A Glimpse at Persistence without Liquidity Events: Asymmetric Effects on Success and Failure

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Performance and its antecedents comprise the overwhelming part of the literature in the study of strategy and organization in general, and entrepreneurship and start-ups in particular. Insights and conceptual refinement regarding this relationship very much hinge on a careful and informed view of performance, yet an ongoing state of unsatisfactory treatment of performance continues. It is either conceived in output terms –ranging from accounting proxies such as EBITA or efficiency to idiosyncratic indicators such as innovation output, new product introduction, employee retention or market share. In the ecological and entrepreneurship literature where such archival information is missing or inaccessible, researchers often resort to a binary state of success or failure. Startups are typically firms whose performance cannot be traced due to their age and their status as private corporations leading researchers to contend with the categories of success and failure with an extensive battery of logistic regression tools to match as revealed by recent papers ([Audretsch, 1991](#_ENREF_16" \o "Audretsch, 1991 #682); [Brüderl et al., 1992](#_ENREF_50); [Brüderl & Schüssler, 1990](#_ENREF_49); [Carroll et al., 1996](#_ENREF_55); [Delacroix & Carroll, 1983](#_ENREF_71); [Delmar & Shane, 2003](#_ENREF_72); [Dowell & Swaminathan, 2006](#_ENREF_78); [Nerkar & Shane, 2003](#_ENREF_174)).

These studies, grounded primarily in the population ecology tradition, invariably define start-up failure as exit from the industry either due to dissolution or acquisition. Survival, the negation of failure, is assumed to proxy success in these studies as the liabilities of newness are severe ([Stinchcombe, 1965](#_ENREF_223)).

In contrast to studies implying success as the opposite of exit, some contributions in the entrepreneurship literature have gone a step further and proposed additional success criteria, including IPO ([Beckman, Burton, & O'Reilly, 2007](#_ENREF_35); [Giot & Schwienbacher, 2007](#_ENREF_96); [Megginson & Weiss, 1991](#_ENREF_164); [Stuart et al., 1999](#_ENREF_227)), and high-valuation trade-sale ([Aggarwal, 2009](#_ENREF_6); [Giot & Schwienbacher, 2007](#_ENREF_96); [Gompers & Lerner, 2004](#_ENREF_99)).[[1]](#footnote--1) Just as the population ecology became entrenched in a rigid perspective on “survival and its negation, these studies typically imputed failure as the opposite of successful events.[[2]](#footnote-0)

In this paper, we show that even in the absence of archival data sources, researcher can do better by identifying bands of outcomes that also map variations between success and failure, a transitory state of perennial failing, which define the firms in this zone as “living dead.” We attempt to identify key factors leading up to such a transitory state by thus flagging startup firms as living dead. We do so in the specific context of newly created firms in capital-intensive sectors where the role of VC firms is paramount.

Persistence in the absence of neither success nor failure has received scant attention. To our knowledge, only one study has explicitly analyzed marginally performing new ventures by incorporating survival with different growth levels as key dependent variables ([Gimeno, Folta, Cooper, & Woo, 1997](#_ENREF_95)). It seems conceptually easier to capture events such as bankruptcy than non-events. In addition, a binary framing of outcomes assumes symmetric effects, implying equivalent but opposite in factors and precluding simultaneous identification of successful and failing ventures. We elaborate here on the zone between success defined as achieving an IPO or a trade sale, providing “harvest” to investors) and failure (defined as dissolution due to bankruptcy, voluntary closure or a distressed sale) outcome. Rather, we show asymmetry when isolating performance antecedents thus conceived and moreover, explore their magnitude when accounting for the transitory state between them.

 Asymmetric effects are not uncommon in the social sciences—for example in behavioral economics with divergent concavity of positive and negative utility curves (e.g., Tversky and Kahneman, 1979; Thaler, 1985) and in political science –e.g., discrepant propensities to vote on class and non-class basis ( Lieberson, 1987. In management science Ragin (2008) has proposed that factors affecting an outcome and its negation do not mirror each other. Similarly, Lavie & Rosenkopf ([2006](#_ENREF_150)), reconcile the conflicting effects of the antecedents of exploration and exploitation by separating these activities across domains and by conceptualizing them to be interdependent—arising within a single continuum instead of separate distinct outcomes. This paper follows the example of these studies to construct a more nuanced categorization of entrepreneurial outcomes—comprising success, failure and the continuum of non-events in between, rather than a simple dichotomous framing.

We believe that explaining asymmetric effects of the same factor on success and failure simultaneously is an important contribution of this paper and serves as a useful empirical tool to unearth persistence-unique conditions. We construe persistence whenever a given antecedent precludes the occurrence of any of these two concrete events—an effort without precedent. We do observe either a liquidity event or a more or less formal dissolution of the startup. The complement of these two events is the transitory state that may or may not cease into some distant future through the event of success or failure (see Figure 1). The complement of failure is success or that nonevent, while the complement of success is failure and that non-event. In the language of set theory, some firms present themselves as persistent when compared with firms that do experience an identifiable event, whether failure such as bankruptcy or fire sale or success such as IPO. As they end up in a state of continuous—the last band in Figure 1 If we identify factors that diminishes failure as well as success we might expose persistence, the last possibility.

Figure . Exposing Persistence



We cast our attention on a *signal of quality*—the breadth of a start-ups’ underlying technology as revealed by third-party acknowledgement of the new firm’s patents—because quality revelation is typically equivocal and manifest possible asymmetric effects. —a much discussed issue in the entrepreneurship literature ([Hsu & Ziedonis, 2008](#_ENREF_133); [Stuart et al., 1999](#_ENREF_227)). Quality information becomes disclosed through a variety of means including founders’ background ([e.g. Burton et al., 2002](#_ENREF_52)), endorsements ([Stuart *et al.*, 1999](#_ENREF_227)), ties with high status strategic partners, and granting of patents ([Hsu & Ziedonis, 2008](#_ENREF_133)). We add to this array of possible signals the breadth of a firm’s IPR portfolio,. When other firms (and patent examiners) acknowledge a venture’s prior art as foundation for new inventions, they behave as “audience” (compare Ruef and Patterson, 2009) and close the loop with the transmitter of inventive output.

The width or scope of a startup’s technology (referred to as technology breadth) through the acknowledgement by other firms and individuals whose patents become classified into assigned domains. When that feedback from others shows dispersion by their patents’ association with different rather than similar classes, breadth is inferred. Forward citations received by a firm are commonly interpreted as a measure of its R&D quality[[3]](#footnote-1)—the more acknowledgements received , the higher its impact and derivatively the better its quality ([Hall et al., 2001](#_ENREF_110); [Hall & Trajtenberg, 2004](#_ENREF_112)). When acknowledgements involve a wide range of domains the firm can be presumed to have breadth. Note, however, that engagement into multiple technology domains resides not only in the purview of the start-up but in the typecasting by others as well. The typecasting is performed by either peer firms, which might compete head-on with the startup, or by patent examiners who conclude that a startup’s forward citations constitute inventions that define the focal venture’s patent as relevant “prior art”. Paradoxically, breadth as signal is a two-sided sword. .

On the one hand, the coverage of a wider range of technology domains offers more choices, a greater odd of lucrative applications. On the other hand, the firm dilutes its knowledge and capabilities over a greater array and will underperform compared with a competitor, which resides only on any one of the domains (compare Zuckerman, 2003; Ruef and Patterson, 2009). Such dilutive effects will render the startup vulnerable. If the startup cannot capitalize on the opportunities offered it might arrive a state of permanent failure rather than dissolution since unrealized potential opportunities motivate and sustain ongoing efforts at commercialization.

Apart from the mixed benefits of greater breadth in possible technology applications, the implied acknowledgment or external feedback might become truly daunting for a startup if that feedback grows into a swell. The sheer magnitude of external acknowledgement might further tax the human resources and other assets associated with the multiple options available to a start-up whose resource endowments are typically limited. By contrast, if the range of technology options is narrow, the resource endowments needed for commercialization require diminished scale and actually more viable and lucrative for a startup if its specialized technology is already widely diffused. In short, we argue that a startup’s generalist portfolio, if commonly accredited or widely diffused drives it more likely into a transitional state of permanent failure while specialized firms stand to benefit from receiving wide acclaim

We test our hypotheses on a sample of U.S. VC–funded wireless new ventures founded in the period 1990-2009 that invested in patenting their technologies. To simultaneously model success and failure events we conduct an event history study within a competing risk framework ([Lee & Wang, 2003](#_ENREF_153)). We find evidence of mechanisms that simultaneously improve life chances of some new ventures while impeding the liquidity prospects of others—giving us a glimpse of factors that might lead to ‘living dead’ outcomes, i.e., persistence at the edge of success and failure. High knowledge diffusion of a start-up’s technology when the underlying inventions are diverse is one such mechanism. More such mechanisms are identified and the implications discussed.

Our paper contributes to the literature on entrepreneurial performance, and more generally to the organizations literature, by providing a nuanced description of performance beyond the success-failure dichotomy and represents one of the first efforts that treat success and failure simultaneously. Second, the paper also contributes to the literature on signals of quality by showing how they alleviate the liability of information asymmetry that haunts incumbents in market for lemons. . The technology breadth of a start-up is an important signal for evaluators—it assists resource providers in assessing the nascent company. Lastly, the signal is also beneficial to the focal start-up by helping them realize applications not conceived by them but discovered by others.

A third contribution comprises a different and new contribution to the patent literature. Forward citation flows have been variously conceptualized as measuring knowledge diffusion, endorsement, and competition ([Jaffe et al., 1993](#_ENREF_136); [Podolny & Stuart, 1995](#_ENREF_183); [Podolny et al., 1996](#_ENREF_184)). Certainly the treatment of annual forward citations as a paper trail of knowledge diffusing is not controversial. Yet its frequent interpretation as either deference, endorsement or competition is at best equivocal and requires understanding its differential impact on different outcomes and adequate conditioning factors to tease apart the positive and negative externalities.

In line with our claim regarding asymmetry of performance antecedents, we show forward citations to have uneven effects for positive and negative performance. We find that for success outcomes, the effect of forward citations as direct ties between firms has a net acknowledgement effect (i.e., more of it lead to higher success odds), in line with analogous findings ([Podolny et al., 1996](#_ENREF_184)) that claim such behavior to amount to “deference.”. In contrast, for failure outcomes, the effect on survival is negative, i.e., the more the inventions of the new firm form the basis of other firms’ R&D, the higher its failure rate, indicating a net competitive effect. Thus far research has never shown the harmful effects of forward citations.

**THEORY AND HYPOTHESES**

Our theoretical framework centers on how start-ups evoke expectations regarding their technology platform —technology breadth, as signaled over time through the diversity of the domains in which its inventions constitute building blocks for other inventions. We analyze the possibilities and promise the range of possible applications, as disclosed through the technology breadth signal, holds for both the venture’s prospects as well as the challenges they pose on their road to a liquidity event for investors. We theorize about these effects for both success (defined as either achieving an IPO or a trade sale) and failure (defined as either dissolution or a distressed sale—see Fig 1). Of special interests are mechanisms revealing causal asymmetry, whereby the factors that promote success do not predict failure and vice-versa thus departing from the clean and symmetric dichotomy among these two outcomes and their antecedents. In the following sections we first define what we mean by breadth, explain our motivation to focus on that disclosure of the venture’s portfolio of possible applications, and then develop testable hypotheses.

**Signal of Technology Breadth – Possibilities & Promises**

The quality of nascent ventures is not directly observable and inferences about its ability to create wealth is surrounded by a good deal of uncertainty. A variety of quality signals have been investigated; they include (1) founders’ demographic backgrounds ([Burton *et al.*, 2002](#_ENREF_52); [Eisenhardt & Schoonhoven, 1990](#_ENREF_82)), (2) endorsements by reputable third parties ([Baum et al., 2000a](#_ENREF_25); [Fitza et al., 2009](#_ENREF_85); [Gulati & Higgins, 2003](#_ENREF_107); [Hsu, 2004](#_ENREF_128); [Megginson & Weiss, 1991](#_ENREF_164); [Stuart et al., 1999](#_ENREF_227)), and (3) patents ([Hsu & Ziedonis, 2008](#_ENREF_133)). We propose a fourth and important signal, mostly overlooked by the entrepreneurial literature, the technology breadth as evidenced by diversity of possible applications. Inventions often have more than one (profitable) application and a given application might represent just one way it can be exploited ([Teece, 1982 ; pg 45](#_ENREF_231)). They are often anticipated a priori, but more crucially they might surface through peer inventors that build on the venture’s technologies. As Bassalla ([1988 ; pg 141](#_ENREF_24)) notes, the applications of an invention may not be known to the firm ex ante, and many applications are never revealed:

*‘When an invention is selected for development, we cannot assume that the initial choice is a unique and obvious one dictated by the nature of the artifact. Each invention offers a spectrum of opportunities, only a few of which will ever be developed during its lifetime. The first uses are not always the ones for which the invention will become best known.’*

The implication is that reliance by other organizations in disparate domains through their acknowledgement of the start-up’s invention conveys its basic technology and its potential for further discoveries by outsiders and the new venture alike. Conceptually, each inventions and its breadth constitutes an ongoing stream of information through the start-up and feedback from significant audiences such as competing firms and patent examiners. This interactive network between ventures and their significant audiences defines the scope of its technology domain and the challenges to control and monetize it.

Technologies vary along a continuum of specificity—some are very unique and idiosyncratic, while others display a very wide range of applications. Engineering distinguishes between General Purpose Technology (GPT) and Specific Purpose Technology (SPT), with applications in many versus one or a few domains respectively ([Bresnahan & Trajtenberg, 1995](#_ENREF_47); [Gambardella & Giarratana, 2009](#_ENREF_89); [Hall & Trajtenberg, 2004](#_ENREF_112); [Rosenberg, 1976](#_ENREF_198)). Obviously, these labels are very coarse but convey a sense of the breadth of domains to which a technology might be applicable. The variety of domains to which the inventions of a venture becomes attached through peer acknowledgement provides information on an important aspect of quality—the range and diversity of possible applications. The more heterogeneous the domains from which these acknowledgements emanate, the greater the opportunity set of applications, and by implication the greater the future potential. We next consider the effect of technological breadth on (1) failure and (2) success.

***Effect on Failure (1)***

The generality of a firms’ technology derives from the diversity of domains to which it serves as a foundation for other innovations ([Hall & Trajtenberg, 2004](#_ENREF_112)). A more general technology yield more applications compared to a specialized or narrow range of technology ([Arora et al., 2004](#_ENREF_15); [Bresnahan & Trajtenberg, 1995](#_ENREF_47); [Helpman, 1998](#_ENREF_123)). An oft cited example of technology thriving outside the intended domain of application is Viagra, originally developed for cardiovascular applications, but actually more applicable to treatment of male sexual dysfunctions ([Rosenkopf & Nerkar, 2001](#_ENREF_199)). Similarly, startups with more general technology could thrive or survive through applications outside their originally intended application area.

Possessing a general technology permits the choice from a broader menu of revenue sources or even stumble upon unexpected applications with cash flows to match. For example, Wireless-Fidelity (Wi-Fi) was originally developed as a wireless Ethernet switch to replace wired local area networks (LAN). However, over time the technology has been extended to many other purposes not originally envisioned, ranging from short distance serial cable replacement to multi-media applications in video game consoles, MP3 players, smart phones, printers, digital cameras, and laptops. Other unexpected applications include cellular coverage extender, location services for navigation, the portable Electrocardiograph (ECG) device to monitor heart patients at home, home security systems and baby monitors. Therefore, a start-up commercializing Wi-Fi technology could potentially either find a market that could make them self-sustaining or provide them the opportunity to extend its technological potential by shifting to a different application. For example, Strix Systems, a company founded with the vision of developing Wi-Fi Mesh networking technology for indoor use, first reinvented itself as a provider of outdoor networks in the face of competition from established incumbents, such as Cisco, and the move of municipalities providing free Wi-Fi access across cities. However, full adoption of large-scale Wi-Fi networks remains unrealized nudging Strix to transform yet again into a developer of Wi-Fi products geared towards providing outdoor surveillance systems to enterprises.

Consequently, holding everything else constant, a firm’s failure odds decline if its technology enjoys wider appeal, while a counterpart with more specialized technology is more prone to failure. The technologically more general venture is endowed by a diverse set of opportunities, while the specialized venture faces a restricted set of possibilities. It is therefore plausible to expect the former to experience better survival prospects.. We therefore hypothesize:

*H1. Holding all else constant, the greater the domain concentration of forward citation flow that a new firm receives, the higher its failure hazard rate.*

***Effect on Success (2)***

Entrepreneurial success, which in the present context refers to the occurrence of a liquidity event such as IPO, does not stem from just being endowed with a more GPT. Rather success will depend on the technology being matched to a high growth area or commercializing applications which might require foresight, resources and capability development, a commensurate commercial strategy, serendipity or luck ([Gompers & Lerner, 2004](#_ENREF_99); [Hsu, 2006a](#_ENREF_129)).. The sheer number or magnitude of acknowledgements might not produce a straightforward outcome, yet the challenges of delivering on the promise that a signal of GPT entails for a start-up presents interesting implications for resource providers and entrepreneurs alike. .

**Challenges When Facing Many Options**

The endowment of a start-up with a particular breadth of technology presents two significant challenges to realize the potential value implied. The first involves the diffusion of proprietary knowledge following the granting of a patent. . As the knowledge regarding the invention spreads, its rent-generating potential might diminish ([Grady & Alexander, 1992](#_ENREF_101)). The technology breadth may dictate the extent of rent dissipation by imposing constraints limiting the value that a resource-strapped new venture can appropriate..

The second challenge relates to commercializing the technology ([Gans et al., 2002a](#_ENREF_90); [Gans & Stern, 2003](#_ENREF_92)). The commercial value of an invention not only depends on its possible applications, but also on factors external and internal to the owner. External factors include growth in the application domain, which in turn might depend on a variety of elements such as existence of necessary industry infrastructures, adoption by users, network effects as well as luck and serendipity ([Denrell, Fang, & Winter, 2003](#_ENREF_75); [Katz & Shapiro, 1994](#_ENREF_142); [Teece, 1986](#_ENREF_232); [Thoma, 2009](#_ENREF_238)). Internal firm-level factors are intriguing given that technology strategy is a consequential choice for the venture. It would be naïve to assume that start-ups can develop many applications when its technology is general. . However, with foresight, luck and more importantly and a appropriate commercial strategy, new firms might well benefit from growing markets. For technology start-ups, collaboration is among the most viable modes of commercialization in view of the resource constraints they face and the need to act fast in a high-velocity environment ([Gans & Stern, 2003](#_ENREF_92)). We therefore analyze the moderating effects of knowledge diffusion and start-up collaboration strategy respectively as precursor for and failure.

**Knowledge Diffusion and Signal of Technology Breadth**

When firms patent their inventions they reveal proprietary information that other firms may co-opt while building their R&D programs. The forward citations that convey indebtness to exiting patents have been conceptualized in a number of ways. In the spillover literature forward citations have served as a paper trail for tracking the diffusion of knowledge ([Jaffe et al., 1993](#_ENREF_136)). In sociological framings, they have been construed as direct ties between organizations, interpreted as ‘deference’ or respect to the cited firm’s contributions ([Podolny & Stuart, 1995](#_ENREF_183); [Podolny *et al.*, 1996](#_ENREF_184); [Stuart & Podolny, 1996](#_ENREF_225)), even if many forward cites are imposed by patent examiners, often not included by the assignee. While forward citations may presage increased competition or litigation, the bulk of the existing literature shows net benefits of forward cites ([Podolny *et al.*, 1996](#_ENREF_184); [Stuart, 1998](#_ENREF_226); [Stuart *et al.*, 1999](#_ENREF_227)).

The more others build on a startup’s inventions, the thinner the rent-generating potential ([Grady & Alexander, 1992](#_ENREF_101); [Martin, 1992](#_ENREF_162)). Rent from an invention is the returns over and above the opportunity costs of producing related products. Government protection will create and maintain some rents while others may arise from either more efficient production of an existing product or from new products that yields benefits in excess of costs. However, the prospects of rich pay-offs stimulate rent seeking from both the inventing firms and others, the net effect of which translates into rent dissipation for the start-up.

Grady & Alexander ([1992](#_ENREF_101)) identify three rent-reducing mechanisms. First, rent anticipation provokes patent races that escalate resource commitment. Second, inventions inform about the existence of follow-on improvements on the focal invention with high expected value thus promoting excessive inventive behavior and consequent resource commitments; again such reactions dissipate some of the rent. Third, in sectors where secrecy is an important value appropriating mechanism and threats of designing around, resources may be diverted to efforts to unlock or engineer around the invention, not to mention the threats of possible litigations. We believe that such rent dissipation scenarios in the wireless sector— the sector of this study, characterized by a weak-appropriability regime—are particularly salient. How rent dissipation conditions performance also depends on the breadth of technology, i.e., the diversity of domains to which the knowledge diffuses. Hence we develop arguments on this interaction for both failure and success next.

***Effect on Failure***

We hypothesized the main effects of being a generalist—i.e., low concentration of application domains—on failure to be positive. However, that beneficial relationship is conditional on the rate of knowledge diffusion (i.e., the flow of forward citations) that the start-ups’ invention experiences. First, startups face considerably more resource constraints when maintaining a wide array of applications, including requisite capabilities and resources for the development and commercialization of the technology, and to monitor their patent portfolio for infringements. They are no match for specialists competing in the same domain. Second, although patents are taken to be a scale-free resource similar to brands without capacity constraints to application in many domains ([Levinthal & Wu, 2010](#_ENREF_156)), imperfections in patent enforcement and appropriability may limit the ability of cash strapped start-ups to monetize them across many product markets. Under conditions of high diffusion levels, firm’s with many applications to exploit, considering everything else equal, will consequently face higher costs in appropriating rents from their intellectual properties than firms with few possible technology application.

Third, ventures with a general technology portfolio face greater rent dissipation due to their knowledge diffusing compared to their specialized. On the revenue side, a broader technology more competition is plausible, leading to higher dissipation ([Fosfuri, 2006](#_ENREF_86)). On the cost side, generalist new firms are faced with multi-point competition, diminished economies of scope due to the dissimilar nature of the peer firms, higher opportunity costs, or perhaps partnering with firms having complementary knowledge that require significant amounts of inter-firm social capital ([e.g. Gulati, 1995](#_ENREF_105)) to coordinate the pooling of complementary technology and other intangible assets. Start-ups whose inventive output is associated with only one or a limited set of applications typically engage similar firms and accordingly may be better able to pool or leverage proximate resources to commercialize their technology. They might also enjoy higher bargaining power with partners who presumably compete in the same market and are complementary with the start-up’s technology. The higher rate of forward citations to a SPT firm’s inventions reinforces this dependency with the attendant prospect of superior survival odds. Therefore the conjecture:

*H2a. The interaction between the forward citations flow and its concentration is negatively related to the focal firm’s failure hazard rate.*

***Effect on Success***

Our reasoning for hypothesis 2a suggested that being a technological specialist with much visibility or acceptance forestalls failure. Such ventures reside in a niche technology attractive to proximate suppliers and competitors. Its limited scale may preclude an IPO or a trade sale. However, the dependency created-- as evidenced by high levels of forward citations from one or merely a handful of domains-- might generate stable cash flow and positive economic profit. These arguments also resonate with the theories of resource partitioning and niche width in population ecology ([Carroll, 1985](#_ENREF_54); [Hannan & Freeman, 1977](#_ENREF_117)). A sector with a core dominated by generalist behemoths but with a periphery abundant in opportunities, much like the industry under investigation, provides the ideal conditions required for market partitioning (Martina). Accordingly, specialists end up in niches with low growth prospects and are not attractive to investors and acquirers, when contrasted with generalists.

Therefore our next hypothesis:

*H2b. The interaction between the forward citations flow and its concentration is negatively related to the focal firm’s success hazard rate.*

**EMPIRICAL SETTING AND METHODOLOGY**

**Industry Context**

 Our study is based in the wireless sector during the period 1990-2009. The sector witnessed transitions from successive generations of standards-based technologies, starting with the second-generation (2G) voice-based technologies and followed by the data-oriented third-generation and fourth-generation (3G & 4G) technologies ([Ansari & Garud, 2009](#_ENREF_13)). The wireless sector exhibits a very complex ‘ecosystem’ that is dominated by firms that are vendors of equipment and handsets through control of important complementary assets. The influence of powerful generalist incumbents such as Ericsson, Nokia, and Apple, who conduct R&D across the value chain, however, has not been a deterrent to venture capital funding at the edges of the core controlled by them. New firms not only introduced new wireless technologies, but also spawned new software, applications, and content, both general and specific. Some examples include antenna technology with applications across various domains such as radar, space exploration, and medicine, and embedded systems and software specifically designed for handsets to general-purpose reprogrammable radio chips.

**Data and Sample**

We collected data on VC-funded firms in the U.S. wireless sector that were founded between the years 1990 and 2009. We only include those new firms that engage in patenting its inventions because the signal of interest is applicable only to these firms. Therefore our sample consists of 283 firms[[4]](#footnote-2).

Obtaining data on the alliances of private companies is extremely challenging. SDC Platinum does not provide comprehensive coverage for such alliances ([Schilling, 2009](#_ENREF_207)). We therefore used Factiva to supplement those alliances ([Lavie, 2007](#_ENREF_151)). These two combined sources also did not provide full coverage. Many of the press releases were not captured by the major news agencies covered in Factiva. We therefore used the company websites with the help of the Wayback machine (http://web.archive.org) to collect such information. Once the alliance information was downloaded we collected information about the industry affiliations of the partners using Hoovers, Zephyr and CorpTech.[[5]](#footnote-3)

Other sources of data include Derwent, a database of global patents maintained by Thomson since 1969 for patents. The historical Web sites of firms in our sample using the Wayback machine were used to source management team information. SDC, Zephyr, Factiva, and Hoovers provided merger and acquisition and IPO information. Finally, COMPUSTAT was accessed for segment data on publicly listed wireless firms.

**Dependent Variables and Empirical Strategy**

We conduct an event history study of success and failure rate using a competing risk framework. We categorize failed firms as those ventures that were liquidated due to outright bankruptcy or that were acquired in a distressed sale. These modes of dissolution were primarily determined through VentureXpert, which maintains this information in the ‘Company Current Situation’ field. For those firms involved in a distressed sale, the information came from SDC and Zephyr, which captures this status in the deal description. Failure, a dummy variable, is set to 1 in the year that the focal firm failed and 0 in all other years from founding. Successful firms are those that achieve Initial Public Offerings (IPO) or that are acquired. The information came from VentureXpert, SDC and Zephyr. Success, a binary variable, is set to 1 in the year that the focal firm had the IPO or sale event and 0 in all other years from founding. All the remaining firm-observations were censored at the end of the study period. We identified 56 failed outcomes and 91 successful ones and created firm-year spells from founding to failure or to the end of 2009 when the data are censored. We model the hazard rates for these two events experienced by the firm.

We use a competing risk Cox proportional hazard model ([Lee & Wang, 2003](#_ENREF_153)) of the two start-up outcome events, success and failure. Prior studies investigating start-up performance have primarily used either a Logit specification for a binary outcome or conducted an event history study of a single event such as failure or IPO with the notable exception of Giot & Schwienbacher ([2007](#_ENREF_96)), who analyze determinants of exit options for US venture capital funds. Since start-ups after birth face the risk of both failing as well as succeeding, conducting an event history study under a competing risk framework is appropriate, especially when the goal is to uncover asymmetric effects that could point towards persistence tendencies. The idea of the competing risks model is to let the hazard rate vary with the end state and the duration corresponding to the state not realized is truncated. From a methodological point of view, this implies that the realized state will contribute to the likelihood function via its density function, while the truncated state contributes to the likelihood function via its survivor function. Competing risks models focus on both the kind of exits (success or failure) and time to exit (duration) unlike event history studies of single events. It is also superior to a Logit model, which besides not handling censoring, would only focus on the type of exit (binary choice); the likelihood function of a Logit model does not take duration into account ([Giot & Schwienbacher, 2007](#_ENREF_96)). The regressions are computed using the *stcox* procedure of STATA.

**Independent Variables**

**Forward Citation Flow**

This is a count of the annual flow of citations that the firm receives from others and captures the episodic rate of knowledge diffusion of the focal venture’s inventions. On average a start-up in our firm receives 5 citations every year with a range of 0 to 158.

**Forward Citation Concentration**

To operationalize the signal of technology breadth, our main independent variable, we gather all the patents that cite the start-up firm’s inventions as prior-art, also referred to as forward citations to the focal patents. We construct a herfindahl measure of the concentration of the different four digits International Patent Classification (IPC) subclass from which a start-up receives forward citation in a given year—the year the citation was received as indicated by the application date. IPC subclasses capture the functions and applications of an invention and hence proxy possible technical domains to which the invention maybe applicable ([Hall, 2002](#_ENREF_111); [Hall et al., 2001](#_ENREF_110); [Hall & Trajtenberg, 2004](#_ENREF_112)). By considering the ongoing addition of forward citation diversity, such an index as signal becomes a time variant indicator of its technological heterogeneity. This variable ranges between 0.07 and 1 with a mean of 0.17.

**Control Variables**

We include controls in seven broad categories. First, we introduce patent related controls. These include annual patents received, the number of IPC classes from which the firm receives forward citations (to control for the number of technology domains a firm i associated with), the stock of patents granted ([Hsu & Ziedonis, 2008](#_ENREF_133)), and the stock of forward citations received in the previous years to capture the value of the patents ([Hall *et al.*, 2005](#_ENREF_113)). The second category relates to market conditions, the IPO and mergers and acquisition activity levels per year, that are important drivers for liquidity events ([Sorenson & Stuart, 2008](#_ENREF_219); [Stuart & Sorenson, 2003](#_ENREF_228)). The third group of controls variables pertain to investor characteristics, including investor quality ([Hochberg *et al.*, 2007](#_ENREF_127)), using the count of VCs featured in the Forbes Midas list between 2000 and 2009 that invest in a start-up, investor confidence, using the total number of VCs that invest, and investor expectations for the start-up, using the count of investors who commit funds in all rounds of financing ([Sorenson & Stuart, 2008](#_ENREF_219)).

 Fourth, we control for the number of rounds of financing received and time from founding to the first VC financing as new ventures need resources to survive ([Lee et al., 2001](#_ENREF_152)). This control is critical to assure that the two-sided effect of technology breadth does not hinge on whether the venture is well endowed and would favor those generalists among them that have access to rich external support and facilitating their status as multi-point competitor. . In the fifth group, we include the start-up experience of the founding team to account for variations in initial quality among the start-ups ([Burton et al., 2002](#_ENREF_52); [Eisenhardt & Schoonhoven, 1990](#_ENREF_82)). The sixth category holds constant the so-called corporate development actions that often assumes endorsement and that have been shown to be significant predictors of a new venture’s success ([Stuart et al., 1999](#_ENREF_227)). Last, we include product market growth at the sector level ([Covin & Slevin, 1989](#_ENREF_69)), using the total sales per year in all business segments in which publicly quoted wireless operators (SIC 4812) and vendors (SIC 3663) operate. Finally, we include the start-up entry year to account for potential violation of the non-informative censoring assumption. Table 9 below provides definitions of all variables used, and Table 10 provides summary statistics and correlations.

**RESULTS**

We report the results for both success and failure from a competing risk Cox regression in Table 3. A glance through the table provides interesting insights on asymmetric effects of factors on outcomes. In our case asymmetry implies that the coefficients for a given factor have the same signs for both success and failure instead of being opposite. We first look at our hypotheses and then analyze some of the interesting effects of the control variables. Models (1)-(3) corresponds to failure while (4)-(6) corresponds to success, each of the three corresponding to the three hypotheses for the two events, success and failure.

Our hypothesis about the effect of the signal of technology breadth finds support in the analysis. We expected high concentration of forward citations (i.e., a signal of SPT) to increase failure while no effect was anticipated for success. Models (1)-(3) reveal positive and highly significant effects on Forward Citation Concentration on failure hazard. Models (4)-(6) demonstrate no statistical significance of this variable on success. The coefficient from model (3) implies that at the mean value of Forward Citation Concentration the failure hazard rate increases by 28%, while the percentage increase in the failure hazard rate for an increase from the mean value to one standard deviation above it is 44%.

Table . Variable Definitions (Chapter 3)

|  |  |
| --- | --- |
| **Variable**  | **Description** |
| **Dependent Variables** |
| *(1) Failure* | A dummy indicating that the firm had experienced a distressed sale or had become defunct in a given year |
| *(2) Success*  | A dummy indicating that the firm had experienced an IPO or trade sale in a given year |
| **Independent Variables** |
| *(3) Forward Citation Concentration* | Herfindahl measure of concentration of IPC classes that forward citations originate from |
| *(4) Alliance Concentration* | Herfindahl measure of concentration of SIC of alliance partners |
| **Control Variables** |
| ***Patenting Related*** |
| *(5) Patent Grant Flow* | Number of new patents granted to the firm in a given year |
| *(6)* *Forward Citation Flow* | Number of new cites received by the firm in a year |
| *(7) Self-Citations* | Total number of self-cites received by the firm in a year |
| *(8) Number of IPC Classes* | Total number of IPC classes from which a firm receives forward citations |
| *(9) Patent Grant Stock at t-1* | Stock of the firm’s patents at the start of a year |
| *(10) Total Forward Cite Stock at t-1* | Stock of forward cites received by the firm at the start of a year |
| ***Exit Market Conditions*** |
| *(11) IPO Heat* | Intensity of IPO activity in the firm’s primary SIC code in a given year |
| *(13) Number of Targets in SIC* | Number of targets acquired in the SIC in a given year |
| ***Investor Characteristics*** |
| *(14) Total Number of Investors* | Number of distinct investors that invested in the firm over all rounds |
| *(15) Number of Investors Investing in All Rounds* | Number of investors that invest in all rounds |
| *(16) Prominent Investor* | Indicator of presence of investor that was in the Forbes Midas list |
| ***Financing Related*** |
| *(17) Number of Rounds Received* | Number of rounds of funding received by the firm till the end of study |
| *(18) Time to First Round* | Time in days from founding to receiving first round |
| ***Initial Firm Quality*** |
| *(19) Founding Team Start-up Experience* | Sum of wireless start-ups founding team worked in prior to the focal firm |
| ***Firm Strategic Action*** |
| *(20) Number of Alliances* | Number of alliances by the firm in a year |
| *(21) Number of Acquisitions* | Number of acquisitions by the firm in a year |
| ***Others*** |
| *(22) Business Segment Sales in Wireless* | Total sales of all public wireless companies in a given SIC code  |
| *(23) Entry Year* | Year of entry of the firm in the risk set |

Table . Summary Statistics and Correlations (Chapter 3)



Absolute correlations above 0.036 are significant at p < .10.

Table . Competing Risk Cox Proportional Hazard Regressions (Chapter 3)



Standard errors in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

To test H2a & H2b we interacted Forward Citation Concentration with the Forward Citation Flow. Model (2) and (5) show the results for this analysis. As supposed we observe an asymmetrical effect on failure and success. High Forward Citation Concentration (signal of SPT) and Forward Citation Flow (the curve with diamond high knowledge diffusion rate) reduces likelihood of failure but at the same time also diminishes success chances as shown by the negative and significant (although weak in the case of success) effects on the two events. We plot the interaction effects in Figure 6 and Figure 7 below.

 Figure 6 illustrates this interaction effect on failure at three levels of Forward Citation Flow – i.e., at the mean, and at one standard deviation above and below the mean of this variable. At low levels of Forward Citation Flow (the curve with diamond shaped points), the relationship between Forward Citation Concentration and failure hazard is monotonically increasing. At mean and high values of Forward Citation Flow (shown by curves with square and triangle shaped points) the relationship reverses. Thus, at high values of concentration (signal of SPT) the failure hazard decreases. Analogously, in Figure 7 at high Forward Citation Flow the success hazard decreases (the curve with triangle shaped points). Therefore, firms that receive signals conveying SPT have lower failure as well as success hazard as high levels of knowledge diffuse out in a given year pointing towards existence of persistence. As hypothesized we see asymmetric effect of both failure and success chances being diminished when a signal of SPT is accompanied with high rate of knowledge diffusion. Consequently, the interaction of these two factors, high rate of forward citations and high concentration of those citations in few domains, provides evidence of a systematic causal factor that leads to neither success nor failure events. Therefore, such firms stand the risk of persisting without any events that provide investors the opportunity to exit.

Figure . Interaction Effect Technology Breadth & Diffusion H2a (Failure)



Figure . Interaction Effect Technology Breadth & Diffusion H2b (Success)



In contrast, H3a & H3b are not supported in the regression analysis. The interaction of Forward Citation Concentration with Alliance Concentration has no statistical significance. The main effect of Alliance Concentration (included for interpreting the interaction) is also not found to be significant. One explanation could be that many of these alliances do not provide economic benefits; rather start-ups pursue them to gain legitimacy and endorsement. For our analysis we did not look at different types of alliances because Factiva does not categorize strategic alliances in the way SDC does. However, scanning the deals we found very few licensing deals reported. Since licensing deals are generally not publicly reported, our data on alliances may be skewed towards those deals that provide intangible benefits rather than direct monetary compensations.

We highlighted before that evidence of asymmetric effects, as we see in the case of H2a and H2b, could be an important empirical tool to investigate non-events. In that spirit, we finally identify the counterintuitive effect of the control variables on performance. The signaling value of patents is symmetric (i.e. decreases failure and increases success rate) and beneficial for both failure and success as current research predicts. The main effect of Forward Citation Flow (included to interpret the hypothesized interaction effect) is indeed fascinating, demonstrating asymmetry. Higher knowledge diffusion seems to benefit success while also increasing failure chances. Thus, forward citation flow has a net endorsement effect for successful firms, but has a net competitive effect for failed firms. Elsewhere (Ghosh and Pennings, 2011) we reported evidence that forward citations from firms with the reputation to litigate fosters start-up failure and interpret the harmful effects. In additional analysis, not reported here, we find no effect on success events when the citations come from alters with a reputation to litigate. Those results, along with the systematically different effect of forward citation flow between failed and successful outcomes lead us to speculate that a deeper understanding of the actual content of the inventions beyond patent classes and prior-art citations would enlighten us further on the exact mechanisms that lead to either acknowledgement—often viewed as “deference” (Podolny and Stuart, 1995) or competition.

Furthermore, a longer gestation period (measured through Time to First Round) has an asymmetric effect on the two dependent variables. They are conducive to survival, decreasing failure, but reduce the desired arrival of a liquidity event. This outcome could be attributed to inertial forces setting in as the firm moves beyond its infancy, shrinking the potential of VCs to influence or change course. Initial founding team experience has symmetric and beneficial effects on performance much like the other signal of quality much discussed in the literature, patents. Our study therefore reinforces the importance and reliability of these signals of quality to overcome information asymmetry and circumvents the so called lemon problem ([Akerlof, 1970](#_ENREF_7)).

Finally, the number of alliances per year has an asymmetric effect in that higher alliance rates is conducive to survival but makes IPO or other pay-out much less likely, perhaps suggesting a substitution effect of alliances with successful exit. They render the start-up less attractive as an acquisition candidate as well as limiting its growth potential. Overall, these results provide evidence of a number of forces that coalesce in generating persistence by lowering success probability and increasing survival prospects.

**DISCUSSION AND CONCLUSIONS**

We want to state upfront that our focus is not on low tech start-ups where intangibles, resources constraints and significant external support are not salient rather we focus on ventures that require extensive inputs from outsiders such as VC firms whose expectations about success set high returns in a clear cut time horizon. In other words, we do not consider low tech ventures, or ventures with minimal external inputs such as capital and IPR, and commensurate expectations—including mom and pop restaurants, street-side shoemakers, children’s lemonade stands or marginal real estate brokers with little sales revenue. We also concede that our findings do not apply to the not- for-profit sector where permanent failing organizations abound (Zucker and Meyer, 1993)

Our goal in this paper was to look at success and failures of start-ups simultaneously to indirectly catch a glimpse of what has been termed as ‘living dead’ firms. To achieve that we exploit asymmetric effects on two start-up outcome events, success (achieving IPO or trade sale) or failure (dissolution due to bankruptcy, distressed sale or closing up business). Extant literature has usually centered on either success or failure, thus excluding the possibility to uncover forces that work towards both inhibiting success and failure. We believe that this is an important contribution and can serve well as an empirical tool to study non-events.

We theorized about a signal of quality of the inventions of a new venture that is uncovered over time through their use by others in different domains. With the assumption that a firm might not know *a priori* about all the possible applications of its technology, we make the assertion that a signal of GPT will be good for survival although success will depend on how they cope with challenges of rent dissipation through diffusion of the knowledge and their ability to cope with the commercial challenges.

We found evidence of asymmetry in causal effects of the signal of nature of technology. Having a GPT did help survival, but had no predictive power for success. The most fascinating result is the moderating effect of the forward citation flow that a start-up receives on the signal of the nature of its technology. In both models of success and failure, firms with high concentration of domains citing them combined with high levels of forward citation per year face a lower probability of either succeeding or failing; strong indication of persistence that VC’s have labeled ‘living dead’ ([Bourgeois & Eisenhardt, 1987](#_ENREF_44); [Ruhnka, Feldman, & Dean, 1992](#_ENREF_203)). Future research should explore explicitly this twilight zone that has received scant attention till date.

A broader theoretical explanation of the asymmetric effect of high technology concentration and high knowledge diffusion on performance can be found in the competitive strategy literature. The simultaneous specificity and diffusion of technology attenuates the differentiation possibilities within an industry thus leading to many middle of the road performers. Decreased differentiation leads to broader niches albeit with lower growth prospects that encourage persistence. Perhaps some of the intriguing results appear in the control variables that we did not theorize about. First, we find that others use more a firm’s inventions; the new venture’s survival and success prospects are affected in contrasting manner. They inhibit survival but promote success. Forward citation flows have been used to measure knowledge trail, deference as well as competitive effects ([Jaffe et al., 1993](#_ENREF_136); [Podolny & Stuart, 1995](#_ENREF_183); [Podolny et al., 1996](#_ENREF_184)). Failures seem to bear the brunt of the harmful effects of rent dissipation through knowledge diffusion and designing around while successes seem to enjoy the endorsement effects. The technology breadth via the interaction effect gives us clue on the mechanisms in play but also raises further questions on why the amplification of the respective harmful and beneficial effects occurs. An interesting research project would probe further on the content of the inventions and why such a stark difference materializes.

A second interesting finding is that longer gestation period before receiving VC funding has an unbalanced effect on performance. Survival chances increases when the time taken to receive first round of funding is longer maybe because the routines and capabilities of the firms get established however the downside is that success chances are lowered pointing towards rigidities developed. This could also reflect some sort of VC selection effect where exciting prospects are picked up early and nurtured to harvest. The VC’s may find it harder to influence outcomes when practices, routines and capabilities are more established. Again these issues merit further investigation.

Finally, the amount of annual alliances that a firm undertakes every year increases survival but prevents successful outcome. While easy to explain the beneficial effects, the adverse impact on harvest points towards the downsides of too many alliances; with more alliances it is likely that the new venture partners with prospective buyers. It is probable that with more alliance partners the value appropriation by the start-up is negatively affected. The knowledge spillovers from alliances with powerful players with much higher resources and ambition may decrease the growth prospects of the new firm. These concerns could shed interesting insights and are worth further attention.

` Our study is not without limitations. It is set in a single context and applies only to those firms that patent. This is not a big concern in high technology sectors where the norm is to seek patent protection. In addition, the empirical method only allows us to infer persistence indirectly. Identifying ‘living dead’ firms and analyzing them directly would therefore be another interesting research project. Our criteria for success are also specific to the context. Therefore replicating the study in other context and using other success benchmark could help us verify generalizability. Limitations notwithstanding, this study makes important contribution to our understanding of the entrepreneurship as well as the broader performance literature.

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1. Studies that use continuous measures such as sales growth are few and limited to non-US setting such as Canada and Scandinavian countries. Majority of the papers treat success as harvest events because of easy availability of such data. [↑](#footnote-ref--1)
2. This observation does not apply to the few studies that use continuous measures of start-up performance. [↑](#footnote-ref-0)
3. We use quality in a broad sense. Quality is multi-dimensional and typically not observed directly and/or ex-ante. Considerable uncertainty surrounds the quality of a new venture and information from a variety of signals permit evaluators to sort start-ups using some criteria. We do not make any definite assertion about the sorting mechanism using quality signal, just the ability to rank them. [↑](#footnote-ref-1)
4. Sample selection bias concerns are allayed by comparing firms that patent and firm that do not as detailed in Chapter 2. [↑](#footnote-ref-2)
5. Alliances were identified using codes reported in Factiva and when the press release explicitly stated in its body a strategic alliance, joint venture or licensing deal. Since we look at aggregate alliances, the main effort was destined towards cleaning duplicates and triangulating the information. Two RA’s with overlapping data points to ensure reliability carried this out. We used a combination of manual and automated methods to remove these duplicates. [↑](#footnote-ref-3)