these firms had delisted from the exchange. Changes in the legal environment in the US in the 1990s made it much easier to obtain patents on software, and ultimately, on business methods, though less than 1/2 of the firms in our sample obtained, or attempted to obtain, patents. For those that did, we hypothesize that patents conferred competitive advantages that translate into higher probability of survival, though they may also simply be a signal of firm quality. Controlling for other determinants of firm survival such as age, venture-capital backing, financial characteristics, and stock market conditions, patenting is positively associated with survival. Quite different processes appear to govern exit via acquisition compared to exit via delisting from the exchange due to business failure. Firms that applied for more patents were less likely to be acquired, though if they obtain unusually highly cited patents they may be a more attractive acquisition target. These findings do not hold true for "business method" patents, which do not appear to confer a survival advantage.

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1 Introduction

Invention, entrepreneurship, and entry are very significant factors driving growth and competition. Patents are tightly linked to these fundamental economic processes, providing signals of quality to investors, some measure of protection from rapid imitation, and a basis for many types of commercial transactions in the market for knowledge (see Arora et al. (2001), Gans et al. (2002), or Scotchmer (2005)). This paper explores the role played by patents in shaping industry dynamics and firm survival during the rapid and unconstrained real time experiment provided by the dot-com boom of the late 1990s. During these "bubble years" new firms had unusually easy access to capital to fund their exploration of commercial opportunities opened up by the explosive growth of the internet. Entrepreneurs rapidly devised and implemented new business models and developed new products, with new firms appearing apparently from nowhere to become household names in financial services, retailing, and many other sectors. Unfortunately, it equally quickly became clear that many of these new businesses were intrinsically unprofitable and the boom years of unrestricted entry, easy access to capital, and extraordinary valuations of untested new companies were quickly followed by an equally dramatic period of collapsing stock prices, exit and bankruptcies.

This remarkable episode took place against a backdrop of a worldwide surge in filing and granting of patents, and the extension of the patent system, particularly in the United States, into new subject matter areas such as software and business methods. Patentability of software per se was firmly established in the US by the mid-1990s, and decisions in the US courts in the late 1990s such as *AT&T v. Excel Communications* and *State Street v. Signature Financial Services* were widely interpreted as opening the door to a flood of patents on methods of doing business, particularly those implemented in computers and networks.

The new dot-com companies therefore had the option of seeking patent protection for their products and business processes — and many inventors and entrepreneurs apparently took advantage of this opportunity, with thousands of "business method" patent applications filed with the USPTO between 1999 and 2002. These patents generated considerable controversy, with many industry participants, legal scholars, and economists concerned about the potential adverse consequences of allowing large numbers of low-quality patents to issue (Hall (2003), Merges (1999), Meurer (2003), Cockburn (2001), Hunt (2001) and many others). Many of these concerns parallel those expressed about the consequences of software patents for innovation and competition. Critics argued that the flood of business method patents would "choke" innovation by blocking new technological developments, making it prohibitively expensive for new firms to enter these markets, or allowing patentees to control entire markets by obtaining patents with inappropriately broad claims, and/or trivial inventive steps over the existing technology. Apparently concerned about the opportunistic assertion of patents on business methods against incumbent firms, the US Congress took the unusual step of singling out business methods for special treatment, creating a limited "earlier inventor" defense against patent infringement (or prior user right) for "a method of doing or conducting business".[1] However the impact of these patents on the profitability and growth of the companies that obtained them, or on the pace of innovation in the industries

[1] 35 USC Sec. 273.

in which they compete is far from clear.

Quantitative research on patents for software and business methods is limited and often contradictory. Lerner (2002) found no clear evidence on the impact of patents on innovation in finance. Lerner & Zhu (2005) found, if anything, a positive impact of strengthened patent protection on software firms. On the other hand, Bessen & Hunt (2004) suggest that increasing numbers of software patents are associated with a decrease in R&D by large software companies. Gambardella & Giarratana (2006) find an important role for patents in the security software industry, where the commercial success of small firms appears to have been driven by their ability to license technology to established downstream competitors. Noel & Schankermann (2006) find evidence for a negative impact of strategic patenting on entry, R&D, and market value of software firms, while Cockburn & MacGarvie (2006) find that while incumbent patents deter entry in software markets, higher numbers of patents held by entrants stimulate entry. Hall & MacGarvie (2006) find mixed effects of changes in legal doctrine on the market value and stock returns of software firms, with a initially negative impact of the strengthening software patent protection on the valuation of incumbent software firms followed by an increase in the market valuation of software patents after 1995. There is, therefore, considerable uncertainty about the economic value and impact of these patents.[2]

Rather than attempt to directly assess the monetary value of these patents, or relate them to technological indicators of the pace of innovation, this paper examines the impact of patenting on a much more basic measure of economic impact — the survival of a sample of internet-based and software firms that went public during the boom phase of the dot-com bubble, and then faced high probabilities of business failure during the bust period that followed. To the extent that patents obtained by these firms improved their competitive position, through mechanisms such as excluding competitors, supporting higher margins, raising rivals' costs, or signaling quality, we hypothesize that they should have conferred a substantial survival advantage. Estimates of the size and significance of such an effect may provide useful insight into the economic impact of these types of patents.

The remainder of the paper proceeds as follows. In Section 2 of the paper we briefly summarize previous findings on firm turn-over and review existing literature scrutinizing software and business method patents. Section 3 contains a short description of the dataset used for the analysis, which combines financial data and patent data for 356 firms that made an IPO on the NASDAQ at the height of the stock market bubble between 1998 and 2001. In Section 4, results are presented from estimating multivariate hazard models relating firm survival to patenting, financing, and economic performance. Finally, Section 5 concludes and offers some implications of our findings for future research and the current debate on patent policy.

[2]It is even unclear whether claims about the poor quality of business method patents are generally true. Hunter (2003) and Allison & Tiller (2003) argue that business method patents compare well to patents in other technologies in terms of citation of prior art, etc.

2 Patents and the Turn-over of Internet Firms

In 1998 the Court of Appeals for the Federal Circuit removed the last obstacles to obtaining patents on pure business methods in the United States with its famous *State Street Bank and Trust Co. vs Signature Financial Group* decision involving US patent No. 5,193,056 in 1998 (Hunt 2001, Conley 2003).[3] As a consequence large numbers of applications for business method patents were filed in the USPTO, and many of the patents that subsequently issued protect inventions closely related to internet business models and software used in various e-business applications. The rapid increase in application and grant figures as well as some widely publicized patent infringement cases initiated a broad debate on the legal and economic consequences of allowing these patents.[4] Concerns expressed by many scholars about the potentially low quality of granted business method and software patents as a consequence of inadequate examination procedures of the USPTO by numerous authors (Dreyfuss 2000, Hunt 2001, Merges 1999, Wagner forthcoming 2007) were accompanied by strong objections and criticism from practitioners and policymakers. In response to this, the USPTO moved to tighten the examination procedures and standards for patents filed in USPTO Class 705, the principal classification for business method patents (USPTO 1999).[5]

Despite the debate on the consequences of granting large numbers of poor quality business method and software patents, their impact on economic outcomes — such as incentives to innovate and the pace of technical change — in affected industries has received little attention. These outcomes are very difficult to measure directly, but some insight into the economic significance of these patents may be gained from looking at whether or not they can affect the improve the economic performance of firms that obtain them.

Much of the literature on the value of patents has focused on indirect measures of their impact on profitability, such as stock market value of the firm. Relatively little systematic evidence has been gathered on relationships between patenting and more basic indicators of firm performance such as growth and survival. These may be particularly useful for small or new firms, where the signal conveyed by market valuation of intangibles may be particularly

[3] "As an alternative ground for invalidating the '056 patent under Section 101, the [district] court relied on the judicially-created, so-called "business method" exception to statutory subject matter. We take this opportunity to lay this ill-conceived exception to rest." *State Street Bank & Trust Co. v. Signature Financial Group, Inc.* 149 F.3d 1368. (Fed. Cir. 1998).

[4] Outcomes of these cases have been mixed. In the *Priceline.com vs. Microsoft/Expedia* case, Priceline.com obtained an undisclosed settlement payment from Microsoft leading to a 30% increase in its stock market capitalization. But in another widely followed dispute, Amazon.com attempted to enforce a patent on "one-click" on-line purchasing against Barnesandnoble.com with only limited success: though Amazon.com succeeded in obtaining a preliminary injunction enjoining Barnesandnoble.com from using the Express Lane feature on its website during the busy Christmas buying season, this was quite quickly vacated on appeal in the face of persuasive evidence questioning the validity of Amazon.com's patent. *A*mazon.com v. Barnesandnoble.com, et al. Civ. Act. No. 00-1109, 239 F.3d 1343 (Fed. Cir., February 14, 2001).

[5] While tighter scrutiny of applications through "second pair of eyes" procedures, recruitment of appropriately qualified examiners, and improved access to relevant prior art may have raised the quality of granted patents in this class, it is not clear whether the rate at which business method patents are being issued has fallen. Applicants are likely to have reacted to this tightened scrutiny of applications in class 705 by framing the content of the application in a way that increases the likelihood of it being directed to a different part of the Patent Office.

difficult to identify against the noise generated by high levels of uncertainty about future growth prospects, thin trading and very volatile asset prices.

One notable exception can be found in recent paper by Mann & Sager (2005). Here the authors combine data on the venture capital financing of software start-ups with data on the patents held by those firms in order to analyze the relation between patenting and their ability to obtain venture financing, as well as and their progress through the venture cycle. They find some correlation between patenting and different proxies for success but also acknowledge that the private value of holding software patents varies greatly between firms even within the same industrial subsegment.[6]

Here we tackle a similar question — is there a private benefit from patenting business methods and software? — with a somewhat different research strategy. Analyzing a set of dot-com firms pursuing business models closely tied to internet services and software, we relate patent holdings to the survival of these firms as publicly traded companies. The survival analysis framework we employ for this purpose has been widely used in previous empirical studies of firm failure and industry dynamics. Compared to a relatively sparse theoretical literature[7], IO economics is rich in empirical evidence on entry and exit, and there is a well-established set of 'stylized facts' on firm survival. Geroski (1995), Sutton (1997) and Caves (1998) provide comprehensive surveys. Considering firm characteristics, the most common result is that survival is positively related to firm size and to firm age. Most studies find that small firms (who are more likely to operate below the minimum efficient scale) exhibit higher failure rates. Moreover, younger firms have higher failure probabilities and Audretsch (1995) argues that firm age is a proxy for the accumulation of information about technology, markets and a firm's own cost function. A greater stock of accumulated information should lead to higher survival chances. In addition to these firm characteristics, industry characteristics and the competitive environment have also been studied in depth. In particular, the point in the product/industry life cycle in which a firm operates has been found to be an important determinant of firm survival (Agarwal & Gort 1996, 2002, Suarez & Utterback 1993, 1995). Further, failure is positively related to overall rates of entry in an industry (Mata et al. 1995, Honjo 2000) and also to average price-cost margins (Audretsch 1991, Audretsch & Mahmood 1995).

A different strand of literature, predominantly from the fields of accounting and finance, relates the occurrence of bankruptcy and M&A-activity to financial ratios based on capital market data and accounting information derived from firms' financial statements. In a comprehensive study, Fama & French (2004) document a strong increase in the number of new lists at the NASDAQ in the period between 1973 and 2001 which is accompanied by a sharp decline in survival rates over time. Fama & French (2004) find that surviving firms exhibit higher profitability and growth rates. Logit models have been used in this context to predict take-over targets (Palepu 1986) or to analyze delistings from stock markets (Seguin & Smoller

[6] In a comment on a closely related paper by Mann, Bessen (2005) points out that some of these findings have to be interpreted with caution.

[7] Among the few theoretical treatments of firm turn-over are Jovanovic (1982) and Hopenhayn (1992) who suggest that in a theory of learning and noisy selection, firm age and size are important determinants of survival. In a recent paper, Cooley & Quadrini (2001) introduce financial markets to this model and analyze the effect of market frictions on firm survival.

1997). Seguin & Smoller (1997) find a higher mortality rate for lower priced stocks than for higher priced issues while mortality in their sample is not influenced by market capitalization. Recently, Shumway (2001) emphasizes the advantages of hazard models compared to static models in predicting bankruptcy using financial and accounting ratios. Employing this type of model to bankruptcy data, Chava & Jarrow (2004) find that accounting variables add little predictive power when market based measures are already included in the model while Beaver et al. (2005) identify additional explanatory power of information based on financial reporting.

A number of recent papers have focused on the cohort of young high-tech firms that went public during the stock market bubble of 1998-2001. These studies seek to characterize both the extraordinary conditions of the equity markets at that time as well as the innovative activities of the new firms, relating these to firm survival after the IPO. Audretsch & Lehmann (2004), for example, analyze the survival times of a sample of 341 firms from various industries listed on the German *Neuer Markt*[8] as a function of firms' human capital and intellectual property assets. Modelling the length of time a firm was listed on the stock market before it was delisted, the authors find that the likelihood of survival is positively related to firm size, the human capital accumulated in the board of directors, and the number of German patents held by a firm. Moreover, Audretsch & Lehmann (2004) find that failure rates are negatively affected by the investment share of venture capital firms prior to IPO. In a related study, Jain & Kini (2000) find that the presence of venture capitalists prior to going public improves the survival prospects of IPO firms.

Other studies have focused on the survival of firms that are based on a business model that relies on the internet to perform transactions, distribute products or provide services, and interact with customers. For instance, Kauffman & Wang (2003) analyzed survival times of 103 such "internet firms" listed on the NASDAQ.[9] Employing a competing risks specification they found that firms which distribute physical goods via the internet (as opposed to firms provided digital services) and firms which target both consumer and business markets have longer survival times until either a merger or a delisting occurs. Botman et al. (2004) analyzed survival of 326 internet firms listed on the NASDAQ between 1996 and 2001, as a function of variables intended to characterize market conditions at the time the IPO took place, the reputation of the management and the investment bank leading the IPO as well as firm characteristics such as financial condition and age. Their results show that surviving firms are associated with lower risk indications in the IPO prospectus, higher underwriter reputation, higher investor demand for the shares issued at the IPO, lower valuation uncertainty, higher insider ownership retention, a lower NASDAQ market level, and a higher offer-to-book ratio compared to non-survivors. Regarding the survivors versus acquired firms they find that acquired firms are smaller in size and have a longer operating history.

Our study focuses on the relevance of patents for the success of dot-com companies. In

[8] *Neuer Markt* was launched as market segment for high-tech and internet start-ups by the German Stock Exchange on March, 10^{th}, 1997. Six years later on June, 5^{th}, 2003 *Neuer Markt* was closed in a re-segmentation of the German Stock Exchange — most likely due to dramatic losses in market capitalization and loss of investor interest.

[9] The authors are not completely clear on whether their sample consists exclusively of NASDAQ-listed firms, but given the US context this seems highly likely.

particular, we seek to analyze the extent to which these firms took advantage of the changing legal landscape with regard to the patentability of business methods, and the impact of these decisions on competitive outcomes. Our study therefore combines data on firm characteristics like age, financial condition, and market environment with detailed information on their patent holdings. The patent portfolios of firms in our sample are characterized not just by counting the number of patents held, but also by measures of patent quality based on citations and international filing patterns.

3 Data and Descriptive Statistics

3.1 Data

To address these questions, we gathered data on 356 firms that made an Initial Public Offering of shares on the NASDAQ stock exchange between February 1998 and August 2001. These firms were characterized by IPO.com, a then popular but now defunct financial research service, as operating in the Internet Services, Internet Software and Computer Software Segments. We were able to obtain comprehensive data on these firms including listing information, financial information, firm age and a variety of measures with regard to their patent holdings. The data were obtained from different sources including the Delphion, USPTO, Compustat, CRSP and Venture-Xpert databases as well as firms' 10K filings and IPO prospectuses. In this subsection we briefly comment on the variables contained in our dataset before presenting descriptive statistics in the subsequent subsection.

Listing Information. For each firm we obtained detailed information on its listing on the NASDAQ stock exchange from the Center for Research on Security Prices *CRSP*-database. This data contains not only the date of the IPO ($ipodate_i$) for each firm i but also information whether or not a firm is still listed on the NASDAQ. If trading in a firm's stock was discontinued, we are able to distinguish between firms which were *delisted* due to business failure[10] and firms which *merged* with other companies. In both cases, we compute the total length of the listing period on the NASDAQ as the time between the date of delisting and the date of the IPO. This "length of listing period" is used as the duration measure in the survival analyses.

Industrial Classification. Based on the classification used by IPO.com we distinguish between three different industrial segments: Internet Services, Internet Software and Computer Software. Dummy variables for these industry segments are included in the multivariate survival analyses, with firms assigned to Computer Software used as the reference group. These categories are far from precise, assignment of firms to segments may be questionable, and some firms may in fact be operating in more than one industry segment. Table 1 shows

[10]This category comprises firms which were delisted due to bankruptcy and firms which have been delisted for trading persistently below the minimum price of $1 per share required by NASDAQ regulations.

Table 1: Breakdown of firms by segment. Table includes selected examples of firms in each segment.

Segment	Firms	Examples
Internet Services	210	1-800-Flowers.com, 24/7 Real Media, Autobytel.com, Buy.com, Drugstore.com, eBay, E-loan, Freemarkets, Genuity, MP3.com, Priceline.com, Razorfish, Verticalnet
Internet Software	82	Critical Path, Entrust, Portal Software, WebMethods
Computer Software	64	Inktomi, Manhattan Associates, Onyx Software, Perot Systems, Quest Software, Red Hat
Total	356	

the breakdown of firms by segment, and lists some high profile examples of firms operating in each segment.

Financial Data. We obtained financial data on a quarterly basis from the *Compustat North America* database. Compustat provides information on operating income and sales for each firm i in quarter t. The cash "burn rate" is often identified as a critical indicator of the financial health of startup firms. Unfortunately we do not directly observe cash outlays by the firms in our sample, nor do we have access to information about unused bank credit lines or other sources of liquidity. However we are able to construct a measure of the financial status or liquidity, $cashburn_{it}$, that captures some aspects of these firms' financial status. $cashburn_{it}$ is calculated as the negative ratio of operating income for the current quarter to the sum of cash and short term investments in the previous quarter. Positive values of this variable thus indicate a consumption of the existing stock of cash and shortterm investments while negative values indicate further accumulation of liquid assets. op_income_{it}, $sales_{it}$ and $cashburn_{it}$ are treated as time-varying coefficients in the multivariate survival analysis of Section 4.[11]

IPO Characteristics. Our dataset contains information on a firm's age when going public (age_ipo_i). It is measured as the difference between its $ipodate_i$ and the date of legal incorporation which was obtained from the *Venture-Xpert* database. If the date of incorporation was not available from *Venture-Xpert* it was obtained from publicly available documents such as 10K reports and IPO prospectuses filed with the SEC. Information in the *Venture-Xpert* and *SDC New Issues* databases we used to determine whether or not each firm was venture capital backed before its IPO. Further, we obtained firms' total assets reported in the quarter when going public ($assets\_tot\_ipo_i$) from the *Compustat North America*-database and include this variable as a measure of a firm's capital endowment "at birth" in our multivariate analysis. Since we are able to identify the levels of Current Assets[12] as well as Property, Plant and Equipment reported in a firm's balance sheet, we further include the shares of

[11] In rare cases, these variables are not available for occasional single quarters. We interpolate missing values by averaging the preceding and subsequent quarters' value.

[12] This position includes Cash and Short Term Investments, Receivables, Inventories and Other Current Assets.

these positions when going public (as a fraction of total assets) in the regressions.

Market Environment. Capital markets in general, and the market for technology related IPOs in particular, were characterized by quite extraordinary "bubble" conditions throughout the period of this study. Investor "exuberance" created market conditions in which large amounts of capital could be raised at remarkably low prices, and with relatively little scrutiny. In order to control for these conditions, we include the average value of the NASDAQ Composite Index in the quarter prior to quarter in which a firm's IPO took place ($nasdaq\_ipo\_lag_i$) as a control variable in our regressions.

Patent Information. Various variables that describe a firm's patent portfolio such as number of patents, international scope of filings, and proxies for patent value were collected from USPTO and other data maintained by Delphion Inc. For each firm in the dataset, Delphion's databases on issued patents and published applications were searched by hand using the company name, along with word stems, common abbreviations, and obvious variations in spelling of companies' names. "Weak" matches were verified by inspecting the inventor names, address information, citations to other patents, and the content of abstracts. In principle, this procedure captured all patent applications and issued patents for which the firm in question was the assignee. Nonetheless is likely that some patents controlled by the firms in this sample were not captured in this search. The search process relies heavily on USPTO's coding of assignee names, and does not capture patents re-assigned to a firm after issuance, exclusively licensed from the inventor, or held in subsidiaries that we were not able to recognize. It is also possible that a significant number of pending applications have been missed in the search, either because the applicant chose to forfeit filing rights outside the US, thus avoiding publication of the application entirely, or because the 18-month period before publication was still in force at the time the search was performed.

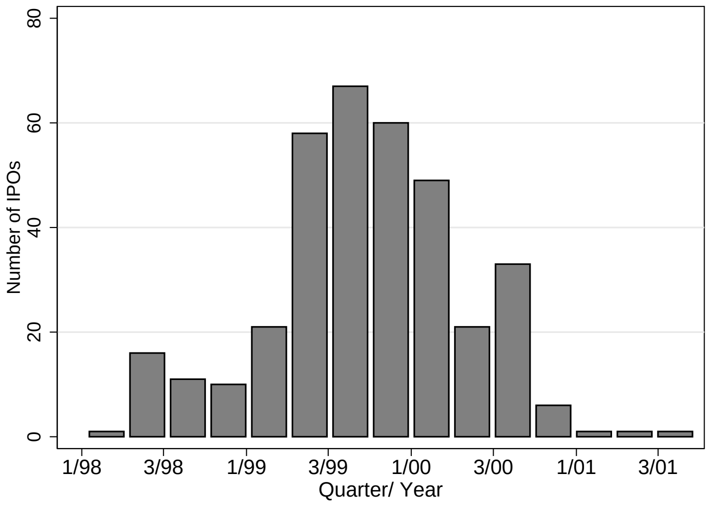
Interestingly, notwithstanding many contemporary commentators' beliefs that business method and software patents were trivially easy to obtain during this period, no issued patents or applications could be found for more than half of the firms in this sample. Dummy variables were coded to indicate whether firms in a particular segment did apply for or hold any patents.

Various measures of the size and characteristics of each firms' patent portfolio were computed. These include the number of USPTO patent applications and grants, as well as counts of applications and grants at the European and Japanese Patent Offices, plus variables which are correlates to patent value: the average family size of a firm's USPTO patents, the average number of forward citations received per grant or application, and the number of forward citations per claim.[13]

It is well-known that the value distribution of patents is highly skewed (Harhoff et al. 1999, 2003) and value measures that average the number of cites per claim over the entire portfolio of patents held by a firm largely obscures this phenomenon. We therefore attempt

[13]Lanjouw & Schankerman (2001) argue that this measure is superior to simple counts of forward citations. Note that this measure is computed using only granted patents since the number of claims is not reported for patent applications.

Figure 1: Distribution of the IPO dates of the 356 firms in our sample.



to capture some aspects of the skewness of the value distribution by counting the the number of patents in a firm's patent portfolio which received 7 or more forward citations (which is approximately the upper quartile of the distribution of number of forward citations in this sample.)

3.2 Descriptive Statistics

Before advancing to our multivariate analysis of firm survival in Section 4 we briefly present major descriptive statistics of the sample. In total, our sample contains 356 firms that went public between February, 25^{th}, 1998 and August, 6^{th}, 2001. These 356 firms make up about 74% of the total number of IPOs reported by IPO.com in the three industry segments considered. (The remainder are firms for which reliable matches were not possible to the databases on NASDAQ trading, venture funding, or financial information.) The distribution of the IPO dates of these firms (Figure 1) shows that most of them went public in the years 1999 and 2000. Strikingly, this distribution tracks the movement of the NASDAQ composite index during this period (see Figure 2).

In total, NASDAQ trading in more than 60% of the firms in our sample had been discontinued by March 1^{st} 2005, the end of the observational period. Table 2 clearly shows that firms from the Internet Services segment exhibit the highest exit rates with 69.5% leaving the sample before August 2005, compared to 59.7% for Internet Software and only 46.9% for Computer software firms. The average time elapsed until trading was discontinued is also presented in Table 2. Note that the average time until firms exited as a result of merger is significantly shorter than the time until delisting due to business failure. Moreover, this difference is much more pronounced for firms from the Computer Software segment compared to firms with a business model related to the internet.

Moving beyond the information in average survival times, Figure 3 presents Kaplan-Meier product-limit estimates of the survivor functions of the firms in our sample i (Kaplan & Meier

Figure 2: NASDAQ composite index for the period 1998 to 2001.

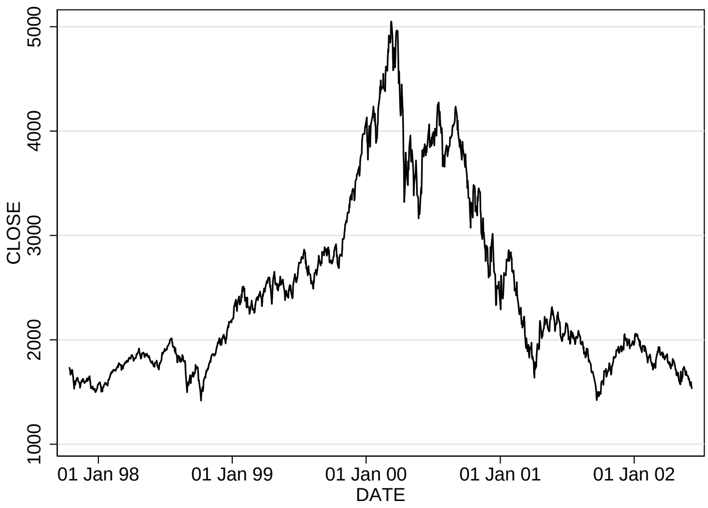
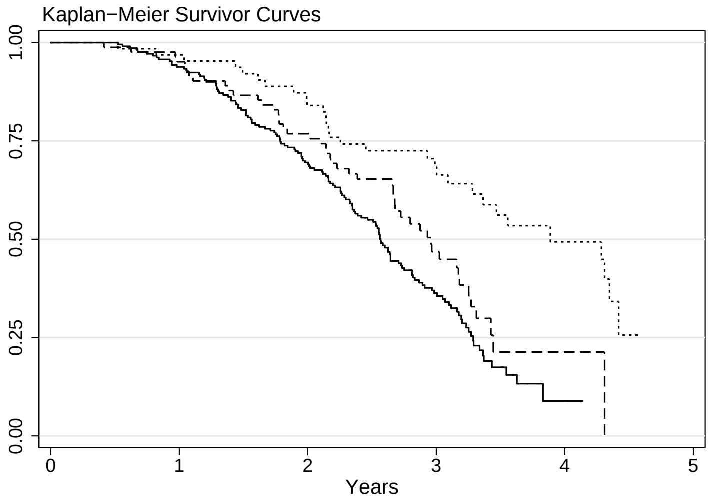


Table 2: Crosstabulation of industrial classification and the listing information for the firms contained in our sample. The second line of each row contains the average listing duration. Note: In a Pearson χ^2-test the differences between firms of different industrial classifications turned out to be significant at the 5% level ($\chi^2(4) = 11.57$).

	Listing Information						
Classification	**Still trading**		**Merged**		**Delisted**		**Total**
Internet Services	64	(30.48%)	87	(41.42%)	59	(28.10%)	210
		.	2.0 Yrs		2.3 Yrs		
Internet Software	33	(40.24%)	31	(37.81%)	18	(29.95%)	82
		.	2.1 Yrs		2.4 Yrs		
Computer Software	34	(53.13%)	18	(28.12%)	12	(18.75%)	64
		.	2.2 Yrs		3.1 Yrs		
Total	**131**	(36.8%)	**136**	(38.2%)	**89**	(25.0%)	**356**
		.	2.1 Yrs		2.4 Yrs		

Figure 3: Kaplan-Meier Survivor Curves for the firms in the sample. (—) Internet Services, (- - -) Internet Software, (· · ·) Computer Software.



1958). The survivor curves again show that firms with internet-based business models drop out much earlier than Computer Software firms. Moreover, once past the one year mark, the survival curves for the three groups do not intersect, indicating that the proportionality assumption of Cox's Proportional Hazard model is likely to hold with regard to the different classifications of our firms (Kalbfleisch & Prentice 2002).

Table 3 summarizes some of the important observable characteristics of the firms at the time of their IPO. First, consider the age of the firm. (Recall that age is measured as time elapsed from the date of incorporation until the date of the IPO.) While the average firm is 5.91 years old when the IPO takes place, firms from the Internet Services segment have a prior firm history of only 4.72 years, while firms from the other industry segments are significantly older: firms in the Internet Software segment averaged 6.78 years since incorporation, and those in Computer Software averaged 8.69 years. There are also differences across segments in the extent to which the IPOs of these firms were backed by venture capital firms. In particular, IPOs in the Internet Software segment were more frequently venture-backed (64%) than Internet Services firms (55%) or Computer Software firms (56%). Differences across industry segments are also apparent in the sales and operating profits reported by the firms for the quarter in which their IPO took place. On average, firms in the Computer Software segment realized the highest sales (US$17.45 million) and made only minor operating losses of US$0.5. Internet Services firms achieved somewhat lower sales, averaging US$12.95 million, and Internet Software firms averaged even less, at US$7.55 million in their first quarter as a public company. Moreover, when going public these internet-related firms were highly unprofitable with operating losses averaging US$9.5 million per quarter in Internet Services and US$5.6 million per quarter in Internet software (see Table 3). These differences in profitability are also reflected by our *cashburn* measure of liquidity, defined as negative ratio of operating profits divided by cash and shortterm investments in the previous period. In the quarter of their IPO, firms from the Internet Services segment had on average operating losses equalling about 45% of their cash and shortterm investments while this measure is only

Table 3: Mean values of major firm characteristics for the quarter when their IPO took place.

Firm Characteristics	**Internet Services** (n=210)	**Internet Software** (n=82)	**Computer Software** (n=64)	**Total** (n=356)
Age (Years)	4.72	6.78	8.69	5.91
Venture-backed	0.55	0.64	0.56	0.58
Sales ($MM)	12.95	7.55	17.45	12.51
Op. Income ($MM)	-9.50	-5.56	-0.49	-6.97
Proceeds from IPO ($MM)	149.49	150.58	112.33	143.06
Assets ($MM)	164.09	84.49	84.89	131.52
Current Assets ($MM)	107.24	77.34	72.60	94.34
Property, Plant and Equipment ($MM)	22.84	4.27	6.49	15.82
Cash and Short-term Investment ($MM)	88.88	64.62	51.19	76.62
Cashburn Rate	0.45	0.26	0.44	0.41

about 26% for Internet Software firms Computer Software firms had on average operating losses of 44% of their cash on short term investments (see Table 3).

Turning to information on the patenting activities of the firms in the sample, Table 4 reports the distribution of patent applications across technology classes, using the US Patent Classification scheme, and classifying patents based on the primary USPC code. Not surprisingly, classes that are relevant to the e-commerce and the internet (networking, databases, cryptography etc.) are well represented. Interestingly Class 705 (in which most business method patents should be classified) accounts for only 11.4% of the 1198 applications in our dataset.[14]

As noted above, a substantial fraction (53.8%) of the firms in our sample did not patent at all prior to March 2005, with significant differences across industry segments: 65.2% of the Internet Services, 51.2% of the Internet Software firms and 45.3% of the Computer Software firms had not filed a published patent application at the USPTO, the EPO, or the JPO. [15]

Table 5 gives summary statistics of the patenting activities of firms that did file at least one published patent application. Firms from the Computer Software segment are most active patentees, averaging 12.29 USPTO applications per patenting firm, compared to 9.62 for Internet Software patenting firms, and only 4.92 USPTO applications for patenting firms in Internet Services.[16] Table 5 also reports the extent of international patenting activity by the sample firms. On average, EPO and JPO applications and grants are significantly lower

[14]These patents are held by 14 firms classified to Internet Services, two firms from Internet Software and only one firm from Computer Software.

[15]Though there were (and are) significant differences in principle across USPTO, EPO, and JPO as regards patentability of software and business methods, this has not in practice prevented firms from obtaining patents on these types of inventions in all of these jurisdictions.

[16]It is possible that these differences are a consequence of differences in firm age. However, the correlation coefficient between the number of USPTO patent applications and the firm age when going public is 0.06 and not significant.

Table 4: Classification of the USPTO patent applications of the firms in the sample.

Class	Description	Patents	Share
709	Electrical computers and digital processing systems: multi-computer data transferring	188	15.69%
705	Data processing: financial, business practice, management, or cost/ price determination	137	11.44%
345	Computer graphics processing and selective visual display systems	134	11.19%
707	Data processing: database and file management or data structures	122	10.18%
713	Electrical computers and digital processing systems: support	111	9.27%
704	Data processing: speech signal processing, linguistics, language translation, and audio compression	42	3.51%
380	Cryptography	38	3.18%
370	Multiplex communications	37	3.09%
434	Education and demonstration	37	3.09%
375	Pulse or digital communications	35	2.92%
379	Telephonic communications	33	2.75%
725	Interactive video distribution systems	26	2.17%
.	Other classes with less than 20 applications (2%)	258	21.54%
Total		**1198**	**100%**

Table 5: Mean values of major patent characteristics of firms who applied for at least one published patent application at the USPTO, EPO, or JPO. Firms without any patenting activities are excluded from the computation of average values. ($^{+}$ indicates statistics only computed for issued USPTO patents since the number of claims is not reported for published applications.)

Patent Characteristics	**Internet Services** (n=74)	**Internet Software** (n=42)	**Computer Software** (n=35)	**Total** (n=151)
Share of firms with 0 applications	0.65	0.51	0.45	0.58
USPTO applications	4.92	9.62	12.29	7.93
USPTO grants	4.28	9.14	10.91	7.17
EPO applications	2.86	3.00	2.94	2.92
EPO grants	1.79	2.19	1.23	1.79
JPO applications	0.28	0.60	0.31	0.38
JPO grants	0.23	0.30	0.23	0.25
Share of international patentees	0.64	0.57	0.54	0.60
Family size at USPTO	4.89	5.36	5.86	5.24
USPTO claims^{+}	22.42	23.91	25.00	23.43
Cites per patent	4.60	5.14	7.32	5.39
Share of patents with ≥ 7 cites	0.21	0.27	0.35	0.26
Cites per claim^{+}	0.50	0.56	0.64	0.55

than at USPTO, with smaller differences across industry segments. Curiously, despite being the least active patentees in terms of the average size of their patent portfolio, the share of international patentees is highest in the group of Internet Services firms, with the opposite effect visible for Computer Software firms.

In addition to the patent counts, Table 5 also reports measures of the value or quality of these firms' patent portfolios. The average number of claims for the patents held by the firms in our sample is 23.43 with small differences across groups. The average patent family size is 5.24. However measures which are correlates to patent value are of highest interest. Interestingly, we observe significant differences in the average number of forward citations per patent, which are highest for Computer Software firms with 7.32 compared to 5.14 for Internet Services and 4.60 for Internet Software firms. Similarly, the average proportion of firms' portfolios that is made up of highly cited patents (7 or more citations received) is highest in Computer Software, as is the average across portfolios of the number of citations received per claim. While it is tempting to interpret these as evidence of higher average quality or value of patents in the Computer Software segment compared to Internet Services or Internet Software, it is important to recognize that some of this variation may simply reflect differences across segments in the nature of technology or citation practices, and most importantly, in the size of the population of potentially citing patents.[17]

Table 6 summarizes our dependent variable of the multivariate analysis of Section 4 (the

[17]Interestingly, though, these differences do not appear to be driven by the age of firms and the age of their patents. Since older patents can be cited for a longer period of time than younger patents, they ought on average to receive more citations. However, the correlation coefficient between the number of citations received and firm age when going public is 0.03 and not significant.

time between the IPO and the delisting of a firm) within different categorizations of important independent variables at the IPO date. Comparing the average duration for firms which filed at least one patent (opposed to firms which did not apply for a patent in the US) we find that patenting is associated with longer survival times. The same is true when distinguishing firms which obtained venture capital funding prior to their IPO with firms which did not. Having obtained venture capital financing is also positively related to the duration of the listing period on the NASDAQ. Finally, we report financial characteristics like operating income and total assets when going public. We categorize these variables in the quartiles of their respective distribution and find that both influence survival chances. The relation between operating income and survival time is straightforward: Firms generating income in the top quartiles tend to exhibit longer survival times than firms from lower quartiles. The relation between assets reported when going public and survival is more complex. On average, we observe a U-shaped relation with firms belonging to the top and the lowest quartile having longer survival times than firms from the middle quartiles. However, firms which delisted their shares due to bankruptcy exhibit longest survival times if their reported assets lie in the 2nd quartile.

Finally, Table 11 provides a summary of important financial variables in the five quarters preceding the delisting. Here, we notice interesting differences between firms that were acquired by other firms and firms that went bankrupt. The most pronounced differences are found in the development of operating income, cash and short term investments as well as the level of working capital employed. Firms which delisted due to business failure exhibit by far lower operating incomes and a sharp decrease in their cash and short term investments prior to their delisting.

In order to disentangle the effects of the different independent variables described above we conduct a multivariate survival analysis based on Cox Proportional Hazards model in the following Section of our paper.

Table 6: This table presents the time between IPO and delisting (duration) measured in years broken down by different categories of independent variables at the IPO date. Note that the table contains only the 225 firms which have been delisted from the NASDAQ within our observational period.

Variable	**Merged Firms**		**Delisted Firms**		**Total**	
	Duration	Obs	Duration	Obs	Duration	Obs
Patents						
At least one patent application	2.14	48	2.59	33	2.32	81
No patent application	2.01	88	2.32	56	2.13	144
Venture Capital						
VC funding obtained	2.25	46	2.54	40	2.39	86
No VC funding obtained	1.95	90	2.32	49	2.08	139
Operating Income						
1st Quartile	1.74	40	2.11	29	1.89	69
2nd Quartile	1.94	36	2.31	25	2.09	61
3rd Quartile	2.27	27	2.77	28	2.52	55
4th Quartile	2.37	33	2.67	7	2.43	40
Total Assets at IPO						
1st Quartile	2.25	36	2.44	24	2.33	60
2nd Quartile	1.92	36	2.56	23	2.17	59
3rd Quartile	1.91	38	2.33	17	2.04	55
4th Quartile	2.17	26	2.33	25	2.25	51
Cash and Short-Term Investments at IPO						
1st Quartile	2.02	25	2.56	21	2.26	46
2nd Quartile	2.05	33	2.41	26	2.21	59
3rd Quartile	2.05	59	2.39	22	2.14	81
4th Quartile	2.10	19	2.32	20	2.21	39

4 Multivariate Survival Analysis

We now proceed to analyze the influence of various firm characteristics, specifically financial data and patent holdings, on firm survival.

4.1 Methodology

In order to analyze the determinants of firm survival we employ a simple hazard model where we consider survival time as a nonnegative random variable T.[18] A basic concept for the analysis of survival times is the hazard function $\lambda(t)$, which is defined as the limit

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{P(t \leq T < t + \Delta t \mid T \geq t)}{\Delta t}$$

and measures the instantaneous failure rate at time t given that the individual survives until t. In the following, different survival models are estimated where the hazard function depends on a set of covariates $x' = (x_1, \dots, x_p)$ that influence the survival time T.

The reference model for multivariate survival analysis is Cox's proportional hazard (PH) model (Cox 1972) where the hazard rate is assumed to be the product

$$\lambda(t, x) = \lambda_0(t) \exp(x_1\beta_1 + \ldots + x_p\beta_p) = \lambda_0(t) \exp(x'\beta).$$

In this model the baseline hazard rate $\lambda_0(t)$ remains unspecified and, through the exponential link function, the covariates x act multiplicatively on the hazard rate. We use a specification which includes both time-variant regressors x_{it} like the quarterly operating income or sales and also time-invariant regressors like firm characteristics at the IPO and the patent characteristics x_j. Hence, the specification we have to estimate is of the form

$$\lambda(t, x) = \lambda_0(t) \exp(x_j\beta_j + x_{it}\beta_i).$$

As noted above, we are able to observe different modes of exit from the sample: firms can either be delisted as a result of bankruptcy or minimal market value, or cease trading as a result of a merger or takeover. We therefore report estimation results from both a pooled model that does not distinguish between different outcomes, as well as a competing risks model that explicitly takes into account the different modes of exit.[19] Schary (1991) emphasizes important economic differences between different forms of exit and argues for a separation of exit types when studying firm survival.

4.2 Results

The results of our multivariate estimations are reported in Tables 8 through 10 at the end of the paper. Table 7 gives descriptive statistics for the regressors.

[18] Recall that the survival time is the defined as the time between the first listing of a firm and the discontinuation of share-trading at the NASDAQ.

[19] Results from alternative parametric estimations are similar to the results from our Cox PH models. Results from log-logistic specifications of the competing risks survival models are not reported but can be obtained from the authors upon request.

In Table 8 results are reported for pooled and competing risks models for two different sets of explanatory variables. The first specification (left part of Table 8) contains only firm-specific characteristics, financial variables, the level of the NASDAQ composite index in the quarter preceding the IPO, and the dummy variables indicating whether a firms from the different segments have filed at least one patent application or not. In the second specification (right part of Table 8) we control for characteristics of firms' patent portfolios using the variables described above.

Column (1) of Table 8 contains the estimation results from the pooled model, which does not distinguish between different exit modes. Large and strongly significant effects are estimated for sales, total assets at IPO, cashburn rate, the level of the NASDAQ composite index in the quarter prior to the IPO and the patent dummy. Unsurprisingly, firms with higher sales exhibit higher survival probabilities. An additional $10MM per quarter in sales (sample average of $21.96MM) increases the probability of survival by about 12%. Moreover, we find that our cashburn measure is a significant determinant of firm survival with higher cashburn rates associated with a strongly increased hazard rate. Curiously, the small but strongly significant effect of total assets at the time of IPO indicates that firms that were able to raise larger amounts of capital were somewhat more likely to exit.

Older firms have a lower risk of failure, with an additional year of pre-IPO existence increasing the probability of survival by about 3%, though the estimated coefficient is not significant. The results for level of the NASDAQ composite index are also interesting, and confirm previous findings. Firms that went public during periods of higher market valuations for high-tech firms have markedly lower survival chances. The estimated coefficient implies that an additional 1000 points on the NASDAQ at the time of IPO would reduce the probability of survival by more than 33%. Not having applied for any patents is also a strong determinant of failure. Firms that filed at least one patent application have a 35% lower probability of exit relative to baseline.

Controls for industry segment show very large (and for Internet Services firms, highly significant) differences in the hazard rates. Firms in Internet Services are twice as likely to exit via a merger as firms in Computer Software. However, we find no significant effect for firms in Internet Software compared to the reference group.

The results from our pooled model conceal some interesting differences across modes of exit from the sample. Results from the competing risks model which distinguishes between delistings due to acquisition or merger of the firm and delistings due to business failure (Columns (2) and (3) of Table 8) are revealing.[20]

While the effect of the operating profits was — somewhat surprisingly — not statistically significant in the pooled risks specification, the competing risks specification clearly shows that this result is due to two offsetting effects. The estimated effect of operating profits is positive for firms that have merged or been acquired since their IPO, but negative and significant for firms whose shares have been delisted due to business failure. Moreover, we

[20]A formal test of whether exits to different states are behaviorally distinct is presented in the Appendix. The null hypothesis of proportionality of cause-specific hazards is strongly rejected $\chi^2(11) = 327.26$ for the models in columns (1) through (3), and $\chi^2(16) = 344.07$ for the models in columns (4) through (6).

also observe different effects for the dummy variable indicating whether firms were venture capital backed prior to their IPO. While venture-backed firms are much more likely to exit via merger/acquisition (Column 2), they exhibit lower (albeit insignificantly different from baseline) hazard rates with regard to a delisting due to business failure (Column 3). Firms that were older at the time of their IPO have a marginally significantly lower hazard rate for being delisted due to business failure, with no effect on the hazard of exiting via merger/acquisition. Turning to the effect of the total assets and the share of cash and short term investements of the total assets reported by a firm at the time of IPO, very substantial differences are apparent in the hazards for different modes of exit. No statistically significant effect of the amount of total assets is found on the hazard of exit via merger/acquisition, however a significant effect of large magnitude is found for the hazard of delisting due to business failure. Puzzlingly, the effect of total assets is positive: having another \$100MM at the time of IPO (compared to the sample average of \$126MM *raises* the likelihood of exit through business failure by 27%). Firms reporting higher shares of Cash and Short Term Investments as a fraction of their total assets have a highly significant lower risk of being acquired.[21] The share of Property, Plant and Equipment significantly lowers the risk of risk of going bankrupt.

The effects described above remain largely unchanged once the variables characterizing the patent portfolios held by these firms are introduced (see right part of Table 8). In the pooled risks model (Column 4) estimated hazard ratios on most of the firm characteristics are very similar in magnitude. Firms which were younger, were venture-backed, were less profitable, had higher assets, and IPO'd when the NASDAQ was at a higher level were less likely to survive. Very similar differences between firms that exited as a result of business failure and firms that were merged/acquired are also apparent.

Among the patent portfolio variables, only the total number of patent applications filed at the USPTO is a significant determinant of firm survival. Applying for one more patent lowers the probability of exit by more than 5% in the pooled risks model. A marked difference in this effect is seen in the competing risks model: firms with more patent applications had a 10% lower hazard of exiting via merger/acquisition, but no significant effect is seen on the hazard of exiting via delisting.[22]

Disappointingly in the light of evidence on correlation between patent quality measures and patent value in other contexts, no significant effects for the variables describing characteristics of the patent portfolios beyond the number of applications were found in the pooled risks model. The same is true for the competing risks model (Columns 5 and 6 of Table 8) with one interesting exception. Having a portfolio with a higher fraction of highly cited patents had a positive and marginally significant effect on the probability of exiting via merger/acquisition. We (cautiously) interpret this as evidence that highly cited patents are a very valuable asset, or a signal that the exiting firm's technology/business model is high quality. (Though the inverse effect is found on the hazard of being delisted due to business

[21] Please note that the estimated large magnitude of this effect is due to the low average value of this variable (see Table 7).

[22] In their analysis of 429 Finnish M&A-transactions, Hyytinen et al. (2005) find that the probability of being acquired by a domestic firm decreases with the number of European patents held by the target. However, the probability of an acquisition by a foreign firm increases with the number of patents.

failure, this effect was not significant.)

Turning to the issue of Business Method Patents (defined as patents filed in USPTO Class 705), Tables 9 and 10 present results from re-estimating the models of Table 8 columns (4) to (6) with a distinction drawn between "705" patents and "non-705" patents. Patents held or applied for by the firms in the sample were divided into two groups, those with USPC class 705 ("Data Processing: financial, business practice, management, or cost/price determination") appearing anywhere in the list of patent classes, and those where 705 appeared nowhere.[23] Panel I of Table 9 repeats the estimation, but with the patent portfolio characteristics computed only from the non-705 patents; in Panel II the patent variables are constructed only from the Class 705 patents.

The estimated hazard ratios in Panel I are almost identical to those obtained in Table 8. In Panel II, where the non-705 patents have been removed from consideration, the estimated effect of number of patent applications falls essentially to zero. We conclude, therefore, that the Class 705 patents seem to have very little effect on the survival of firms, with the possible exception of patents with a high number of citations received per claim. The coefficient on this variable implies a a large, positive, and strongly significant estimated effect on the probability of exiting via merger/acquisition: raising citations per claim by one unit (compared to a sample average of 0.23) increases the hazard of exit via merger by almost 80%. Note that there is no significant effect of this variable on the hazard of exiting via delisting.

Table 10 evaluates differences between Class 705 and non-705 patents somewhat differently. Here the specification of the model is expanded to include two sets of patent portfolio characteristics: those computed from the applications in the Class 705 category, and those computed from the applications outside class 705. Again, separating out the Class 705 patents has little effect on the results. Estimated hazard ratios on all the firm characteristics are very similar to those obtained previously.

5 Conclusion

Many new enterprises were created in the 1990s based on innovation in internet-enabled business models and supporting software technologies. Some of these firms took advantage of the option opened up by changing legal doctrine to protect their competitive position by filing patent applications on their inventions. The 356 newly-listed firms studied here collectively filed at least 1198 US patent applications, however these applications were generated by only 42% of the firms in the sample. Our results suggest that the firms that were unable or unwilling to seek patent protection were much less likely to survive the collapse of the dot.com bubble after 2001. After controlling for age of the enterprise, sales, assets, profitability and liquidity, as well as stock market valuations and venture capital backing prior to their IPO, we find that firms with no patent applications had a much higher hazard of exiting the sample.

[23]This is slightly more expansive definition of a Business Method Patent, capturing an additional 55 patents beyond the 137 that have 705 as their primary USPC class. It does not, however, capture any patents that have been carefully worded to avoid the extra scrutiny applied by the USPTO to business methods applications since 2000.

This is true both for the firms that exited as a result of being delisted from the NASDAQ due to apparent business failure, and for those that exited as a consequence of a merger or acquisition (which presumably reflects higher value of the firm's assets in a different corporate context.)

Of course, these estimated effects may not just represent the value of patents as a competitive asset in these markets. The estimated positive association between patenting and firm survival may also reflect a correlation between patenting and the underlying quality of the firm's products, business model, management, and other intangible assets. But it suggests a significant role for patents in driving industry dynamics in these technologies, especially within Internet Software. Puzzlingly, though applying for additional patents is associated with lower probability of exit, conventional measures of the quality or value of the patents held by a firm have little explanatory power in our regressions, though we find a hint that that highly cited patents may be an attractive asset for acquirers.

Interestingly for the debate about business method patents, we find that they have very little impact on survival compared to patents classified in other classes. There is one intriguing exception to this general result: firms which hold business method patents that attract more forward citations per claim appear to be more attractive targets for merger or acquisition.

Our estimates also point to some serious problems with adverse selection and the functioning of the US capital markets in the late 1990s. Firms that raised greater amounts of money before and during their IPO were significantly more likely to exit, particularly through delisting due to business failure. We also find a very large and significant effect of prevailing stock market valuations preceding the IPO: firms that went public at the height of the dot-com bubble faced much larger probabilities of being subsequently delisted.

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A Test of Proportionality of Competing Risk Specification

Narendranathan & Stewart (1991) provide a test of whether exits to different states are behaviorally distinct (rather than simply incidental) for continuous time proportional hazards models. This is a test of the hypothesis that the cause-specific hazards are all proportional to one another (i.e. that all parameters except the intercepts are equal across the hazards). The test statistic TS proposed by Narendranathan & Stewart (1991) is given by

$$TS = 2[\ln(L_{CR}) - \ln(L_{SR}) - \sum_j n_j \ln(p_j)] \tag{1}$$

where $\ln(L_{RC})$ is the maximised log-likelihood from the competing risk model (the sum of those from the component risk models), $\ln(L_{SR})$ is the maximised log-likelihood from the single-risk model, n_j is the number of exits to state j and $p_j = n_j / \sum_j n_j$, where there are $j = 1, \ldots, J$ destination states. The test-statistic is distributed Chi-squared with degrees of freedom equal to the number of restrictions.

For our basic models reported in Table 8, we can reject the null hypothesis of risk proportionality at 1% of significance both for the models not including patent characteristics ($TS = 327.27$) as well as for the model containing patent characteristics ($TS = 344.07$). Hence, we reject the hypothesis that the different forms of exit are behaviorally equal.

For our models containing only the set of no-705-patents and the set of 705-patent (as reported in Table 9), we can reject the null hypothesis of risk proportionality at 1% of significance for both specifications ($TS = 343.01$ and $TS = 342.07$). Hence, we reject that the different the hypothesis that the different forms of exit are behaviorally equal.

For our models distinguishing between no-705-patents and 705-patent (as reported in Table 10), we can reject the null hypothesis of risk proportionality at 1% of significance ($TS = 349.09$). Hence, we reject that the different the hypothesis that the different forms of exit are behaviorally equal.

Table 7: Descriptive statistics on variables used in the regressions.

Variable	Obs	Mean	Std. Dev.	Min	Max
Age at IPO (years)	3671	6.013	4.481	0	29.351
Dummy for Venture-backed	3671	0.615	.	0	1
Operating Income ($10MM)	3671	-0.832	3.244	-50.659	10.729
Sales ($10MM)	3671	2.196	3.841	0	36.476
Total Assets at IPO ($100MM)	3671	1.260	3.015	0.032	46.666
Share of Cash and ST Investment at IPO	3671	0.642	0.280	0.063	0.987
Share of Property, Plant and Equipment at IPO	3671	0.073	0.090	0	0.672
Cash-burn rate	3671	-0.258	18.473	-771.50	109.80
NASDAQ index prior to IPO	3671	2.687	0.721	1.691	4.428
Dummy for at least one patent applications	3671	0.4616	.	0	1
Dummy for any international applications	3671	0.276	.	0	1
No. of applications	3671	3.984	11.438	0	152
No. of applications outside class 705	3671	3.302	10.928	0	152
No. of applications in class 705	3671	0.682	2.573	0	25
Average forward citations per claim	3671	0.234	0.736	0	7.382
Average forward citations per claim (non-705)	3671	0.205	0.741	0	8.292
Average forward citations per claim (class 705)	3671	0.086	0.351	0	5.820
No. of patents with 7 or more forward citations	3671	1.079	3.888	0	56
No. of patents with 7 or more forward citations (non-705)	3671	0.873	3.674	0	56
No. of patents with 7 or more forward citations (class 705)	3671	0.206	1.096	0	16
Average family size	3671	2.508	5.037	0	45.257
Average family size (non-705)	3671	2.048	4.407	0	45.257
Average family size (class 705)	3671	1.310	4.026	0	34.929
Internet Services	3671	0.553	.	0	1
Internet Software	3671	0.235	.	0	1
Computer Software	3671	0.213	.	0	1

Table 8: Results from Cox Proportional Hazards Regression. Estimates from pooled and Competing Risks Specification are presented. Z-Values in parentheses. ** 1%, * 5%, + 10% significant.

	Pooled	**Competing Risks**		**Pooled**	**Competing Risks**	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables		Merged	Delisted		Merged	Delisted
Age at IPO	0.9710	0.9804	0.9383	0.9745	0.9863	0.9342
	(1.61)	(0.88)	(1.94)+	(1.43)	(0.62)	(2.02)*
Venture-backed	1.0959	1.4501	0.8016	1.0822	1.3894	0.8156
	(0.64)	(1.96)+	(0.98)	(0.55)	(1.73)+	(0.89)
Operating income	0.9984	1.1423	0.9618	0.9944	1.1367	0.9630
(10 MM USD)	(0.07)	(1.61)	(2.46)*	(0.27)	(1.51)	(2.39)*
Sales	0.8809	0.9527	0.6344	0.8813	0.9612	0.6356
(10 MM USD)	(3.27)**	(1.31)	(4.57)**	(3.15)**	(1.03)	(4.48)**
Total assets at IPO	1.0807	0.9296	1.2731	1.1016	0.9527	1.2806
(100 MM USD)	(2.36)*	(0.68)	(4.57)**	(2.80)**	(0.45)	(4.43)**
Share of Cash/ STI	0.4320	0.0522	3.0739	0.4455	0.0601	3.2097
at IPO	(1.05)	(2.12)*	(1.15)	(1.00)	(2.02)*	(1.17)
Share of PPE at IPO	0.6915	0.9449	0.3906	0.7313	0.9856	0.4536
	(1.42)	(0.17)	(2.33)*	(1.20)	(0.04)	(1.91)+
Cash-burn rate	1.0619	1.0073	1.0844	1.0554	1.0045	1.0852
	(4.83)**	(0.20)	(5.66)**	(4.22)**	(0.21)	(5.07)**
NASDAQ prior to IPO	1.3265	1.2297	1.3892	1.3563	1.2777	1.4156
	(2.54)*	(1.47)	(1.76)+	(2.72)**	(1.76)+	(1.82)+
Patent dummy	0.6455	0.6187	0.6858			
	(2.89)**	(2.51)*	(1.50)			
NO. of US applications				0.9411	0.8955	0.9971
				(2.15)*	(2.47)*	(0.08)
Int'l patent dummy				0.9010	0.8831	0.9557
				(0.52)	(0.49)	(0.13)
Avg. no. of foward citations per claim				0.9695	1.0480	0.7683
				(0.28)	(0.39)	(0.87)
No. of patents with 7 or more citations				1.0698	1.1791	0.9311
				(0.94)	(1.72)+	(0.57)
Avg. family size of patents				1.0007	1.0108	0.9790
				(0.03)	(0.35)	(0.40)
Internet Services	2.1628	2.3064	2.0967	2.0677	2.2696	1.8940
	(3.28)**	(2.82)**	(1.88)+	(3.02)**	(2.71)**	(1.57)
Internet Software	1.6174	1.6998	1.5351	1.6030	1.6776	1.5596
	(1.89)+	(1.65)+	(1.01)	(1.84)+	(1.61)	(1.01)
Observations	3671	3671	3671	3671	3671	3671
Firms	356	356	356	356	356	356
Exits	225	136	89	225	136	89
Log Likelihoood	-1107.61	-689.27	-393.57	-1105.08	-685.55	-392.07

Table 9: Results from Cox Proportional Hazards Regression. Estimates from pooled and Competing Risks Specifications. Note: Patent characteristics used in Panels I and II are computed from different sets of patents. Z-Values in parentheses ** 1%, * 5%, + 10% significant.

	I: No 705 Patents			**II: Only 705 Patents**		
	Pooled	**Competing Risks**		**Pooled**	**Competing Risks**	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables		Merged	Delisted		Merged	Delisted
Age at IPO	0.9724	0.9828	0.9366	0.9760	0.9862	0.9425
	(1.54)	(0.77)	(1.96)+	(1.33)	(0.62)	(1.82)+
Venture-backed	1.0846	1.3950	0.8025	1.0971	1.4358	0.7790
	(0.57)	(1.76)+	(0.97)	(0.65)	(1.91)+	(1.09)
Operating income	0.9945	1.1258	0.9623	0.9992	1.1516	0.9610
(10 MM USD)	(0.27)	(1.43)	(2.41)*	(0.03)	(1.64)	(2.51)*
Sales	0.8780	0.9563	0.6292	0.8856	0.9602	0.6357
(10 MM USD)	(3.31)**	(1.21)	(4.54)**	(3.03)**	(1.03)	(4.54)**
Total assets at IPO	1.1028	0.9493	1.2865	1.0749	0.9317	1.2707
(100 MM USD)	(2.86)**	(0.49)	(4.55)**	(2.15)*	(0.66)	(4.52)**
Share of Cash/ STI	0.4723	0.0666	3.2385	0.4940	0.0675	3.3342
at IPO	(0.93)	(1.96)*	(1.19)	(0.88)	(1.95)+	(1.23)
Share of PPE at IPO	0.7345	1.0050	0.4341	0.6781	0.9012	0.4197
	(1.18)	(0.01)	(2.04)*	(1.49)	(0.31)	(2.12)*
Cash-burn rate	1.0559	1.0051	1.0796	1.0566	1.0057	1.0785
	(4.35)**	(0.21)	(5.22)**	(4.42)**	(0.21)	(5.33)**
NASDAQ prior to IPO	1.3732	1.2954	1.4179	1.3449	1.2658	1.3793
	(2.83)**	(1.85)+	(1.83)+	(2.65)**	(1.68)+	(1.72)+
No. of US applications	0.9344	0.8759	0.9985	0.9891	0.9891	0.9643
	(2.11)*	(2.45)*	(0.04)	(0.17)	(0.14)	(0.26)
Int'l patent dummy	0.9069	0.9035	0.8955	0.7629	0.7712	0.7753
	(0.50)	(0.42)	(0.33)	(1.49)	(1.13)	(0.83)
Avg. no. of citations	0.9546	1.0129	0.6463	1.4589	1.5057	0.3069
per claim	(0.32)	(0.08)	(0.75)	(1.42)	(1.67)+	(0.85)
No. of patents with 7	1.1698	1.4055	0.8878	1.0851	1.1598	1.3182
or more citations	(1.04)	(1.72)+	(0.46)	(0.40)	(0.64)	(0.60)
Avg. family size of patents	0.9915	1.0098	0.9743	0.9495	0.9388	0.9832
	(0.29)	(0.28)	(0.48)	(1.43)	(1.38)	(0.27)
Internet Services	2.0302	2.1935	1.8728	2.2607	2.4053	2.3338
	(2.94)**	(2.58)**	(1.55)	(3.49)**	(2.98)**	(2.11)*
Internet Software	1.5983	1.6753	1.5103	1.5391	1.5918	1.6571
	(1.83)+	(1.59)	(0.96)	(1.68)+	(1.44)	(1.15)
Observations	3671	3671	3671	3671	3671	3671
Firms	356	356	356	356	356	356
Exits	225	136	89	225	136	89
Log Likelihoood	-1104.87	-685.27	-392.19	-1107.50	-688.47	-393.29

Table 10: Results from Cox Proportional Hazards Regression. Estimates from pooled and Competing Risks Specifications. Note: Z-Values in parentheses. ** 1%, * 5%, + 10% significant.

	Pooled	**Competing Risks**	
	(1)	(2)	(3)
Variables		Merged	Delisted
Age at IPO	0.9735	0.9840	0.9377
	(1.47)	(0.71)	(1.94)+
Venture-backed	1.1064	1.4146	0.7771
	(0.71)	(1.83)+	(1.09)
Operating Income	0.9953	1.1324	0.9614
(10 MM USD)	(0.22)	(1.46)	(2.51)*
Sales	0.8841	0.9636	0.6299
(10 MM USD)	(3.08)**	(0.95)	(4.50)**
Total assets at IPO	1.0979	0.9521	1.2876
(100 MM USD)	(2.70)**	(0.46)	(4.54)**
Share of Current Assets	0.4752	0.0743	3.2212
at IPO	(0.93)	(1.89)+	(1.18)
Share of PPE at IPO	0.7228	0.9775	0.4648
	(1.24)	(0.07)	(1.86)+
Cash-burn rate	1.0560	1.0053	1.0791
	(4.35)**	(0.21)	(5.17)**
NASDAQ prior to IPO	1.3803	1.3183	1.4138
	(2.86)**	(1.97)*	(1.81)+
No. of applications	0.9376	0.8798	1.0008
(outside 705)	(1.99)*	(2.34)*	(0.02)
Int'l patent dummy	0.9239	0.9335	0.9722
(outside 705)	(0.40)	(0.28)	(0.08)
Avg. no. of citations per	0.9713	1.0529	0.6189
claim (outside 705)	(0.19)	(0.32)	(0.78)
No. of patents with 7 or	1.1550	1.3709	0.8512
more citations (outside 705)	(0.95)	(1.58)	(0.61)
Avg. family size	0.9943	1.0116	0.9776
(outside 705)	(0.19)	(0.34)	(0.41)
No. of applications	0.9800	0.9968	0.9233
(inside 705)	(0.30)	(0.04)	(0.50)
Avg. no. of citations per	1.3791	1.4475	0.2230
claim (inside 705)	(1.18)	(1.50)	(1.09)
No. of patents with 7 or	1.1102	1.1940	1.4756
more citations (inside 705)	(0.50)	(0.75)	(0.79)
Avg. family size	0.9701	0.9541	1.0124
(inside 705)	(0.77)	(0.97)	(0.18)
Internet Services	1.9890	2.1444	1.9578
	(2.85)**	(2.49)*	(1.63)
Internet Software	1.5092	1.5759	1.6432
	(1.59)	(1.39)	(1.11)
Observations	3671	3671	3671
Firms	356	356	356
Exits	225	136	89
Log Likelihoood	-1103.50	-683.31	-391.27

Table 11: Mean and median values for key financial variables in the five quarters prior to an observed exit.

Quarters until delisting		**4**	**3**	**2**	**1**	**0**
				Merged		
Sales (in MIO USD)	Mean	17.73	19.01	17.47	17.82	18.21
	Median	10.43	10.39	9.43	9.70	9.61
Operating Income (in MIO USD)	Mean	-5.49	-4.64	-3.69	-4.34	-4.27
	Median	-3.83	-3.77	-3.23	-3.58	-2.78
Cash & Short Term Investments (in MIO USD)	Mean	71.39	67.73	66.56	64.31	60.62
	Median	48.68	43.09	42.80	40.09	38.77
Working Capital (in MIO USD)	Mean	62.75	56.69	58.22	52.40	52.70
	Median	45.68	40.06	44.11	36.83	29.16
Quick Ratio	Mean	4.90	4.89	5.27	4.26	4.39
	Median	3.79	3.53	3.76	3.29	3.20
				Delisted		
Sales (in MIO USD)	Mean	17.52	17.64	16.53	15.06	14.06
	Median	6.92	6.66	6.24	5.44	5.33
Operating Income (in MIO USD)	Mean	-13.98	-14.87	-16.81	-10.38	-14.52
	Median	-8.26	-5.29	-5.39	-5.02	-3.64
Cash & Short Term Investments (in MIO USD)	Mean	75.35	62.05	48.32	39.21	41.07
	Median	21.23	14.75	9.60	2.66	2.85
Working Capital (in MIO USD)	Mean	63.44	43.95	32.33	-10.83	-20.67
	Median	22.69	19.33	15.30	10.75	8.83
Quick Ratio	Mean	4.16	4.49	4.26	5.89	5.88
	Median	2.71	2.20	1.56	1.24	1.22