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# Tuning into the Digital Channel: Evaluating Business Model Fit for Internet Firm Survival

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# Tuning into the digital channel: evaluating business model characteristics for Internet firm survival

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**Abstract** More than 5,000 Internet firms have failed since the beginning of 2000. One common perception is that the downturn in the economy drove many firms out of business. But then, why have some firms survived? In this research, we provide an empirical analysis by examining how the business model characteristics of an Internet firm affect its survival. We analyze a panel data set of 130 public Internet firms using two different techniques: non-parametric survival analysis, and the semiparametric Cox proportional hazards model. We characterize the survival rates throughout the lifetimes of the public Internet firms in our sample. Our results reveal that smaller firms that facilitate customer-provider interactions, are transaction brokers, and that rely on advertising as their primary source of revenue sources have had a lower likelihood of bankruptcy or failure. In addition, the detrimental effects on failing to serve as interaction platforms for individuals and businesses, and a larger firm size diminish over time as Internet firms mature, and the weaker ones are forced out of the marketplace. Our research also points out important dimensions of an Internet firm's business model that affect its survival.

**Keywords** Business models · Competitive strategy · Duration analysis · Empirical methods · Internet firms · Strategic management · Survival analysis

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## 1 Introduction

Fueled by advances in information technologies (IT) in the 1990s, Internet firms emerged to facilitate online transactions and leverage unique characteristics that set them apart from bricks-and-mortar businesses. The emergence of Web portals, online financial sites, and business-to-business (B2B) e-intermediaries has allowed market entrants to benefit from the emerging digital channel to deliver information and services that were not previously available. According to Webmergers.com [36], however, about 5,000 Internet companies shut down or were acquired during the 3-year period from 2000 to 2003. Organizational ecologists [11, 14, 15, 22] and evolutionists [2, 12] both argue that the most well-adapted organizations survive in a competitive selective environment. In the digital marketplace, how can we understand the degree of a match between Internet firms' business models and the digital channel, and how do their selected business model characteristics affect survival? In addition, the hype around Internet firms in the late 1990s and the subsequent large-scale failures demonstrate that Internet firms went through their initial

development stages in a sensitive period. How did these unique market conditions affect survival?[1]

Building upon previous interdisciplinary research on organizational evolution and business failure, we provide an empirical analysis of the drivers of Internet firm survival. We answer these questions:

- How can different theories contribute to our knowledge of Internet-focused firm performance?
- What theory can we use to distinguish healthy Internet firms from those near bankruptcy?
- Can we develop indices that gauge the suitability of the characteristics of an Internet firm's business model relative to the Internet channel, and use them to explain and predict survival?

Although research on firm survival can be conducted at different levels, our focus is the *firm-to-business process level*, where there are identifiable, controllable characteristics that may affect survival. Similar to Barua et al. [10], we define an *Internet firm* as one that mainly generates its revenues from the Internet.[2] By analyzing the duration of 130 public Internet firms after their initial public offerings (IPOs), we obtained four major results. First, failures of publicly traded Internet firms occurred between 1 and 6 years after their IPO. The reason we compare firms starting from IPO issuance is because, in survival analysis, observations are usually compared based on age, not on calendar time. Second, the characteristics of a firm's business model and its use of the Internet affected survival. The important dimensions include whether a firm serves as an interaction platform for individuals and businesses and is a transactional intermediary. Finally, the impact of appropriate business model characteristics with the digital channel on firm survival diminished over time, as the competition intensified and only the stronger ones were left. The results allow us to integrate theories and results from previous research, and provide a theoretical perspective that identifies key dimensions of business model characteristics that affect Internet firm survival.

A key managerial take-away from this research is the importance of marketplace dynamics during periods when Internet firms experienced a high probability of failure. We also report on various aspects of Internet firms' business models that seem to have affected their survival. Even though an Internet firm's business model was difficult to change once it is established, companies that tried to nurture online communities with their websites enhanced their chances of survival.

## 2 Literature and theory

We next discuss relevant theories that provide a conceptual framework for understanding Internet firm morphing and survival, and help us identify relevant indices for business model characteristics in the digital channel that affect survival. We first review the organizational ecology and evolution literature. Next, we discuss the relevant literature and the uniqueness of the digital channel that lead to our development of indices for the suitability of business model characteristics between the Internet firm and the digital channel.

### 2.1 The organizational ecology and organizational evolution literatures

The organizational ecology literature examines organizational populations through the lens of Darwinian selection [11, 14, 15, 22]. The central research question the organizational ecology literature tries to answer is why organizations are different in their forms. According to this theory, the external social, political, and economic environments in which organizations exist have limited resources available. This forms an environment in which selection occurs. Only those organizations that are well suited to the environment will be able to acquire the necessary resources and survive. When environmental conditions change, we observe organizational form changes as new organizational forms that best match the new environment gradually gain dominance, while those that do not are selected out. According to this literature, organizational form changes usually occur soon after an organization has been established, and thereafter organizations exhibit increasing inertia and have a tendency to maintain existing structures as they age.

The organizational evolution literature is similar to the organizational ecology literature in that there is also a selection process at work and only the fittest organizations

[1] For example, the NASDAQ Composite Index increased by 238% from 1,520 in the beginning of 1996 to its highest of 5,132 on March 10, 2000. Then within a short two and a half year period, it lost 78% of its value and decreased to a low of 1,136 on October 9, 2002. Seventy-nine out of our sample of 130 Internet firms went public during the five-quarter period from the beginning of 1999 to the first quarter of 2000, after which Internet firm IPOs dramatically fell in number. The 6-month U.S. Treasury bill interest rate went from a high of 6.25% in the third quarter of 2000 to a low of 0.94% in the second quarter of 2004, further indicating the changing fundamentals of the American economy.

[2] Barua et al. [10] define a *dotcom* as a firm that generates 100% of its revenues via the Internet. In another related study, they recognized that Internet firms also generate revenues through traditional channels and used 95% as the cutoff. In this research, we use 90% as the cutoff point so that we are able to include in our sample companies that are generally considered Internet firms by most observers of the digital economy. The 95 and 100% levels for Internet-based revenue generation actually leave out a number of well-known names among these firms. Some examples are Garden.com and GlobalNet Financial.com.

are likely to survive [2, 12]. However, the organizational evolution literature focuses on a cycle involving *variation*, *selection*, and *retention*. During the variation stage, new organizations emerge and diversity increases. The selection process determines that only the best-suited organizations will be selected and survive. This further turns into the retention process where the selected species are institutionalized. As new variations emerge, a new cycle of variation, selection, and retention starts. In addition, the selection mechanism can occur at multiple levels, including individuals, groups, organizations, populations, and communities.

The organizational ecology and evolution literatures[3] both emphasize the importance of the suitability between an organization and its environment relative to the organization's survival. They offer contrasts also. The main difference between the two is that the organizational ecology literature views organizational form as fixed at the birth or shortly after the birth of a firm. On the other hand, the organizational evolution literature views organizational forms as changing continuously through cycles involving variation, retention, and selection. In the digital marketplace, the degree of match between the business activities of Internet firms and the digital channel will also be important to their survival. We next discuss the relevant literature and the unique aspects of the digital channel that allow us to develop indices for how well-suited are the characteristics of an Internet firm's business model.

### 2.2 Unique aspects of the digital economy

Although existing theories of firm survival also apply to Internet firms, the unique characteristics they possess point out the inadequacy of just applying existing theories to them without any adjustments or extensions. We propose a set of indices to measure the suitability of the characteristics of an Internet firm's business model with the digital channel, as a means to explain Internet firm survival.

The digital economy is unique in five aspects. First, the Internet offers a basis for global connectivity and interaction. A virtual location on the World Wide Web allows a firm to easily reach more domestic and international customers, as we have seen with the global expansion of companies such as Amazon.com, Yahoo!, and Google. In addition, the Internet allows companies to improve their business processes and achieve more efficient and effective operations in support of far-flung customers [7]. Although these are advantages all Internet firms enjoy, some have been taking advantage of this global interactivity and offering services to facilitate the interaction among their customers in special ways. For example, eBay has been providing a marketplace that connects sellers and buyers everyplace. Compared with local or special-purpose auctions, where the number of participants rarely goes above a few thousands and geographical barriers exist, eBay connects millions of businesses and individuals from around the world. Online communities such as Women.com and eChapman.com target different demographics, allowing people with similar interests to interact. YouTube.com allows Internet users to express themselves and share videos with each other. Many of these websites do not sell their own products or provide their own content, but rather they rely on user-generated content and serve as the platforms that allow businesses and individuals to meet and interact with each other. Such large-scale global connections among individuals and businesses are unprecedented and impossible without the Internet, and increase the business and social networks that firms and individuals face. As a result, these business models take advantage of global connectivity from the Internet, which increases their suitability for the digital channel and their chances of survival.[4] Hence, we assert:

**Hypothesis 1** (The Interaction Platform Hypothesis) Internet firms that connect individuals and businesses and serve as a platform for their interactions are more likely to survive.[5]

Second, the Internet is not only a new battleground for existing business models, but also a test bed of *brand new* business models. Examples include search engines, portal sites, and website hosting service providers. These business

[3] For example, de Koning [18] uses the concept of *survival of the fittest* to examine the success or failure of organizational collaborations and acquisitions. Lawless and Finch [34] also examine how the suitability of an organization's strategy to its environment affects its survival.

[4] An *interaction platform* is not business model-specific. It can be a B2B, B2C, or C2C firm, as long as it provides a platform that permits individuals and businesses to interact with one another.

[5] The reader should note that each of our hypotheses might include two additional qualifiers, to ensure the accuracy in interpretation of the tests that we carried out in this research. Our theoretical assertions pertain to the *time frame of our data*, and should not be mistaken as "once and for all" assertions; as the times and the technologies change, so will the predictions of theory change. In spite of many changes that have occurred since the dotcom era, this actually is true with different theories in many different industry settings. So, although all of our hypotheses are stated in the present tense, it is appropriate for the reader to think of the tests of theory that we will conduct as having an historical or past tense flavor to them. Nevertheless, we believe that the bulk of what we have asserted will continue to be true. Still, there are changes and nuances that have crept into the current online marketplace and the broader digital economy that reflect the major efforts with reintermediation on the part of well-established leading companies with very large resource bases. As a result, we have seen pure-play Internet firms increasingly combined with other more traditional firms, such as Pets.com with PETsMART, and other emerging technology and emerging services partners, such as eBay and Skype.

models have emerged due to the Internet and they exist on the Internet only. As a result, their positioning for the digital channel is better. In addition, they compete in breakthrough markets, where they provide brand new products and services and face less competition from traditional businesses due to the nature of the changes they bring to the marketplace [17]. In contrast, other business models, such as online retailers and B2B marketplaces, were not designed specifically for or due to the Internet. These business models were shifted by entrepreneurial firms from the offline channel to the online channel, so their suitability to the digital channel was necessarily a little worse.

This is also similar to the tenets of the *product life cycle* (PLC) *theory* [20]. According to PLC theory, new startups are more likely to survive when an industry is young and competition is less intense. In contrast, when an industry is mature and the dominant design has emerged, competition is fierce and new firms face a higher likelihood of failure. For Internet firms that employ brand new Internet-only business models, they are the new entrants into new industries where the dominant players are yet to emerge or are in the process of emerging. Hence, they are more likely to survive. In contrast, for businesses that adjust their existing business models to the online environment, they face fierce competition from established market leaders in the offline channel.[6] As a result, their likelihood of survival is lower. Thus, we propose:

**Hypothesis 2** (The New Internet-Only Business Model Hypothesis) Internet firms that employ newly emerged Internet-only business models are more likely to survive.

Third, the digital channel also enables a company to provide a variety of products or services with different suitability to Internet-based selling. Some provide digital goods and services that can be directly delivered via the Internet, thus are well suited to the digital channel. Examples are online portal sites such as Yahoo! and MSN.com that provide information and services which can be directly accessed via the Internet. Another example is eBay, which offers a marketplace for buyers and sellers, but is not itself involved in order fulfillment. In addition, MP3.com and Audible.com allow customers to download digital content directly from the Internet, transforming the ways that consumers can acquire entertainment and information goods. Barua et al. [8, 9] report that digital product dotcoms have achieved higher productivity than the physical product firms that sell on the Internet. They attribute the difference to a higher level of digitization of business processes at digital product dotcoms and lower operational costs. Electronic delivery substitutes for more traditional approaches and it also is possible now for digital product dotcoms to avoid the costs associated with holding physical inventory. Physical products such as books, CDs, and electronics all have to be shipped to customers. The digital channel offers limited support for customer tryouts of physical products, since the orders have to be physically delivered to customers. The match between their business model and the digital channel is worse as a result. Finally, perishable products such as groceries, flowers, plants, and gardening supplies have either limited delivery areas or high delivery costs (or both), so their business models are the least advantageous for the Internet firms that sell them. This leads us to assert:

**Hypothesis 3** (The Digital Goods Hypothesis) Internet firms that sell digital goods that are more suited to the digital channel are more likely to survive.

Fourth, the Internet offers lower transactional costs. The digital channel allows intermediaries to match buyers and sellers more efficiently and carry out the transactions at lower costs due to higher levels of digitization and the automation of their business processes [6]. If one compares the costs online versus offline for such typical transactions as checking bank account balances, trading stocks, and paying bills, the costs online are just a fraction of those offline [32]. Even though all Internet firms obtain the advantages offered by the Internet, some firms are able to leverage this advantage to a greater extent for profitability and value creation. They are *transaction brokers* whose business models involve the intermediation of transaction-making. Their functions include supporting search, identifying transaction partners, aiding in price discovery, assisting with settlement over the digital channel and indemnifying transaction completion and buyer/seller performance [6, 16]. Our next hypothesis follows from these observations:

**Hypothesis 4** (The Transaction Broker Hypothesis) Internet firms that are transaction brokers are more likely to survive.

Fifth, advertising via the Web has become a major source of revenues for many Internet firms. The digital channel is a medium through which companies can communicate with their customers. When a Web site attracts traffic, advertising revenue generation opportunities arise. To Internet firms such as Yahoo! and Google, which provide their content and services to individuals for free, advertising has become the *most* significant source of their revenues. Along with these opportunities, however,

[6] We want to point out that *new Internet-only business models* are not equivalent to *pure-play Internet firms*. Examples of companies that are pure-players, but did not use brand new business models are Amazon.com and Buy.com. They only exist online, but they are retailers. So their business models are not new; they existed before the Internet.

advertising-based revenue models present some challenges to Internet firms. On the positive side, the ease of customization on the Internet gives Web sites the opportunity to provide *targeted advertising*, making the digital channel even more attractive for advertisers. The customized display of advertisements at Google based on user-supplied search keywords is one such example. In addition, for Web sites that rely mainly on advertising for revenues, their content and services are usually free. Such free services attract Internet users, allowing these companies to accumulate Web site traffic, increasing advertisers' incentives to advertise with them. On the negative side though, Internet firms relying primarily on advertising for revenues are vulnerable to fluctuations in corporate advertising spending. After the stock market downturn in Spring 2000, many businesses reduced their advertising expenditures. As a result, Internet firms that used to provide their content for free and to rely on advertising as revenues had to switch to subscription-based business models [27]. When consumers became unwilling to pay for previously free services, these Internet firms experienced pressure. Despite the challenges Internet firms have faced, advertising has proven to be a reliable source of revenue for many due to the advantages this source of revenues has offered. Hence, we argue:

**Hypothesis 5** (The Advertising as Main-Source-of-Revenue Hypothesis) Internet firms that rely on advertising as their main source of revenues are more likely to survive than those that do not.

We next discuss our empirical research approach, and the statistical methods we use to test our hypotheses and develop new knowledge in this research domain.

## 3 Empirical models and analysis approach

Our empirical analysis involves two steps. We first give a visual representation of the survival patterns that our sample of public Internet firms demonstrated. We then model Internet firm survival in *IPO time* to support firm age-based and calendar time-based analyses. IPO time is the amount of time that has passed since the firm established its capital base from public investors in the stock market. Our methods are intended to triangulate to support a rich and in-depth understanding of Internet firm survival.

### 3.1 Duration modeling and survival analysis

*Survival analysis* is widely used in public health to study the effectiveness of medical treatments on patients and in criminology to examine patterns in criminal recidivism. Several concepts are essential. The occurrence of an event involves a *failure process* that starts from a certain point in time, such as birth or the start of a treatment. *Duration* is the elapsed time since the start of observation until the occurrence of the event of interest or the end of the study period, if the event does not occur and the subject is still at risk [35]. Such an observation is said to be *right-censored*. When an individual is still at risk right before time $t$, the *hazard rate* is the instantaneous failure rate at time $t$. Survival analysis is based on a *stochastic failure process*, so observations are usually compared based on individual durations, rather than calendar time.

Age-based firm comparisons eliminate the possibility of learning effects associated with firm age. We use both nonparametric and semiparametric survival analysis to compare firms with the same number of quarters elapsed since their IPOs.[7] The *survival function* is the probability that the firm's duration will exceed $t$. It also reflects the proportion of individuals in the population that will have a survival time longer than $t$. We use the *Kaplan–Meier* (KM) *estimator*, a non-parametric survival analysis technique, to construct survival functions for firms. Then, we use the Cox *proportional hazards model* to test the impact of explanatory variables on Internet firm survival. We also use a calendar time-based semiparametric survival analysis, so we can control for the impact of market conditions.[8] The strength of this multi-method approach is that it allows us to visually construct a curve that depicts the survival patterns for Internet firms and then examine what drives observed Internet firm bankruptcy and survival.

[7] *Non-parametric survival analysis* does not involve any assumption about the functional form of the hazard function. In contrast, *semiparametric survival analysis* places restrictions and assumptions on the functional forms of portions of the hazard function. In addition, *parametric survival analysis* permits an analyst to fully specify the functional forms of the hazard and survival functions, which may depend on either a set of covariates or time, or both. Typical models that are used include the Weibull and exponential models. Other models that can be used to specify statistical distributions for the hazard include the log-logistic, log-normal, and gamma distributions. For additional details on the rationale for using these different models, the interested reader should see Le [35], Hosmer and Lemeshow [25], and Lawless [33].

[8] In *age-based analysis*, we compare firms at the same age, that is, the same number of quarters after IPO. Performing age-based comparison allows us to eliminate the impact on the hazard rate and survival of the *learning effect associated with firm age*. In *calendar time-based analysis*, we compare Internet firm survival on a calendar quarter-by-calendar quarter basis. This way, we can compare the survival and failure outcome of all firms that were at the risk of failure during a specific calendar quarter. Performing a calendar time-based analysis allows us to eliminate the confounding effects of environmental factors on firm survival. This is especially important for our research since our sample period includes periods of "boom and bust" for the Internet firms.

### 3.2 The KM estimator

The KM estimator calculates the survival function at age $t$ using $\hat{S}_t = \prod_{t(q) \leq t} \frac{n_{t(q)} - d_{t(q)}}{n_{t(q)}}$ $(q = 1,..., Q)$ [35], where $Q$ is the number of distinct event times, $t(q)$ is the time (for the number of quarters after the IPO occurs) of a bankruptcy, liquidation, merger, or acquisition, and $n_{t(q)}$ is the number of firms still in operation up until time $t(q)$ and still at risk at time $t(q)$. $d_{t(q)}$ is the number of firms that has the event of interest at time $t(q)$. From the formula, we can see that the survival function is calculated as a product of the survival ratios not only at time $t$, but also at earlier times when the event was observed for some individuals. As a result, the KM estimator allows us to take into account the survival history of all firms when calculating the survival function at a specific time. Survival rates at different times can be plotted against firm duration, resulting in *KM curves*.

### 3.3 The Cox proportional hazards model

The Cox proportional hazards model assumes that a firm's hazard rate at time $t$ has a non-parametric baseline hazard $h_0(t)$ that is dependent on $t$, and a parametric part (with $\beta$s) that reflects the impact of firm and market variables on the hazard rate. Together, this model is represented by the following: $h(t, \boldsymbol{x}, \boldsymbol{\beta}) = \boldsymbol{h_0}(\boldsymbol{t}) \exp(\boldsymbol{\beta}'\mathbf{x})$. The independent variables $x$ change over time and also differ across firms. Based on the hazard function, the *cumulative baseline hazard function* [35] is $H_0(t) = \int_0^t h_0(y)dy$. The *partial likelihood function* is $PL(\boldsymbol{\beta}) = \prod_{i=1}^{I} \left[ \frac{\exp(\boldsymbol{\beta}' \boldsymbol{x}_{i,t(i)})}{\sum_{j \in R(t(i))} \exp(\boldsymbol{\beta}' \boldsymbol{x}_{j,t(i)})} \right]^{c_i}$, where $I$ represents the sample size and each firm is denoted by $i$ [25]. The notation $t(i)$ refers to firm $i$'s duration up to its exit. $R(t(i))$ is the *risk set*, the set of firms that are at risk of failing at $t(i)$, when we observe firm $i$'s exit. $R(t(i))$ includes all firms with durations equal to or longer than firm $i$'s duration. The vector of independent variables for firm $i$ at the time of its exit is $\boldsymbol{x_{i,t(i)}}$, and the vector of time-varying covariates for firm $j$ that is at risk of exit is $\boldsymbol{x_{j,t(i)}}$. The variable $c_i$ is a censoring indicator, with the value 0 if the observation $i$ is censored, and 1 otherwise. When we calculate the ratio of firm $i$'s hazard rate over the sum of the hazard rates of all firms in the risk set, the baseline hazard cancels out.[9]

[9] There is no need for an intercept because the baseline hazard absorbs all the variations in the hazard rate that are the same for all firms at the same age. The *PL* function we present assumes no *tied durations*. That is, no two firms exited at the same duration after IPO. Adjustments to the *PL* function can be made to account for the conjoint probability of observing two or more events at the same duration. Our empirical results reflect this adjustment.

## 4 Sample, variables, and econometric models

We next explain our data collection procedure and the unique qualities of our data set for this kind of research. We also provide descriptive statistics on our sample. We then discuss the definitions of our model variables in order to reveal to the reader the variety of choices we faced to effectively specify an empirical model. We further discuss some of the estimation issues that arise as a result of our instantiation of the variables. Finally, we present the econometric models we use to estimate the parameters, and discuss the reasons why we believe they will be able to effectively capture the theorized effects that we wish to explore.

### 4.1 Sample

We define an Internet firm in parallel with Barua et al. [10]: a *dotcom firm* generates all of its revenues though the Internet. They set the cutoff point at 95% of revenues, recognizing that Internet firms receive revenues though traditional channels such as phone or fax. We use 90% as the cutoff and include well-known public Internet firms.[10] Our data cover the second quarter of 1996 to the second quarter of 2006; financial data for private firms were unavailable during this period. We also eliminated firms that went public as traditional firms and later became Internet firms. Their success ought to be explained somewhat differently than for firms founded as Internet firms, and modeled somewhat differently as a result too. Our data come from multiple sources: COMPUSTAT, Mergent Online, corporate filings with the SEC, and the EDGAR Online IPO Express database. We eliminated firms with revenues allocated between the channels, when information on relative portions was missing. Our final main sample consists of 130 publicly traded Internet firms. We coded the independent variables based on these companies' business descriptions. We report our sample descriptive statistics for the numbers of IPOs, bankruptcies, mergers, acquisitions, and the total firms in Table 1.

### 4.2 Variables

We analyze two sets of models that provide triangulating evidence for the various hypotheses that we wish to test. Table 2 summarizes the variables.

[10] We admitted Barua et al.'s [8, 9] Layers 3 and 4 firms in our sample. *Layer 3 firms* are e-intermediaries that provide e-markets to facilitate buyers and sellers to meet and conduct transactions. *Layer 4 firms* are e-commerce firms that engage in online selling of products or services. See Appendix 1 for a list of firms in our data set.

**Table 1** Summary statistics for IPO and exit years

| Year | No. of IPOs | No. of bankruptcies | No. of mergers | No. of acquisitions | No. of firms |
|---|---|---|---|---|---|
| 1996 | 6 | 0 | 0 | 0 | 6 |
| 1997 | 10 | 0 | 0 | 0 | 16 |
| 1998 | 10 | 0 | 0 | 0 | 26 |
| 1999 | 62 | 0 | 4 | 2 | 82 |
| 2000 | 23 | 3 | 6 | 5 | 91 |
| 2001 | 0 | 7 | 8 | 16 | 60 |
| 2002 | 1 | 7 | 4 | 3 | 47 |
| 2003 | 3 | 6 | 3 | 1 | 40 |
| 2004 | 10 | 0 | 4 | 2 | 44 |
| 2005 | 5 | 2 | 0 | 3 | 44 |
| 2006 | – | 0 | 2 | 0 | 42 |
| Total | 130 | 25 | 31 | 32 | – |

**Table 2** Definitions of model variables

| Variable | Definition |
|---|---|
| Dependent variables | |
| Status | Model 1 (bankruptcy/liquidation): 1 if bankrupt/filed bankruptcy protection/liquidated/ terminated Internet-related business, else 0 |
| | Model 2 (failure): 1 if bankrupt/ filed bankruptcy protection/liquidated/ terminated Internet-related business, or M&A preceded by declining sales; else 0 |
| Duration | Number quarters from IPO to bankruptcy or bankruptcy protection filing, liquidation, termination of Internet-related business, M&A, or study period end, whichever is sooner |
| Independent variables—main effects | |
| InteractionPlatform | 1 if the firm's business model is mainly to serve as a platform that connects individuals to one another for interaction and transactions, and consumers and businesses for B2C and B2B interactions and transactions with each other; and 0 otherwise |
| NewNetBusMod | 1 if the firm's business model is new based on what the technological innovations associated with the Internet make possible; 0 otherwise |
| DigitalGoods | 3 if the firm provides digital products or services; 2 if the firm sells non-perishable physical products; 1 if the firm sells perishable physical products |
| TransBrokerBusMod | 1 if the firm's business model is as a transaction broker; 0 otherwise |
| AdvtBusMod | 1 if the firm's majority of revenues are from advertising; 0 otherwise |
| Independent variables—controls | |
| Competition | Number of competing public Internet firms |
| FinCapital | The firm's financial capital in millions of inflation-adjusted 1982 dollars |
| ln(Employee) | The natural logarithm of the number of employees |
| ln(NASDAQ) | The natural logarithm of the NASDAQ composite index |

*Note*: There are no cases in which the value of *DigitalGoods* is equal to 0

#### *4.2.1 Dependent variables*

There are two dependent variables in our model. *Duration* is defined the same in the two sets of models as the number of quarters elapsed from the time an Internet firm issued an IPO until the time of its bankruptcy or bankruptcy protection filing, liquidation, the termination of the Internet-related business, merger, acquisition, or the end of the study period, if the firm was still operating. *Status* is a binary censoring indicator and is defined differently in each model. In the first model, we examine the impact of our explanatory variables on bankruptcies and liquidations. The binary indicator, *Status*, is 1 if a firm went bankrupt, filed for bankruptcy protection, was liquidated, or terminated its Internet-related business, and 0 otherwise. Some firms in our data set experienced mergers and acquisitions (M&As). Although bankruptcies and liquidations generally can be viewed as failures, M&As are sometimes the

desirable strategic choice of a firm's management. Hence M&As cannot all be treated as failures. In model 2, we examine the different causes of M&As and view declining sales prior to a merger or an acquisition as an indictor of failure, and treat the others as survival cases. In this model, the binary indicator, *Status*, is 1 if a firm went bankrupt, filed for bankruptcy protection, was liquidated, terminated its Internet-related business, or had a merger or acquisition preceded by a 20% or more sales decline compared to the same quarter a year earlier, and otherwise 0.

#### 4.2.2 Independent variables

Based on our hypotheses, we have five independent variables: *InteractionPlatform*, *NewNetBusMod*, *DigitalGoods*, *TransBrokerBusMod*, and *AdvtBusMod*. *InteractionPlatform* is 1 if an Internet firm's business model mainly aims at connecting individuals and businesses so as to allow them to interact with each other. Online auction sites, online communities, B2B marketplaces, and online career Web sites are examples; otherwise *InteractionPlatform* is 0. *NewNetBusMod* is 1 if an Internet firm employs a new business model which exists only on the Internet; otherwise *NewNetBusMod* is 0. Examples are search engines, online portals, and Internet domain registrars. *DigitalGoods* is an ordinal variable which measures the degree to which an Internet firm's products and services are suitable for Internet-based selling, using three categories.[11] *TransBrokerBusMod* is 1 if a company employs the transaction broker business model, and 0 otherwise. Examples include online travel agencies, stock brokerage firms, insurance agencies, medical claim processing firms, etc. Finally, *AdvtBusMod* is 1 if the majority of a firm's revenue is from advertising on its Web site, and 0 otherwise.[12]

#### 4.2.3 Control variables

Previous research on business survival suggests that factors such as competition, firm size, financial capital, and the condition of the market and economy are important determinants of survival [5, 23, 24, 31]. We include them as control variables in our models, for this reason. Based on the business descriptions of our sample Internet firms, we identified 35 different market sectors in which they operated and measure competition based on the number of publicly traded Internet firms in the same sector. We do not use the number of business establishments by the *North American Industry Classification System* (NAICS) because this does not accurately capture the extent of competition in the digital marketplace. For example, different Internet firms such as online portals, online auction houses, content sites, and online career sites are all categorized as "computer programming and data processing firms" (NAICS 518111).[13] We control for firm size measured by ln(*Employee*), the natural logarithm of the number of firm employees. *FinCapital* representing the firm's financial capital is measured as the firm's assets minus its liabilities in millions of U.S. dollars. We adjusted *FinCapital* to 1982 dollars using the Producer Price Index. To control for financial market conditions, we also include the natural logarithm of the NASDAQ composite index, ln(*NASDAQ*), as a control variable in the analysis of our empirical models.

### 4.3 Estimation forms of the empirical models

One important assumption of the Cox regression is that as the covariates change, their impacts on the hazard rate change proportionally. Testing using scaled Schoenfeld residuals [21] suggested that *InteractionPlatform* and ln(*Employee*) violate this assumption at the .05 level. So we added the interaction terms between each variable and the natural logarithm of time $t$ to examine how the impact of these variables change as a firm matures.[14] We use fixed values for our five explanatory variables to predict Internet firm survival. We analyze the process by which the independent variables vary across firms over time and how that affects survivability.

Based on the above definitions of our model variables and after applying appropriate lags for the independent and

[11] We assessed a couple of different coding approaches for the underlying construct here. One approach that we evaluated was to use two variables, *PerishableProduct* and *Non-PerishableProduct*. The variables represent *perishable physical products* (1,0) and *non-perishable physical products* (0,1) as the alternative cases, with digital products as the base case when the variables are (0,0). We settled on coding *DigitalGoods* in continuous categorical form, as follows: 3 if the company provides digital products or services that can be directly presented or downloaded via the Internet; 2 if the company sells non-perishable physical products that have to be physically delivered to the customers; and 1 if the company sells perishable products such as groceries, flowers, and plants that have limited delivery radius or high delivery costs. The results of the models which we present later in the article were essentially the same for both codings, so we chose to present the leanest, one-variable version [28].

[12] The two authors independently coded each Internet firm in our sample for values of the independent variables. We then discussed our differences until we reached consensus. The inter-coder consistencies were 90, 99, 100, and 98% for *InteractionPlatform*, *NewNetBusMod*, *DigitalGoods*, and *TransBrokerBusMod*, respectively.

[13] Many online retailers are categorized as "catalog and mail-order houses" with the exception of Barnes and Noble.com (www.bn.com), which is categorized as a "miscellaneous shopping goods store."

[14] It is standard in survival analysis to add time-dependent variables to correct for violations of the proportionality assumption [3, 4, 13, 29]. This is usually done by adding an interaction term between a variable with time or the logarithm or natural logarithm of time. We chose to do this with the latter specification of the variables.

control variables, the Cox proportional hazards model on the hazard rate of firm $i$ at quarter $t$ after its IPO is:

$$\begin{aligned} h(i,t) = h_0(t)\exp[&\beta_1 InteractionPlatform_i \\ &+ \beta_2 NewNetBusMod_i + \beta_3 DigitalGoods_i \\ &+ \beta_4 TransBrokerBusMod_i \\ &+ \beta_5 AdvtBusModi \\ &+ \beta_6 Competition_{i,t-1} + \beta_7 FinCapital_{i,t-2} \\ &+ \beta_8 \ln(Employee_{i,t-1}) \\ &+ \beta_9 \ln(NASDAQ_{i,t-1}) \\ &+ \beta_{10} InteractionPlatform_i \cdot \ln(Time) \\ &+ \beta_{11} \ln(Employee_{i,t-1}) \cdot \ln(Time)] \end{aligned} \quad (1)$$

Note that we use one-quarter-lagged data for ln(*Employee*) and ln(*NASDAQ*). We use two-quarter-lagged *FinCapital*, however, because financial data for the quarter immediately before firm bankruptcy or liquidation are usually not available.

In addition to performing an age-based analysis where we compare Internet firm survival based on firm age since IPO, we also perform a calendar time-based analysis following Honjo [24]. Calendar time-based analysis allows us to examine the impacts of our explanatory variables on firm survival based on calendar time and eliminate the confounding impact of temporal market effects. This is especially helpful since our sample Internet firms went through a unique period characterized first by market hype and then by a sharp downturn in their prospects. We are also able to cross-check our results from the age-based and calendar time-based analyses. In the calendar time-based analysis, we omit the variable ln(*NASDAQ*) since the NASDAQ composite index is always the same in the same quarter. We add two new variables, *AgeSinceIPO* and $(AgeSinceIPO)^2$, to control for the impact of firm age on survival.

$$\begin{aligned} \tilde{h}(t,i) = \tilde{h}_0(t)\exp[&\tilde{\beta}_1 InteractionPlatform_i \\ &+ \tilde{\beta}_2 NewNetBusMod_i + \tilde{\beta}_3 DigitalGoods_i \\ &+ \tilde{\beta}_4 TransBrokerBusMod_i \\ &+ \tilde{\beta}_5 AdvtBusMod_i + \tilde{\beta}_6 Competition_{i,t-1} \\ &+ \tilde{\beta}_7 FinCapital_{i,t-2} + \tilde{\beta}_8 \ln(Employee_{i,t-1}) \\ &+ \tilde{\beta}_{10} InteractionPlatform_i \cdot \ln(Time) \\ &+ \tilde{\beta}_{11} \ln(Employee_{i,t-1}) \cdot \ln(Time) \\ &+ \tilde{\beta}_{12} AgeSinceIPO_{i,t} \\ &+ \tilde{\beta}_{13} (AgeSinceIPO_{i,t})^2] \end{aligned} \quad (2)$$

#### 4.3.1 Econometric issues

We report the descriptive statistics for our variables in Table 3. Table 4 displays appropriately lagged correlation matrix for the variables. Because the number of employees is reported annually, values for ln(*Employee*) are the same for the four quarters in the same year. No two variables have a correlation higher than .60.

#### 4.3.2 Endogeneity

In our empirical models, the independent variables represent choices that most Internet firms in our sample made when they were established. There may be an *endogeneity* issue though: firms with smarter management teams may have chosen to employ business models more suited for the digital channel. As a result, firms that made these decisions are more likely to survive because of their better management. We believe this is not a major concern in our analysis for two reasons. First, firms typically choose their primary market, product and service offerings, and the industry they want to compete in prior to deciding to launch a stock IPO. Our sample began with firms' IPOs, a time by which the firms' product and industry choices should have been established. Second, the market hype for Internet firms with different business models in the late 1990s was equally high as reflected by the press coverage and the amount of funding many Internet firms received. Though many firms failed later, they were perceived as equally innovative and had promising business models at the time of their founding and IPOs.

## 5 Results

We first report our non-parametric survival analysis results. Then we discuss the semiparametric Cox proportional hazards model analysis results.

### 5.1 Results from the KM curve analysis

Non-parametric survival analysis involves plotting KM curves for the sample. Due to space constraints, we only show the KM curves with firm failure as the event. Failure here means a bankruptcy, liquidation, termination of Internet-related business model, or merger or acquisition proceeded by declining sales of 20% or more compared with the same quarter in the prior year. We first report the KM curve for our 130 sample firms, then we compare the KM curves for subgroups of firms based on the five explanatory variables.

The KM curve aggregates all 130 firms in Fig. 1. The curve reveals that the majority of the failures for Internet firms occurred between Quarters (Qtr) 6 and 24 in their lifetimes. The period between Years 1 and 6 after an Internet firm has gone public is critical to its long-term survival. The plateau in the KM curve suggests that no bankruptcy or failure outcomes occurred after Qtr 24. During the first year after its IPO, a firm is able to use the funds it obtained to continue its operations. So we see a low failure rate. Thereafter, however, firms become more

**Table 3** Descriptive statistics (130 firms, 1,641 observations)

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| InteractionPlatform (0/1) | .30 | .46 | 0 | 1 |
| NewNetBusMod (0/1) | .16 | .37 | 0 | 1 |
| DigitalGoods (1/2/3) | 2.79 | .45 | 1 | 3 |
| TransBrokerBusMod (0/1) | .18 | .39 | 0 | 1 |
| AdvtBusMod (0/1) | .30 | .46 | 0 | 1 |
| *Competition* (number of competing firms) | 5.54 | 4.90 | 0 | 21 |
| *FinCapital* (in millions of dollars) | 189.34 | 663.12 | −1,130 | 6,195 |
| ln(Employee) | 5.36 | 1.40 | 0 | 9.44 |
| ln(NASDAQ) | 7.70 | .36 | 7.07 | 8.43 |

**Table 4** Correlation matrix (130 firms, 1,641 observations)

| | Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | InteractionPlatform | 1.00 | 0.24*** | 0.30*** | −0.08*** | 0.15*** | −0.20*** | 0.14*** | 0.17*** | −0.06** |
| 2 | NewNetBusMod | – | 1.00 | 0.20*** | −0.20*** | 0.42*** | 0.01 | 0.15*** | 0.06** | −0.08*** |
| 3 | DigitalGoods | – | – | 1.00 | 0.22*** | 0.31*** | −0.47*** | 0.12*** | −0.12*** | −0.10*** |
| 4 | TransBrokerBusMod | – | – | – | 1.00 | −0.32*** | −0.33*** | 0.06** | 0.09*** | −0.06** |
| 5 | AdvtBusMod | – | – | – | – | 1.00 | 0.04* | 0.06** | −0.03 | −0.01 |
| 6 | Competition | – | – | – | – | – | 1.00 | −0.10*** | 0.02 | 0.32*** |
| 7 | FinCapital | – | – | – | – | – | – | 1.00 | 0.43*** | 0.00 |
| 8 | ln(Employee) | – | – | – | – | – | – | – | 1.00 | −0.01 |
| 9 | ln(NASDAQ) | – | – | – | – | – | – | – | – | 1.00 |

*Note*: The correlations involve appropriately lagged variables

Significance: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

susceptible to negative operational outcomes and market turbulence, which is consistent with the higher failure rate in the KM curve. KM curves also allow us to plot the survival pattern, even though they do not pinpoint the causes of failure. Since most of the Internet firms in our sample issued IPOs in 1999 and 2000, the effect of the high failure rate after Year 1 may be due to the tough market environment that has ensued since March 2000. The higher likelihood of survival after Year 6 suggests that more established public Internet firms may have had more time to build up their resources to buck the Internet firm market decline.

We next plot the KM curves for subgroup comparisons based on our five explanatory variables in Fig. 2a–e. From Fig. 2a, we see that public Internet firms that connected individuals and businesses via the digital channel and served as interaction platforms achieved higher survival rates soon after their IPOs. However, after Year 3, the trend reversed and Internet firms that served as interaction platforms for individuals and businesses started to have a lower survival rate than that of the other group.

One possible explanation is that the market perceived Internet firms which connected individuals and businesses as having business models that were better suited to the digital channel early on, making them more likely to survive right from the start. The installed base of customers was extremely important for these companies, however, and not all were so resistant to failure. As the competition intensified, firms that failed to attract Internet traffic faced increasing survival pressure and had to exit the marketplace.

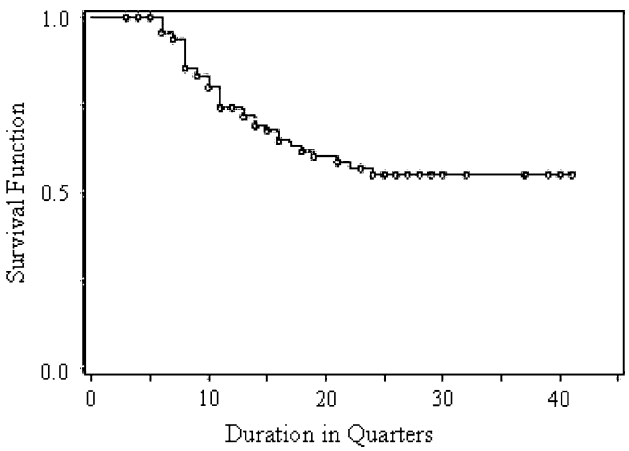


**Fig. 1** The KM curve for our sample of publicly traded Internet firms (130 firms). *Note*: Circles on the curves indicate censored observations. Firm duration begins with the IPO of its stock, which is the start of the stochastic failure process

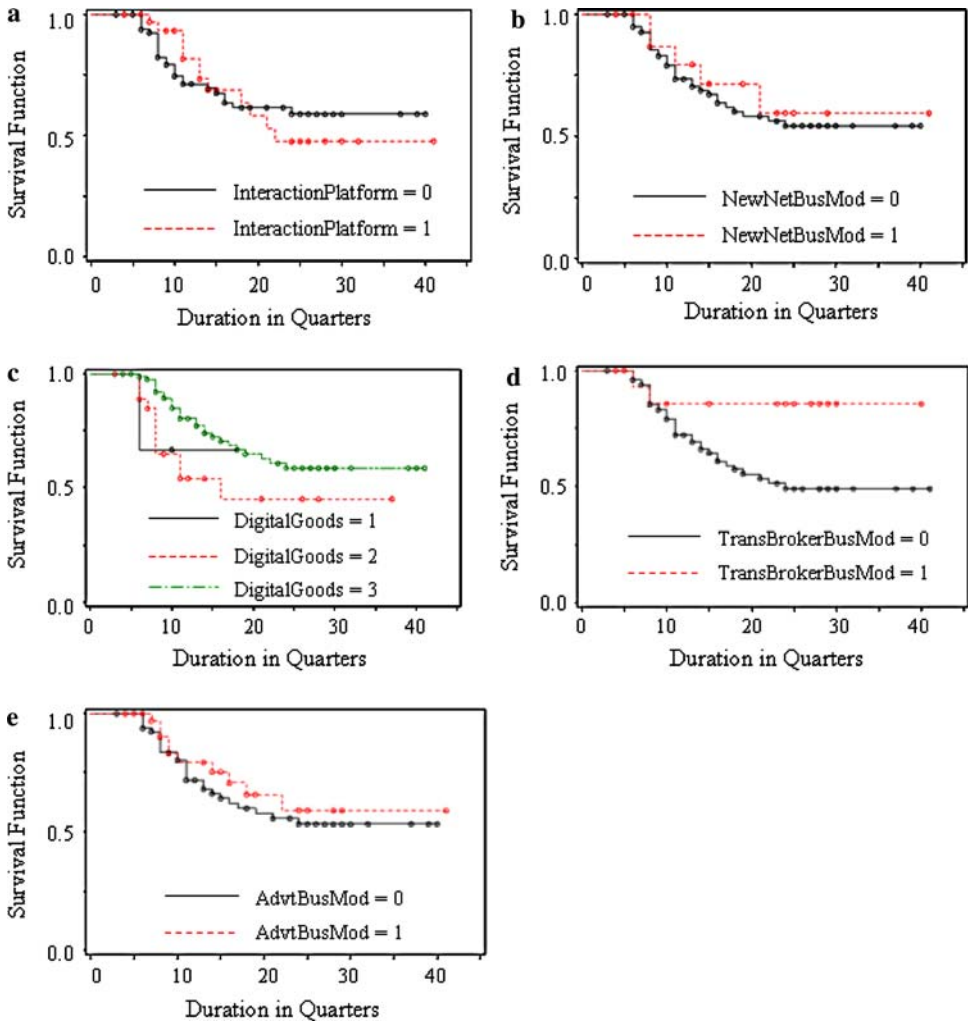


**Fig. 2** (**a**) KM curves for *InteractionPlatform*. (**b**) KM curves for *NewNetBusMod*. (**c**) KM curves for *DigitalGoods*. (**d**) KM curves for *TransBrokerBusMod*. (**e**) KM curves by *AdvtBusMod*

Figure 2b is the KM curve comparison based on whether a public Internet firm used a new business model that emerged due to the Internet. The results show that, overall, our sample of public Internet firms with new business models had higher survival rates than those without, even though the final survival fraction of the former was lower. These results suggest that, possibly due to the better match of the characteristics of their business models with the Internet, firms with new business models had lower survival pressure up to Year 6 after their IPOs. However, since most of these companies are search engines and online portals and there was significant consolidation in these marketplaces as firms grew larger, they experienced a higher likelihood of failure after Year 6.

The KM curves in Fig. 2c for the three subgroups of companies based on the suitability of their products and services for Internet-based selling show that the more well-suited a firm's products are for sale via the digital channel, the higher its survival likelihood. Figure 2d shows that public Internet firms that were transaction brokers enjoyed higher survival rates, possibly due to their lower operational costs and the lower prices they were able to provide to their customers.

Public Internet firms that relied primarily on advertising for their revenues had higher survival rates compared with others, as shown in Fig. 2e. This reveals the advertising industry's recognition of the value of Internet-based advertising.

Even though our KM curve comparisons allow us to visually examine the survival patterns of Internet firms with different characteristics and business models, the results are not conclusive: we are only examining their survival along one single dimension. To address this shortcoming, we next will perform an age-based analysis and a calendar time-based analysis using the Cox proportional hazards model. This will permit us to further investigate how these factors *simultaneously* affect Internet firm survival.

### 5.2 Results from the Cox proportional hazards model

To gauge the impacts of various drivers on firm survival, we now present the age-based results of a Cox proportional

**Table 5** Cox model results for age-based analysis

| Variable | Model 1: bankruptcies and liquidations (25 events) | | Model 2: bankruptcies, liquidations, and M&A's with declining sales (37 events) | |
|---|---|---|---|---|
| | Coeff (SD) | Hazard ratio | Coeff (SD) | Hazard ratio |
| InteractionPlatform ($\beta_1$) | $-13.186^{***}$ (4.777) | 0.000 | $-9.018^{***}$ (3.012) | 0.000 |
| NewNetBusMod ($\beta_2$) | −0.091 (0.674) | 0.913 | −0.383 (0.548) | 0.682 |
| DigitalGoods ($\beta_3$) | 0.193 (0.525) | 1.213 | 0.196 (0.456) | 1.217 |
| TransBrokerBusMod ($\beta_4$) | $-2.191^{**}$ (1.084) | 0.112 | $-1.584^{**}$ (0.783) | 0.205 |
| AdvtBusMod ($\beta_5$) | $-0.969^{*}$ (0.597) | 0.379 | −0.365 (0.435) | 0.694 |
| Competition ($\beta_6$) | 0.031 (0.043) | 1.032 | 0.049 (0.037) | 1.050 |
| FinCapital ($\beta_7$) | −0.002 (0.002) | 0.998 | −0.003 (0.002) | 0.997 |
| ln(Employee) ($\beta_8$) | $4.264^{***}$ (1.355) | 71.124 | $3.652^{***}$ (1.132) | 38.569 |
| ln(NASDAQ) ($\beta_9$) | −0.393 (0.808) | 0.675 | −0.897 (0.690) | 0.408 |
| InteractionPlatform · ln(Time) ($\beta_{10}$) | $5.380^{***}$ (1.826) | 217.057 | $3.884^{***}$ (1.206) | 48.599 |
| ln(Empl) · ln(Time) ($\beta_{11}$) | $-1.786^{***}$ (0.549) | 0.168 | $-1.499^{***}$ (0.456) | 0.223 |
| Likelihood ratio statistic | 36.3, 11 df, $p < 0.01$ | | 35.1, 11 df, $p < 0.01$ | |

*Notes*: Standard deviations in parentheses. Estimation without an intercept, so $\beta_0$ is omitted

Time period covered is second Qtr 1996 to second Qtr 2006

Significance * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

hazard model in Table 5. Here we distinguish between the *hazard ratio* (HR), a statistic that is similar to the marginal effects on failure in the logit model, and the *hazard rate*, the instantaneous failure rate at time $t$ assuming a firm is still at risk up until that time. The HR depicts the marginal impact of a one-unit increase of an explanatory variable on the hazard rate. The HR is written as $\exp(\beta_i)$, where $\beta_i$ is the estimated coefficient for an explanatory variable $x_i$. Overall, our models have likelihood ratio statistics of 36.3 and 35.1, and are both significant at the .01 level.

The results show that the predictors of bankruptcies and failures are similar but not identical. In model 1, significant variables include *InteractionPlatform, TransBrokerBusMod, AdvtBusMod, InteractionPlatform* · ln(*Time*), ln(*Employee*), and ln(*Employee*) · ln(*Time*).[15] The coefficient estimate for *InteractionPlatform* is negative and significant with a HR smaller than one ($\beta_1 = -13.186$, $p < .01$, HR = 2e−6). The HR shows that the hazard rate of a public Internet firm that served as interaction platforms for individuals and businesses was only .0002% of that of a firm that did not provide such platforms, *ceteris paribus*. This suggests that the Interaction Platform Hypothesis ($H_1$) is supported. In addition, the interaction term between *InteractionPlatform* and the natural logarithm of time $t$ is also significant with a positive parameter and a larger than one HR ($\beta_{10} = 5.380$, $p < .01$, HR = 217.057). These results suggest that as our sample Internet firms matured and the stronger ones were left after the weaker ones either went bankrupt or liquidated, the impact of *InteractionPlatform* on survival diminished.

The parameter estimate for *TransBrokerBusMod* is significant and negative with a smaller than one HR ($\beta_4 = -2.191$, $p < .05$, HR = .112). The HR statistic indicates that the hazard rate of a public Internet firm that was a transaction broker was 11.2% of that of another firm. Thus, the Transaction Broker Hypothesis ($H_4$) also is supported. *AdvtBusMod* is weakly significant with a negative parameter estimate and a smaller than one HR ($\beta_5 = -.969$, $p < .10$, HR = .379). These results suggest that, for public Internet firms that relied mainly on advertising as their source of revenues, their hazard rate of going bankrupt or being liquidated was only 37.9% of other firms that had other primary revenue streams. Thus, we see that the Advertising as Main-Source-of-Revenue Hypothesis ($H_5$) is supported too.

ln(*Employee*) has a positive and significant parameter estimate with a larger than one HR in model 1 ($\beta_8 = 4.264$, $p < .01$, HR = 71.124). The HR suggests that when the natural logarithm of a public Internet firm's number of employees increased by one, its hazard

[15] We observed large coefficient estimates for a few of our variables, including *InteractionPlatform*, ln(*Employee*), and *InteractionPlatform*·ln(*Time*). This was mainly due to the inclusion of *InteractionPlatform*, ln(*Employee*), as well as their interaction terms with ln(*Time*) together in the same model. When we only included *InteractionPlatform* and ln(*Employee*) without the interaction terms, the coefficients were much smaller. However, the model violated the proportional hazards assumption. When we added the interaction terms, the coefficients for each variable and its corresponding interaction term with ln(*Time*) had opposite signs and became much larger. This is due to these coefficients picking up changes in the impacts of these variables over time as firms grew.

rate due to bankruptcy or liquidation increased to about 71 times its original value. The interaction term between ln(*Employee*) and ln(*Time*) is significant with a negative parameter estimate and a smaller than one HR ($\beta_{11} = -1.786$, $p < .01$, HR = .168). This reveals that although firm size had a negative impact on survival right after a firm's IPO, this impact diminished over time. No other variable was significant in model 1. We conclude from these findings that the New Internet-Only Business Model Hypothesis ($H_2$) and the Digital Goods Hypothesis ($H_3$) were not supported.

In model 2 where we examine the impact of the explanatory variables on firm failure, the significant variables are *InteractionPlatform, TransBrokerBusMod*, ln(*Employee*), *InteractionPlatform* · ln(*Time*), and ln(*Employee*) · ln(*Time*). The signs of *InteractionPlatform* and *InteractionPlatform* · ln(*Time*) in model 2 are similar to those in model 1, indicating that our sample public Internet firms that served as interaction platforms for individuals and businesses online and allowed them to interact with each other enjoyed lower hazard rates of failure, even though the difference diminished over time as firms matured. Again, we see evidence that the Interaction Platform Hypothesis ($H_1$) should be accepted. *TransBrokerBusMod* had a negative parameter estimate and smaller than one HR, indicating that Internet firms in our sample that were transaction brokers experienced a lower likelihood of failure compared with other firms. Thus, we assert that the Transaction Broker Hypothesis ($H_4$) also is supported in this instance. Similar to the results in Model 1, ln(*Employee*) and ln(*Employee*) · ln(*Time*) were both significant with positive and negative signs, respectively. Hence, our sample of public Internet firms first experienced decreased likelihood of survival as their sizes increased, but then as they grew and competition intensified, the larger ones started to gain survival advantage. No other variables are significant though. From this, we conclude that the New Internet-Only Business Model Hypothesis ($H_2$), the Digital Goods Hypothesis ($H_3$), and the Advertising as Main-Source-of-Revenue Hypothesis ($H_5$) do not appear to be supported for the data set that we evaluated related to the prediction of Internet failures.

We summarize our hypothesis testing results in Table 6. The Interaction Platform Hypothesis ($H_1$) and the Transaction Broker Hypothesis ($H_4$) were supported by results from both models, while the Advertising as Main-Source-of-Revenue was only partially supported in the prediction of bankruptcies and liquidations. These results suggest that although Internet firms which relied primarily on advertising as their revenue source experienced a lower probability of bankruptcy and liquidation during our sample period, they were equally likely to fail compared with other firms, when the possibility of an M&A due to declining sales is also taken into consideration. The New Internet-Only Business Model Hypothesis ($H_2$) and Digital Goods Hypothesis ($H_3$) were not supported by the results from either of our models though, indicating that these factors were not important dimensions affecting public Internet firm survival.

Because of the dramatic change in market conditions during our sample period, it is possible that ln(*NASDAQ*) itself is not able to completely capture the impact of the market and the macroeconomy. To explore this, we performed a calendar time-based semiparametric survival analysis. We compared Internet firm hazard rates during the same calendar quarter. This approach allowed us to tease out the impacts of the macroeconomic environment and investor psychology during different periods, and permitted us to focus on the firm and e-commerce related drivers of survival. We eliminated ln(*NASDAQ*) since there was no variation in this time-specific variable across firms in the same calendar quarter. We also added *AgeSinceIPO* and $AgeSinceIPO^2$ to capture their separate effects on survival. We obtained similar results to the age-based survival analysis in terms of both the parameter estimates and their significance levels for *InteractionPlatform*, *TransBrokerBusMod*, *AdvtBusMod*, ln(*Employee*), and the interaction terms between *InteractionPlatform* and ln(*Employee*) with ln(*Time*). These results strengthen the support that is provided by our Internet firm age-based analysis.[16]

## 6 Discussion

Our analysis of the drivers of Internet firm survival has five major findings. First, the plateaus in the KM curves give a visual representation of the survival patterns and show that after surviving the initial competition, an Internet firm faced a reduced risk of failure. This selection process started one year after IPO issuance and continued for another five years. Second, our age- and calendar time-based Cox proportional hazards model results are consistent and suggest that the suitability of the characteristics of an Internet firm's business model for the digital channel does indeed affect survival. The important dimensions include whether a company: (1) is able to take advantage of the global interactivity the Internet offers to serve as

[16] *AgeSinceIPO* was significant with positive parameter estimates and greater than one HRs in both models. $AgeSinceIPO^2$ was significant with a negative parameter estimate and smaller than one HR in both models. These results suggest that our sample Internet firms' likelihood due to failure first increased with age, then it decreased as the weaker ones exited the market and the more successful ones were left.

**Table 6** Hypothesis testing results

| Hypothesis | Model 1: bankruptcies and liquidations | Model 2: bankruptcies, liquidations, and M&A's with declining sales | Supported (Yes/No) |
|---|---|---|---|
| $H_1$: The Interaction Platform Hypothesis | − | − | Yes |
| $H_2$: The New Internet-Only Business Model Hypothesis | Not significant | Not significant | No |
| $H_3$: The Digital Goods Hypothesis | Not significant | Not significant | No |
| $H_4$: The Transaction Broker Hypothesis | − | − | Yes |
| $H_5$: The Advertising as Main-Source-of-Revenue Hypothesis | − | Not significant | Partially |

*Note*: Minus signs represent the marginal effects of the variables on the hazard rate

interaction platforms for individuals and businesses; (2) facilitates online transactions; and (3) relies on advertising as the primary source of revenue.

No other medium can match the Internet's capabilities in connecting millions of individuals and businesses across the world and allowing them to provide user-generated content and interact with each other. When an Internet firm takes advantage of the opportunity to serve as an interaction platform, it is well suited to the digital channel and benefits from a higher likelihood of survival early on. As the installed base of customers is extremely important for these companies, however, the competition among them intensifies quickly. As a result, the firms face increasingly higher pressure for survival in the midst of market consolidation.

Another finding is that Internet companies which act as transaction brokers were less likely to go bankrupt or be liquidated. The digital channel allows customers to serve themselves and enable businesses to automate and digitize many of their business processes. This leads to increased customer satisfaction and loyalty, as well as reduced operational costs for the companies. Interestingly, our results show that Internet firms which relied primarily on advertising as their revenue source were less likely to go bankrupt or be liquidated. As we mentioned earlier, the Internet is an attractive advertising medium due to the ease of implementing customized and targeted advertising. On the other hand, Internet firms primarily relying on advertising as their revenues have been vulnerable to fluctuations in corporate advertising expenditures. Our results nevertheless show that the benefits of online advertising are valuable.

Third, our results also revealed the dynamics of how the impact on firm survival of serving as an interaction platform and firm size changed over time as an Internet firm matured. There are three possible explanations for the diminishing impact of these variables. First, as an Internet firm grew and matured, it was more likely to withstand the survival pressure coming from factors such as less-than-best match with the digital channel and tough market conditions. Second, as the weaker Internet firms went bankrupt or failed, only the more successful ones were left. These stronger firms were able to cope better with the disadvantageous position of operating in competitive markets or tough financial market conditions. Third, as the Internet sector grew, firms may have started to compete among themselves based on size, resulting in the diminished impact of factors such as whether a firm offered an Internet-based interaction platform.

Our research also contributes to the organizational ecology and evolution literature in identifying aspects of an Internet firm's business model's match with the digital channel that affects survival. These include taking advantage of the capabilities that the Internet offers as an interaction platform for individuals and businesses, and being a transaction broker to reduce transaction costs in the digital channel. Examples of the first include online auctions that connect buyers and sellers and online communities that allow people from around the world to share their opinions and interests with each other. Examples of transaction brokers include online travel agencies and security brokerage firms. In addition, the organizational ecology and evolution literature also point out directions of future research. For example, the organizational evolution literature examines the variation, selection, and retention cycle firms go through. Future research can examine how Internet business models evolve over time through this cycle and reveal the dynamics in the process that has led to the observed successes and failures.

## 7 Conclusion

We developed and tested an empirical model of Internet firm duration to extend our knowledge of IT firm

performance and survival. By identifying unique characteristics of the digital channel, we were able to examine how the extent to which the related characteristics of an Internet firm's business model were well suited to the Internet, and affected its survival. We performed nonparametric and semiparametric survival analyses on a sample of public Internet firms. Our most interesting results suggest that Internet firms that served as interaction platforms for individuals and businesses, facilitated online transactions, and relied on advertising as the primary revenue source were more likely to survive. Large firm size, we found, was also associated with a higher likelihood of bankruptcy or liquidation among Internet firms. Our results also reveal the dynamics of the impacts of firm size and being an interaction platform, and that an Internet firm's survival was less affected by these factors as the business grew and matured.

Our research has some limitations. First, Internet firms are relatively young, so our results may not characterize the ways they survive or fail once they mature (e.g., 15–20 years from their establishment). Our sample period from early 1996 to early 2006 was a time that was characterized by some "irrational exuberance," as past U.S. Federal Reserve Bank chairman, Alan Greenspan, has noted. This restricts the generalizability of our results. Still, this study increases our understanding of the turbulent digital marketplace. Managers can learn about the drivers for survival, and address the most crucial ones to maintain a healthy Internet business. Although the impact of factors such as the NASDAQ Composite Index may be affected by the unique quality of the market during this period, other variables (e.g., a firm's capacity to provide an Internet-based interaction platform, business model unique to the Internet, and being a transaction broker) are likely to be important at other times too.

Second, our results may not generalize to private Internet firms. Most private dotcoms are still in their early stages of development and have been less successful. They more often incurred high setup costs and had to work to establish steady revenue streams. During the Internet boom, venture capital backing was the most important factor influencing their survival. Thus, systematic differences between private and public Internet firms may be present, but our results nevertheless suggest that there are business model characteristics affecting survival which should still apply to private firms.

Third, due to our limited sample size or unavailable data, we were not able to include all of the variables that might affect survival. PLC theory suggests that a firm's efficiency relative to the industry's *minimum efficient scale* size affects its survival [1]. We were unable to obtain scale size data, which do not yet exist for Internet firms. Another consideration is *business model quality* [27]. The e-grocer, Webvan, used an unsuccessful business model, which spotlighted its leaders' apparent poor business vision and faulty management practices. These played important roles in its demise. The quality of the senior management team should be explored in future research, along with these other considerations.

We hinted earlier that another limitation may arise in the context of our econometric estimation of Internet firm survival due to *endogeneity* [30]. Endogenous variables "have outcome values determined through joint interaction with other variables in the system ... [and] affect the outcomes of the exogenous variables" [26, p. 564]. The choices that management makes (e.g., business model, product and focal industry to enter, etc.) are likely to be jointly determined with the dependent variable, the likelihood of survival for the firm. Rational senior managers will deploy technology to enter the most attractive market environments with products and services that are likely to sell, based on their research. This kind of problem arises in many technology investment settings [19]. So we caution the reader to interpret our results within the bounds of this additional consideration.

Future research also should examine Internet firm survival using a larger sample size. Even though it is difficult to obtain financial information about private firms, researchers can perform small-scale analysis of the performance of private Internet firms and then compare them with public firms, and, in that way, shed more light on the differences between them relative to survival.

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## Appendix

Firms in Our Data Set

| Company name | Business description | Company name | Business description |
|---|---|---|---|
| About.com | Internet portal | El Sitio | Internet portal |
| Amazon.com | Online retailer | E-Loan | Online loan broker |
| AmeriTrade Holding Corp. | Online stock brokerage | Emerge Interactive | Online B2B marketplace |
| Answers Corp. | Content site | Emusic.com | Digital music/audio content |
| Aptimus | Online direct marketer | eToys | Online retailer |
| Arbinet Thexchange Inc. | Online B2B marketplace | Excite | Internet portal |
| ARTISTdirect | Content site | Expedia | Online travel agency |
| Ashford.com | Online retailer | FactSet Research Systems | Online informediary |
| Audible | Digital music/audio content | Fashionmall.com | Internet portal |
| Audiohighway.com | Digital music/audio content | Fogdog | Online retailer |
| Autobytel | Online auto buying services | FreeMarkets | Online B2B marketplace |
| Autoweb.com | Online auto buying services | Garden.com | Online retailer |
| Babyuniverse, Inc. | Online retailer | GeoCities | Web hosting services |
| Baidu.com, Inc. | Internet search engine | GetThere.com | Online travel agency |
| BN.com | Online retailer | GlobalNet Financial.com | Content site |
| Beyond.com Corp. | Online retailer | Go2Net | Internet portal |
| BigStar Entertainment | Online retailer | Google, Inc. | Internet search engine |
| Bofi Holding, Inc. | Online bank | Headhunter.net | Online recruiting site |
| Blue Nile, Inc. | Online retailer | HomeGrocer.com | Online grocer |
| Broadcast.com | Internet broadcasting/radio | HomeStore.com | Online informediary |
| Buy.com | Online retailer | HotJobs.com | Online recruiting site |
| CareerBuilder | Online recruiting site | Housevalues, Inc. | Online informediary |
| CDnow (New) | Online retailer | IasiaWorks | ISP and web hosting service provider |
| Claimsnet.com | Online healthcare ASP | IGN Entertainment | Internet portal |
| Comtex News Network | Online informediary | ImproveNet | Online home improvement e-market |
| CoolSavings | Online direct marketer | Infoseek Corp. | Internet portal |
| Crosswalk.com | Internet portal | Inphonic, Inc. | Online retailer |
| Cybergold | Online direct marketer | InsWeb Corp. | Online insurance agency |
| Cyberian Outpost | Online retailer | INT Media Group | Content site |
| Dice (Earthweb) | Online recruiting site | iPrint Technologies | Online retailer |
| DrKoop.com | Content site | Launch Media | Content site |
| Drugstore.com | Online retailer | LendingTree | Online loan broker |
| E*Trade Group | Online stock brokerage | LifeMinders | Online direct marketer |
| eBay | Online auction house | Liquid Audio | Digital music delivery tech. provider |
| eChapman | Internet portal | LiveWorld | Online community service provider |
| eCost.com, Inc. | Online retailer | Lycos | Internet portal |
| EDGAR Online | Online corporate filings | MarketWatch.com | Content site |
| Egreetings Network | Online greeting cards | McAfee.com Corp. | Consumer software ASP |
| Mediconsult.com | Content site | Quotesmith.com | Online insurance agency |
| Medscape | Content site | Redenvelope, Inc. | Online retailer |
| Mortgage.com | Online loan broker | Register.com | Internet domain name registration |
| MotherNature.com | Online retailer | Salon Media Group | Content site |
| MP3.com | Digital music/audio content | Shanda Interactive Entertainment, Ltd. | Online entertainment, games, wagering |
| Multex.com | Content site | Shopping.com, Ltd | Online informediary |
| MyPoints.com | Online direct marketer | SmarterKids.com | Online retailer |
| N2K | Online retailer | Sohu.com | Internet portal |

**Appendix** continued

| Company name | Business description | Company name | Business description |
|---|---|---|---|
| NetCreations | Online direct marketer | SportsLine.com | Content site |
| Netease.com | Internet portal | Stamps.com | Online retailer |
| NetRadio Corp. | Internet broadcasting/radio | Streamline.com | Online grocer |
| Nimbus | Online retailer | Switchboard | Online yellow pages |
| Odimo, Inc. | Online retailer | Telocity | Internet service provider |
| Onvia.com | Online B2B marketplace | TradeStation Group | Online stock brokerage |
| Orbitz, Inc. | Online travel agency | uBid | Online auction house |
| Overture Services | Online direct marketer | Uproar | Online entertainment, games, wagering |
| PartsBase | Online B2B marketplace | Value America | Online retailer |
| Paypal | Online P2P payment | Varsitybooks.com | Online retailer |
| Peapod | Online grocer | Vistaprint, Ltd | Online retailer |
| Planetout, Inc. | Virtual community | VitaminShoppe.com | Online retailer |
| PlanetRx.com | Online retailer | Web Street | Online stock brokerage |
| Preview Travel | Online travel agency | WebMD Corp./Healtheon | Online healthcare transaction ASP |
| Priceline.com | Online travel agency | Webvan Group | Online grocer |
| Provide Commerce, Inc. | Online retailer | Women.com Networks | Content site |
| PurchasePro.com | Online B2B marketplace | WorldQuest Networks | Internet telephony |
| Quepasa.com | Internet portal | Yahoo! | Internet portal |
| Quokka Sports | Content site | Youbet.com | Online entertainment, games, wagering |

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