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Optimal Investment, Monitoring, and the Staging of Venture Capital

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ABSTRACT

This paper examines the structure of staged venture capital investments when agency and monitoring costs exist. Expected agency costs increase as assets become less tangible, growth options increase, and asset specificity rises. Data from a random sample of 794 venture capital-backed firms support the predictions. Venture capitalists concentrate investments in early stage and high technology companies where informational asymmetries are highest. Decreases in industry ratios of tangible assets to total assets, higher market-to-book ratios, and greater R&D intensities lead to more frequent monitoring. Venture capitalists periodically gather information and maintain the option to discontinue funding projects with little probability of going public.

THE ASYMMETRIC INFORMATION ASSOCIATED with startup companies makes project governance extremely important. During the screening process, venture capitalists review business plans of young companies and design contracts with entrepreneurs that minimize potential agency costs. Sahlman's extensive field research (1990) describes venture capital in terms of the control mechanisms employed to manage these agency costs. Three control mechanisms are common to nearly all venture capital financing: 1) the use of convertible securities; 2) syndication of investment; and 3) the staging of capital infusions. The first two control mechanisms are examined by Gompers (1993a, 1993b) and Lerner (1994a). This paper examines factors affecting the structure of periodic investment by venture capitalists. The evidence indicates that the staging of capital infusions allows venture capitalists to gather information and monitor the progress of firms, maintaining the option to periodically abandon projects.

Sahlman notes that staged capital infusions are the most potent control mechanism a venture capitalist can employ. Prospects for the firm are peri-

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odically reevaluated. The shorter the duration of an individual round of financing, the more frequently the venture capitalist monitors the entrepreneur's progress and the greater the need to gather information. The role of staged capital infusion is analogous to that of debt in highly leveraged transactions, keeping the owner/manager on a "tight leash" and reducing potential losses from bad decisions. While the duration of a particular round is one potential metric for the intensity of monitoring, the size of each investment, total financing provided, and number of financing rounds are also important measures of the staged investment structure.

This paper develops predictions from agency theory that shed light on factors affecting the duration and size of venture capital investments. Venture capitalists weigh potential agency and monitoring costs when determining how frequently they should reevaluate projects and supply capital. Venture capitalists are concerned that entrepreneurs' private benefits from certain investments or strategies may not be perfectly correlated with shareholders' monetary return. Because monitoring is costly and cannot be performed continuously, the venture capitalist will periodically check the project's status and preserve the option to abandon. The duration of funding and hence the intensity of monitoring should be negatively related to expected agency costs. Agency costs increase as the tangibility of assets declines, the share of growth options in firm value rises, and asset specificity grows.

Agency theory predicts that the information generated by venture capitalists is valuable. Models of venture capital have emphasized the role of information production.[1] Chan (1983) develops a model in which venture capitalists improve allocational efficiency by overcoming asymmetric information. Admati and Pfleiderer (1994) derive robust financial contracts when lead venture capitalists are better informed than other investors. They demonstrate that a contract in which the lead venture capitalist maintains a constant fraction of the firm's equity is the only form of financing that is robust to small changes in possible outcomes.

This paper utilizes a unique data set to test the agency and monitoring cost predictions. A random sample of 794 venture capital-financed companies provides a detailed picture of the structure of venture capital investments and the distribution of outcomes for venture-backed projects (e.g., initial public offering (IPO), merger, bankruptcy, etc.). The results confirm the predictions of agency theory. Venture capitalists concentrate investments in early stage companies and high technology industries where informational asymmetries are significant and monitoring is valuable. Venture capitalists monitor the firm's progress and if they learn negative information about future returns, the project should be cut off from new financing. Firms that go public (these firms yield the highest return for venture capitalists on average) receive more total

[1] Amit, Glosten, and Muller (1990) present an alternative model in which venture capitalists cannot generate information and separate high ability entrepreneurs from low ability entrepreneurs. In this case, adverse selection leads only low ability entrepreneurs to accept venture capital financing.

financing and a greater number of rounds than other firms (those that go bankrupt or are acquired). I also find that early stage firms receive significantly less money per round. Increases in asset tangibility increase financing duration and reduce monitoring intensity. As the role of future investment opportunities in firm value increases (higher market-to-book ratios), duration declines. Similarly, higher R&D intensities lead to shorter funding durations.

The paper also provides evidence about the relationship between investment and liquidity in the venture capital market. In periods when venture capitalists are able to raise more capital for new investments, they invest more money per round and more frequently in the firms they finance. Greater commitments to new venture capital funds may measure entry of new, inexperienced venture capitalists or free cash flow agency costs.

The paper is organized as follows. Section I presents predictions about factors that should affect the structure of staged capital infusions. The data set is described in Section II, and trends in venture capital investing are discussed. Factors affecting the staging of venture capital investments are analyzed in Section III. Section IV examines alternative explanations. Section V concludes the paper.

I. Factors Affecting the Structure of Staged Venture Capital Investments

A. Agency and Monitoring Costs

Venture capitalists claim that the information they generate and the services they provide for portfolio companies are as important as the capital infused. Many entrepreneurs believe that venture capitalists provide little more than money. If the monitoring provided by venture capitalists is valuable, certain predictions can be made about the structure of staged capital infusions.

If monitoring and information gathering are important, venture capitalists should invest in firms in which asymmetric information is likely to be a problem. The value of oversight will be greater for these firms. Early stage companies have short or no histories to examine and are difficult to evaluate. Similarly, firms in industries with significant growth opportunities and high R&D intensities are likely to require close monitoring. A significant fraction of venture investment should therefore be directed toward early stage and high technology companies.

Total venture financing and the number of financing rounds should also be higher for successful projects than for failures if venture capitalists use information in investment decisions. Venture capitalists monitor a firm's progress and discontinue funding the project if they learn negative information about future prospects. In Venture Economics' (1988) review of returns on venture capital investments, venture capital-backed companies that eventually did initial public offerings yielded the highest return for venture investors, an average 59.5 percent per year (7.1 times invested capital returned over 4.2 years). Acquisitions offered average returns of only 15.4 percent per year (1.7

times invested capital returned over 3.7 years) while liquidations lost 80 percent of their value over 4.1 years. Firms going public should, therefore, receive greater total funding and more rounds of financing than firms that are acquired or liquidated.

The positive relationship between going public and level of investment is not obvious unless venture capitalists use information during the investment process. If venture capitalists only provide capital, firms that go public might quickly turn profitable and would need *less* venture capital financing and fewer rounds than companies that are acquired or liquidated.

If asymmetric information and agency costs do not exist, the structure of financing is irrelevant. As Hart (1991) points out, if entrepreneurs pursue shareholder value maximizing strategies, financing is simple. Venture capitalists would give entrepreneurs all the money they need and entrepreneurs would decide whether to continue the project based on their information. In the case of startups, entrepreneurs would derive stopping rules that maximized shareholder value using methods described in Roberts and Weitzman (1981) and Weitzman, Newey, and Rabin (1981). Based on their private information, they would decide whether to continue the project or not.

The private benefits from managing the firms they create, however, may not always be perfectly correlated with shareholders' monetary returns. Entrepreneurs may have incentives to continue running projects they know have negative net present value (NPV). Similarly, entrepreneurs may invest in projects that have high personal benefits but low monetary returns for investors. If venture capitalists could costlessly monitor the firm, they would monitor and infuse cash continuously. If the firm's expected NPV fell below the stopping point, the venture capitalist would halt funding of the project.

In practice, venture capitalists incur costs when they monitor and infuse capital. Monitoring costs include the opportunity cost of generating reports for both the venture capitalist and entrepreneur. If venture capitalists need to "kick the tires" of the plant, read reports, and take time away from other activities, these costs can be substantial. Contracting costs and the lost time and resources of the entrepreneur must be imputed as well. Each time capital is infused, contracts are written and negotiated, lawyers are paid, and other associated costs are incurred. These costs mean that funding will occur in discrete stages.

Even though venture capitalists periodically "check up" on entrepreneurs between capital infusions, entrepreneurs still have private information about the projects they manage. Gorman and Sahlman (1989) indicate that between financing rounds, the lead venture capitalist visits the entrepreneur once a month on average and spends four to five hours at the facility during each visit. Non-lead venture capitalists typically visit the firm once a quarter for an average of two to three hours. Venture capitalists also receive monthly financial reports. Gorman and Sahlman show, however, that venture capitalists do not usually become involved in the day-to-day management of the firm. Major review of progress, due diligence, and the decision to continue funding are

generally done at the time of refinancing. Venture capitalists are concerned that between evaluations, entrepreneurs might behave opportunistically.

Two well-known companies illustrate how venture capitalists use staged investment to periodically evaluate a firm's progress. Apple Computer received three rounds of venture capital financing. In the first round, venture capitalists invested $518,000 in January 1978 at a price of $0.09 per share. The company was doing well by the second round of venture financing in September 1978. Venture investors committed an additional $704,000 at a price of $0.28 per share, reflecting the progress the firm had made. A final venture capital infusion of $2,331,000 was made in December 1980 at $0.97 per share. At each stage, the increasing price per share and the growing investment reflected resolution of uncertainty concerning Apple's prospects.

Federal Express represents a second example of how venture capitalists use staged capital infusions to monitor the firm. Federal Express also received three rounds of venture capital financing, but the firm's prospects developed in a much different manner. The first venture financing round occurred in September 1973 when $12.25 million was invested at a price of $204.17 per share. The firm's performance was well below expectations and a second venture financing round was necessary in March 1974. $6.4 million was invested at $7.34 per share and reflected the poor performance of the company. Performance continued to deteriorate and a third round of financing was needed in September 1974. At this stage, the venture capital investors intervened extensively in the strategy of the company. The $3.88 million investment was priced at $0.63 per share. Ultimately, performance improved and Federal Express went public in 1978 at $6 per share, but the staged investment of the venture capitalist allowed the venture investors to intervene and price subsequent rounds so they could earn a fair rate of return.

Two related types of agency costs exist in entrepreneurial firms. First, entrepreneurs might invest in strategies, research, or projects that have high personal returns but low expected monetary payoffs to shareholders. For example, a biotechnology company founder may choose to invest in a certain type of research that bring him/her great recognition in the scientific community but provides less return for the venture capitalist than other projects. Similarly, because entrepreneurs' equity stakes are essentially call options,[2] they have incentives to pursue high variance strategies like rushing a product to market when further testing may be warranted.

Second, if the entrepreneur possesses private information and chooses to continue investing in a negative NPV project, the entrepreneur is undertaking inefficient continuation. For example, managers may receive initial results from market trials indicating little demand for a new product, but entrepre-

[2] The entrepreneurs' equity stakes are almost always junior to the preferred equity position of venture capital investors. The seniority of the venture capitalists' stake makes the entrepreneur's payoff analogous to levered equity, hence it is also equivalent to a call option. Similarly, if the firm is doing poorly and the option is "out of the money," entrepreneurs may have incentives to increase risk substantially.

neurs may want to keep the company going because they receive significant private benefits from managing their own firm.

The nature of the firm's assets may have important implications for expected agency costs and the structure of staged venture capital investments. The capital structure literature motivates a search for those factors. Much of this literature (see Harris and Raviv (1991)) has emphasized the role of agency costs in determining leverage. Asset characteristics that increase expected agency costs of debt reduce leverage and make monitoring more valuable. Therefore, factors reducing leverage should shorten funding duration in venture capital transactions.

Williamson (1988) argues that leverage should be positively related to the liquidation value of assets. Higher liquidation values imply that default is less costly. Liquidation value is positively related to the tangibility of assets because tangible assets (e.g., machines and plants) are on average easier to sell and receive a higher fraction of their book value than do intangible assets like patents or copyrights. In empirical research on capital structure, many researchers including Titman and Wessels (1988), Friend and Lang (1988), and Rajan and Zingales (1995) use the ratio of tangible assets to total assets as a measure liquidation value. All find that use of debt increases with asset tangibility.

In the context of staged venture capital investments, intangible assets would be associated with greater agency costs. As assets become more tangible, venture capitalists can recover more of their investment in liquidation, and expected losses due to inefficient continuation are reduced. This reduces the need to monitor tightly and should increase funding duration.

Shleifer and Vishny (1992) extend Williamson's model by examining how asset specificity might affect liquidation value and debt levels. They show that firms with assets that are highly industry- and firm-specific would use less debt because asset specificity significantly reduces liquidation value. Firms that have high R&D intensities likely generate assets that are very firm- and industry-specific. Bradley, Jarrell, and Kim (1984) and Titman and Wessels (1988) use the ratio of R&D to sales to measure uniqueness of assets in investigating the use of debt. Both find a negative relationship between leverage and R&D intensity. Similarly, Barclay and Smith (1993) use the ratio of R&D to firm value to explore debt maturity.

Asset specificity would also influence the structure of staged venture capital investments. Industries with high levels of R&D intensity would be subject to greater discretionary investment by the entrepreneur and increase risks associated with firm- and industry-specific assets. These factors increase expected agency costs and shorten funding durations.

Finally, Myers (1977) argues that firms whose value is largely dependent upon investment in future growth options would make less use of debt because the owner/manager can undertake investment strategies that are particularly detrimental to bondholders. Myers suggests that a firm's market-to-book ratio may be related to the fraction of firm value that is comprised of future growth opportunities. Empirical results support this prediction. Rajan and Zingales (1995) find a negative relationship between firm market-to-book ratios and

leverage. Similarly, Barclay and Smith (1995) find that debt maturity declines with a firm's market-to-book ratio.

Entrepreneurs have more discretion to invest in personally beneficial strategies at shareholders' expense in industries where firm value is largely dependent upon future growth opportunities. Firms with high market-to-book ratios are more susceptible to these agency costs, thus increasing the value of monitoring and reducing funding duration.

Why can other financial intermediaries (e.g., banks) not do the same sort of monitoring? First, because regulations limit banks' ability to hold shares, they cannot use equity to fund projects.[3] Asset substitution becomes a problem if banks provide debt financing for very high risk projects. Though several papers focus on monitoring by banks (James (1987), Petersen and Rajan (1994, 1995), Hoshi, Kashyap, and Scharfstein (1991)), banks may not have the necessary skills to evaluate projects with few collateralizable assets and significant ex ante uncertainty. In addition, Petersen and Rajan (1995) argue that banks in competitive markets will be unable to finance high-risk projects because they are unable to extract rents in subsequent transactions with the company. Taking an equity position in the firm allows ex post settling up, guaranteeing that the venture capitalist benefits if the firm does well.

In addition, because the probability of failure is so high, venture capitalists need a substantial fraction of the firm's equity in order to make a fair return on their portfolio of investments. Even if banks were to make loans to high-risk firms, required interest payments would be extraordinarily high, creating severe liquidity problems that would limit a firm's growth and exacerbate risk-shifting problems. Finally, venture capital funds' high-powered compensation schemes examined by Gompers and Lerner (1995) give venture capitalists incentives to monitor firms more closely because their individual compensation is closely linked to the funds' returns.

B. Venture Capital, Liquidity, and Investment

The growth of inflows to new venture capital funds may also have effects on the structure of investment. During the past twenty years, the venture capital industry has gone through several fund raising cycles. Figure 1 shows the amount of capital committed to new venture capital funds. During periods of low fundraising, venture capitalists might be liquidity constrained. Liquidity constraints and their effects on investment have been examined in several contexts (Fazzari, Hubbard, and Petersen (1988); Hoshi, Kashyap, and Scharfstein (1991); Petersen and Rajan (1994)). Venture capitalists would like to make more and bigger investments (which are positive NPV), but they are unable to raise enough money to invest in all of these projects. If constraints restrict investment, greater commitments to new funds lead venture capitalists to invest more money per round and to invest more often.

[3] Banks and their affiliates in other countries do venture capital-like financing (Sahlman (1992)), but their ability to hold equity is critical.

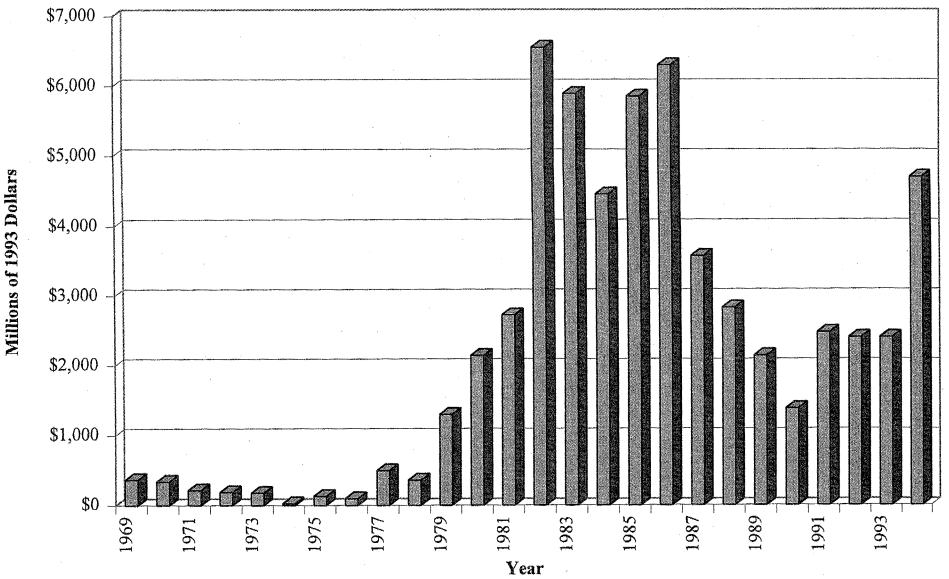

Figure 1. New commitments to venture capital funds in constant 1993 dollars.

Free cash flow theory (Jensen (1986)) also predicts that increases in commitments to venture capital funds would lead to larger investments and shorter time between investments. Venture capitalists would try to put the increased level of commitments to use. Free cash flow agency costs have been documented by Blanchard, Lopez de Silanes, and Shleifer (1994), who provide evidence that cash windfalls adversely affect companies' investment behavior. Law suit winners seem to invest in bad projects rather than give cash to shareholders. If free cash flow problems affect venture capitalists, more frequent and larger investment implies venture capitalists may be overinvesting.

Similarly, growth of the venture capital pool may measure entry by inexperienced venture capitalists. These new entrants may overinvest and may not monitor companies as effectively as experienced venture capitalists. As in the case of free cash flow agency costs, the increase in investment is excessive.

II. Sample Description

A. Individual Firm Financing Information

A random sample[4] of 794 firms that received venture capital financing between January 1961 and July 1992 was gathered from the Venture Econom-

[4] The random sample was generated as follows: At the time the data were collected, approximately 7000 firms were contained in the Venture Economics database. Each firm is given a number from 1 to 7000 by Venture Economics. 800 unique random numbers were generated from 1 to 7000 in a spreadsheet. These 800 numbers were used as firm reference numbers. Six firms were eliminated from the final sample because their data were suspect. The six firms had venture financing dates that were more than ten years apart. Apparently, for each of these six entries two firms with the same name had been venture financed and their records merged.

ics' Venture Intelligence Database, which collects funding information on venture capital-backed firms. The firms were included in the sample if their first round of venture capital financing occurred before January 1, 1990. This ensured that I had data for at least the first thirty months of the companies' existence. Data collected included: 1) name of the company; 2) date founded; 3) present status; 4) total amount of venture capital funding to date; 5) dates of individual fundings; 6) amount of capital committed in each stage; 7) identity of venture capital investors; 8) type of financing (e.g., seed, start-up, etc.); 9) industry code; and 10) date of IPO, if relevant.

The current status of each firm was verified with Lexis/Nexis databases. COMPANY and NEWS databases were searched for all records concerning the firms. If no news stories or legal filings were found, the firm was assumed to be private. The data are limited in several respects. First, I do not know how well each company is doing at each round of financing. Second, the data do not have information on other types of financing that the firms receive.

B. Venture Capital Funds Information

I utilize a database of venture capital funds compiled by Venture Economics' Investors Services Group to collect annual information on total venture capital funds under management, new capital commitments to the industry, and the amount of venture capital invested. The Venture Economics' database includes over two thousand venture capital funds, Small Business Investment Companies (SBICs), and related organizations and is used in preparation of directories such as their annual volume *Venture Capital Performance.* This database is compiled from information provided by venture capitalists and institutional investors.

C. Industry and Macroeconomic Data

Because accounting data for private firms is unavailable, I collect annual SIC industry averages from COMPUSTAT for each firm that received venture capital financing to control for industry effects. If the four digit Standard Industrial Classification (SIC) group had fewer than four companies, the three digit industry was used. Similarly, if the three digit group had fewer than four companies, I collected the two digit SIC group averages. Variables were collected to calculate various measures of asset tangibility (the ratio of tangible assets to total assets), growth opportunities (market value of equity to book value), and research intensity (either the ratio of R&D expenditures to total assets or R&D expenditures to sales). The data were matched by date and industry to each firm and each round of financing. The inflation rate and real return on Treasury bills and common stocks were collected for each month from 1961 to 1992 from Ibbotson Associates.

D. Summary Information and Statistics

Table I provides summary information on the dates and amounts of total venture capital financing for the 794 firms. These 794 firms received 2143

Table I

Time Series of Random Sample from the Venture Economics Database

The sample is 794 randomly selected companies from the set of firms that received their first venture capital investment prior to January 1, 1990. The table shows the number of rounds, total amount invested, and the number of new firms in each year in the sample of random firms. Amount of known investment is in thousands of dollars.

Year	Rounds of Venture Capital Financing	Amount of Venture Capital Investment (Thousands of Dollars)	Number of New Firms Receiving Venture Capital
1961	1	280	1
1962	1	200	1
1968	1	250	1
1969	3	2,135	2
1970	6	1,911	4
1971	8	2,257	4
1972	4	2,470	1
1973	9	19,436	6
1974	9	16,384	1
1975	14	10,775	9
1976	17	18,174	9
1977	23	9,064	12
1978	35	17,733	24
1979	44	64,788	30
1980	55	34,392	30
1981	77	113,794	50
1982	126	179,965	64
1983	170	380,648	82
1984	208	518,408	84
1985	179	517,447	66
1986	204	484,405	95
1987	219	434,966	60
1988	225	594,322	85
1989	234	418,940	67
1990	142	157,786	0
1991	109	142,878	0
1992	16	42,771	0

individual rounds of venture capital financing and represent roughly 15 percent of all venture capital over this period.[5] The coverage of the data seems to be better for the latter half of the sample period. This may reflect increasing completeness of the Venture Economics database over time. During the 1970s venture capital investing was modest in size. The number of rounds per year, the number of new firms financed, and total venture investment show a dramatic rise after the liberalization of ERISA's "prudent man" rule in 1979, which eased pension fund restrictions on investments in venture capital.

[5] My sample represents slightly more than 15 percent because certain data on financing amounts were missing.

Table II

Percentage of Investment by Industry and Stage of Development in Each Year

Data are 2143 financing rounds for a random sample of 794 venture capital-backed firms. Panel A shows the industry composition of venture investments in the sample through time. Industry classifications are reported by Venture Economics. Panel B shows how the stage of firm development for venture investments varies in the sample. Early stage investments are seed, startup, early, first, and other early stage investments. Late stage financing is second, third, or bridge stage investments. All values are in percent.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Panel A: Percentage of Rounds Invested by Industry															
Communications	28.6	23.5	18.2	8.6	18.2	11.1	13.3	12.9	14.9	13.3	12.4	12.3	11.9	12.0	11.5
Computers	0.0	0.0	0.0	2.9	2.3	3.7	4.0	8.9	10.1	10.1	6.2	3.9	4.6	4.4	1.3
Computer related	0.0	5.9	4.5	11.4	15.9	11.1	13.3	21.8	19.6	16.1	17.5	14.2	14.2	11.1	15.8
Computer software	7.1	0.0	0.0	0.0	0.0	0.0	6.7	10.5	13.7	9.6	14.7	13.2	11.4	9.3	11.1
Electronic components	0.0	0.0	4.5	0.0	2.3	5.6	2.7	0.8	3.6	3.2	4.5	3.4	4.6	3.6	3.0
Other electronics	28.6	35.3	4.5	2.9	4.5	11.1	10.7	8.9	3.6	7.8	6.8	4.4	4.1	4.9	5.6
Biotechnology	7.1	0.0	0.0	2.9	6.8	3.7	2.7	5.6	3.6	3.7	1.1	4.4	5.0	6.7	6.4
Medical/health	0.0	0.0	9.1	20.0	4.5	9.3	2.7	6.5	10.1	11.0	16.4	13.2	14.6	15.6	12.0
Energy	14.3	0.0	31.8	5.7	6.8	7.4	4.0	3.2	3.0	0.0	0.6	1.5	0.5	1.3	0.9
Consumer products	0.0	11.8	4.5	17.1	13.6	18.5	10.7	4.8	6.0	11.9	9.6	9.3	11.4	15.1	13.7
Industrial products	7.1	17.6	4.5	14.3	9.1	9.3	17.3	9.7	4.2	6.0	4.0	7.8	7.8	9.8	8.5
Transportation	0.0	0.0	18.2	0.0	4.5	0.0	1.3	2.4	0.6	0.9	0.6	2.0	0.9	1.8	0.0
Other	7.1	5.9	0.0	14.3	11.4	9.3	10.7	4.0	7.1	6.4	5.6	10.3	9.1	4.4	10.3
Panel B: Percentage of Rounds Invested by Stage of Development															
Early stage	69.2	92.9	85.7	63.3	70.6	66.7	52.3	59.5	54.9	55.3	47.7	43.1	39.7	40.0	34.5
Late stage	30.8	7.1	14.3	36.7	29.4	33.3	47.7	40.5	45.1	44.7	52.3	56.9	60.3	60.0	65.5

Table II looks at the distribution of investments across various industries by the percentage of rounds invested. Industry trends can be discerned. Computer firms received significant amounts of financing from 1982 to 1984, but investment subsequently declined. After the oil embargoes of the 1970s, energy related investments were popular; these declined substantially after the early 1980s when domestic exploration declined. On the other hand, medical and health related firms have been receiving increasing attention from venture capitalists.

What is evident from the industry results, however, is the focus on high technology firms (e.g., communication, computers, electronics, biotechnology, and medical/health). The percentage of venture capital invested is high technology firms never falls below 70 percent of annual investments. For firms in the sample, the average *industry* ratio of R&D to sales is 3.43 percent (median 3.82 percent). The average for all COMPUSTAT industries during the time period 1972–1992 was 1.30 percent (median 2.66 percent). Asymmetric information and agency costs are a major concern in R&D intensive firms which may require specialized knowledge to monitor. Industry investment composi-

tion suggests that venture capitalists specialize in industries in which monitoring and information evaluation are important.

Table II also examines the distribution of investment by stage.[6] The table documents the relative decline in early stage financing and the growing importance of later stage investments. This trend reflects the effects of a maturing industry. While the venture capital industry was growing rapidly in the early 1980s, more investment went to early stage companies. As the industry matured, the investment mix reflected previous investments. Early stage investments in the mid-1980s became late stage investments in the late 1980s. Even with the decline, a substantial fraction of investment is in early stage companies where monitoring is important.

The distribution of outcomes for firms that received venture capital financing is examined in Table III. Firms can go public (IPO), undergo a merger or acquisition, file for bankruptcy, or remain private as of July 31, 1992. For purposes of Table III, I classify only those firms that had not received a venture capital infusion since January 1, 1988 as venture-backed firms that remain private. Other firms may yet receive another venture capital investment or may achieve some other exit (e.g., IPO, merger, etc.) While this measure is imprecise, and it is impossible to be certain of the eventual status of all projects, the present classification gives some indication of relative outcomes. Such a determination is critical if research is to determine how investment structure affects a firm's success.

Table III shows that in the entire sample 22.5 percent of the firms go public, 23.8 percent merge or are acquired, 15.6 percent are liquidated or go bankrupt, and 38.1 percent remain private. In transportation, biotechnology, and medical/health, the proportion of firms that go public is quite high. This may reflect either the relative success of companies in this industry or their need for large capital infusions which an IPO provides. In electronic components, industrial products, and other (services), the proportion of IPOs is quite low and many more firms remain private. These results may understate the proportion of liquidations, however. First, some of the acquisitions/mergers may be distressed firms that provide little more than physical assets to their acquirer.[7] The return to the venture capitalist from these firms would be very low. Similarly, a number of the firms classified as private may have been liquidated, but I was unable to locate any record of the event. Firms without any debt would have no need to file for bankruptcy.

Funding statistics by industry and outcome are presented in Table IV. Average total funding received, number of rounds, and age at first funding show considerable variability across industries. High technology ventures receive more rounds and greater total financing than low technology ventures.

[6] Rounds are classified as early stage if the investment is seed, startup, or early stage. The investment is classified as late stage if it is expansion, second, third, or bridge financing.

[7] Initial public offerings and acquisitions may also be viewed as one large financing round. Examining the amount of venture capital invested, classifying firms by outcome, is still important for understanding the venture capitalists' return.

Table III

Outcomes for 794 Venture Capital-Backed Firms by Industry

The number of firms that had performed an initial public offering, merged, went bankrupt, or remained private as of July 31, 1992. The first column is firms that went public. The second column is all firms that were acquired or merged with another company. The third column is all firms that filed for bankruptcy. The fourth column is all firms that are still private and have not received venture capital financing since January 1, 1988. Percentage of outcome classification for each industry are in parentheses.

Industry	IPOs	Mergers/ Acquisitions	Liquidations/ Bankruptcies	Private
Communications	17	17	9	26
	(24.6)	(24.6)	(13.0)	(37.7)
Computers	5	7	9	4
	(20.0)	(28.0)	(36.0)	(16.0)
Computer related	20	19	15	15
	(29.0)	(27.5)	(21.7)	(21.7)
Computer software	11	9	11	20
	(21.6)	(17.6)	(21.6)	(39.2)
Electronic components	2	6	0	9
	(11.8)	(35.3)	(0.0)	(52.9)
Other electronics	6	9	6	9
	(20.0)	(30.0)	(20.0)	(30.0)
Biotechnology	9	5	2	2
	(50.0)	(27.8)	(11.1)	(11.1)
Medical/health	17	17	12	10
	(30.4)	(30.4)	(21.4)	(17.9)
Energy	4	3	2	11
	(20.0)	(15.0)	(10.0)	(55.0)
Consumer products	19	10	6	33
	(27.9)	(14.7)	(8.8)	(48.5)
Industrial products	4	20	6	27
	(7.0)	(35.1)	(10.5)	(47.4)
Transportation	5	2	1	4
	(41.7)	(16.7)	(8.3)	(33.3)
Other	8	10	9	45
	(11.1)	(13.9)	(12.5)	(62.5)
Total	127	134	88	215
	(22.5)	(23.8)	(15.6)	(38.1)

The four industries with the highest total funding per firm are communications, computers, computer related, and biotechnology. Four of the five industries with lowest total funding per firm are energy, industrial products, transportation, and other (primarily services). Age at first funding does not seem to follow any clear pattern even though one might think that high technology companies need access to venture capital soon after incorporation. Biotechnology, electronic components, and medical/health companies are relatively young. Firms in computers, consumer products, and transportation are substantially older on average. Most firms are not startup; they are typically well over one year old when they receive their first venture capital infusion. These

firms received other funding (personal, "angel," or bank financing) before receiving venture capital.

Table IV also stratifies funding data by outcome. Examining the structure of funding by outcome can determine whether venture capitalists periodically evaluate a firm's prospects. The total amount and number of rounds of financing are greater for the sample of IPO firms than for either the entire sample or the subsamples that go bankrupt or are acquired/merged. The data indicate that venture capitalists stage capital infusions to gather information and monitor the progress of firms they finance. New information is useful in determining whether or not the venture capitalist should continue financing

Table IV

Number of Investments, Age at First Funding, and Total Funding Received by Industry and Outcome

The sample is 794 venture capital-backed firms randomly selected from the Venture Economics database. The number of rounds, age at first funding, and total venture capital financing (in constant 1992 dollars) are tabulated for various industries and various outcomes. Firms can either go public in an IPO, go bankrupt, or be acquired. Average total funding is in thousands of dollars. Average age at first funding is in years. Median values are in parentheses.

	Number of Rounds				Age at First Funding			
Industry	Full	IPO	Bankrupt	Acquired	Full	IPO	Bankrupt	Acquired
Communications	2.78	3.41	2.44	2.47	3.46	3.29	2.56	5.11
	(2)	(2)	(2)	(2)	(0.92)	(1.34)	(1.87)	(1.34)
Computers	3.89	4.60	4.33	3.42	4.19	1.11	2.75	2.30
	(3)	(6)	(4)	(3)	(1.33)	(0.17)	(1.84)	(1.29)
Computer related	3.66	4.0	3.47	3.32	4.29	3.74	4.10	4.10
	(3)	(4)	(2)	(3)	(1.88)	(1.67)	(2.75)	(2.75)
Computer software	2.99	2.91	2.00	3.22	3.59	3.83	4.30	4.30
	(3)	(2)	(1)	(3)	(1.92)	(3.67)	(2.59)	(2.59)
Electronic components	3.27	4.00	na	3.50	0.86	0.53	na	0.77
	(2)	(4)		(3.5)	(0.00)	(0.53)		(0)
Other electronics	3.21	2.50	3.50	2.78	3.45	2.54	5.67	5.46
	(2)	(2)	(2.5)	(2)	(2.38)	(3.17)	(3)	(3.92)
Biotechnology	3.69	3.56	4.00	4.60	1.21	0.89	0.37	2.08
	(4)	(3)	(4)	(4)	(0.71)	(0.50)	(0.37)	(2)
Medical/health	2.98	3.94	1.91	2.53	1.97	2.30	0.58	1.59
	(2)	(3)	(1)	(2)	(1.00)	(1.41)	(0.12)	(0.71)
Energy	1.91	2.25	2.00	1.67	2.85	7.01	2.13	2.00
	(1)	(2)	(2)	(1)	(2.00)	(5.17)	(2.13)	(2)
Consumer products	2.14	2.16	2.33	1.20	5.90	7.63	0.98	17.92
	(1)	(2)	(2)	(1)	(1.67)	(4.41)	(0.75)	(17.35)
Industrial products	2.09	3.75	2.17	1.65	3.79	5.94	18.97	4.66
	(1)	(2)	(1.5)	(1)	(2.25)	(6.38)	(10.46)	(2.46)
Transportation	1.93	2.00	2.00	2.50	6.33	15.84	na	9.09
	(2)	(2)	(2)	(2.5)	(5.67)	(5.27)		(9.09)
Other	1.60	1.63	1.78	1.80	5.83	12.48	1.00	10.11
	(1)	(1)	(1)	(1)	(2.25)	(3.17)	(0.46)	(5.96)

Table IV—*Continued*

Industry	Total Funding (Thousands of Dollars)				Number of Firms			
	Full	IPO	Bankrupt	Acquired	Full	IPO	Bankrupt	Acquired
Communications	7,402	7,017	2,841	4,693	98	17	9	17
	(3,300)	(4,260)	(2,000)	(1,447)				
Computers	16,162	20,483	15,507	5,363	27	5	9	7
	(7,750)	(20,483)	(6,000)	(2,492)				
Computer related	8,062	13,386	7,432	4,965	90	20	15	19
	(4,050)	(8,766)	(5,000)	(4,323)				
Computer software	4,537	7,584	2,978	6,108	77	11	11	9
	(2,092)	(3,463)	(1,500)	(1,604)				
Electronic components	10,479	12,425	na	6,914	22	2	0	6
	(3,484)	(12,425)		(2,483)				
Other electronics	5,228	6,371	6,777	3,160	41	6	6	9
	(4,000)	(6,330)	(1,637)	(1,875)				
Biotechnology	8,562	12,716	7,659	8,066	29	9	2	5
	(5,500)	(10,957)	(5,716)	(12,000)				
Medical/health	5,680	10,246	2,853	3,736	90	17	12	17
	(3,000)	(3,645)	(1,236)	(3,400)				
Energy	3,086	3,918	4,698	1,963	22	4	2	3
	(899)	(2,434)	(4,698)	(850)				
Consumer products	6,551	11,161	2,654	5,694	103	19	6	10
	(2,237)	(5,473)	(1,259)	(958)				
Industrial products	2,982	9,855	3,149	2,274	89	4	6	20
	(1,500)	(7,875)	(1,881)	(1,200)				
Transportation	4,983	6,468	4,000	5,875	15	5	1	2
	(3,252)	(2,500)	(4,000)	(5,875)				
Other	4,526	12,889	2,810	8,738	96	8	9	10
	(1,968)	(8,000)	(1,664)	(4,277)				

the project. Promising firms receive new financing while others either are liquidated or find a corporate acquirer to manage the assets of the firm.

III. The Structure of Staged Investment

A. The Duration and Size of Financing Rounds

The analysis in this section classifies each financing according to the company's stage of development at the time of financing as reported by Venture Economics (e.g., seed, startup, first stage, etc.) This information is self-reported by venture capital firms. There are no clear divisions between the definitions of each stage, so divisions should be seen as relative measures of firm development rather than absolute measures. To overcome some of the potential reporting biases in the regression results, I group various stages into either early rounds, middle rounds, or late rounds. I

Table V

Duration, Amount of Investment, and Cash Utilization by Stage of Development

The sample is 794 venture capital-backed firms randomly selected from the Venture Economics database. Investment type is self-reported stage of development for venture capital-backed firms at time of investment. Median values are in parentheses. Time to next funding is the duration (in years) from one reported financing round to the next. Amount of funding is the average size of a given type of financing round (in thousands of 1992 dollars). Cash utilization is the rate at which the firm is using cash between rounds of financing (in thousands of 1992 dollars per year).

Type of Funding	Time to Next Funding	Amount of Funding (Thousands of Dollars)	Cash Utilization (Thousands of Dollars per Year)	Number
Seed	1.63	921	565	122
	(1.17)	(290)	(248)	
Startup	1.21	2,387	1,987	129
	(1)	(1,098)	(1,098)	
Early stage	1.03	1,054	1,023	114
	(0.83)	(750)	(904)	
First stage	1.08	1,928	1,785	288
	(0.92)	(1,000)	(1,087)	
Other early	1.08	2,182	2,020	221
	(0.75)	(1,200)	(1,600)	
Expansion	1.26	2,343	1,860	377
	(0.88)	(1,000)	(1,136)	
Second stage	1.01	2,507	2,482	351
	(0.83)	(1,350)	(1,627)	
Third stage	0.86	2,784	3,237	181
	(0.75)	(1,200)	(1,600)	
Bridge	0.97	2,702	2,785	454
	(0.83)	(1,500)	(1,807)	

classify all seed and startup investments as early rounds. These investments are usually made in very young companies. First stage and early stage investments are classified as middle rounds because even though the firms are still relatively young, they are further developed than seed or startup companies. Finally, second, third, expansion, or bridge stage funding is considered to be late stage financing.

Table V summarizes average duration, amount of venture capital funding, and the rate at which the firm uses cash during that particular round (in dollars per year) for various types of investment. In general, the duration of financing declines for later stage companies and the average amount of financing per round generally rises. Venture capitalists may know more about later stage firms and may therefore be willing to invest more money and for longer periods of time. Later stage companies would be associated with lower agency costs. Similarly, the rate of cash utilization rises for later stage firms. Cash utilization rates for later rounds might be higher because the need for invest-

ment in plant and working capital accelerates as the scale of the project expands.[8]

Regression results in Table VI present a clearer picture of the factors affecting venture capital staging patterns. The regressions include dummy variables to control for early and middle stage financing using the Venture Economics classifications for type of investment.[9] The regressions also include industry accounting variables to control for the nature of the firm's assets and investment opportunities. Because private firm balance sheet data is unavailable, industry averages from COMPUSTAT should be viewed as instruments for the private firms' true values. To the extent that any of the coefficients on the industry variables are significant, significance levels for firms' true values are probably even higher.

From the previous discussion, firms that are subject to greater agency costs should be monitored more often, and funding durations should be shorter. The ratio of tangible assets to total assets for the industry should be related to the liquidation value of the firm. The coefficient on the ratio of tangible assets to total assets should be positive in regressions for the duration of financing rounds. Tangible assets lower expected agency costs of inefficient continuation. The market-to-book ratio should rise as the fraction of growth options in firm value rises. Because potential agency costs associated with investment behavior rise with growth options, the coefficient on the market-to-book ratio should be negative. I also include two measures of research and development intensity, R&D expenditure to sales and R&D expenditure to total assets. R&D intensive firms are likely to accumulate physical and intellectual capital that is very industry- and firm-specific. As asset specificity increases, so do expected losses in liquidation. Therefore, coefficients on R&D measures should be negative in the duration regressions.

I also include firm age when it receives venture financing. Older firms may have more information available for venture capitalists to evaluate. Therefore, holding stage of development and all else constant, informational asymmetries are smaller and the funding duration should be longer (i.e., the coefficient on age should be positive in the duration regressions).

Finally, I measure the effects of venture capital market growth on financing using the amount of money (in constant 1992 dollars) raised by venture capital funds in the year before the financing of the firm. If venture capitalists cannot make all the investments they would like because they have insufficient capital, more liquidity should decrease the duration of financing (firms receive follow-on funding sooner) and increase the amount of funding per round.

[8] A second possibility is that only poorly performing firms receive later rounds of financing (profitable firms generate their own cash). The higher cash utilization rate indicates a selection bias caused by selecting poor performers. Evidence from the sample of 127 firms going public indicates that the selection bias is not a problem. Successful firms have *higher* cash utilization rates.

[9] The results are unchanged if firm development is measured by using round number (e.g., first investment, second investment, etc.) instead of dummies for early, middle, and late stage firms.

The dependent variable in Panel A is the duration of a particular venture financing round, the time in years from one particular financing to the next. The estimation of regressions with duration data introduces certain methodological issues. First, the data is right censored: we only observe the duration of financing when a subsequent financing occurs. A subsequent financing might not be observed for two reasons: firms may be in the middle of an

Table VI

Regressions for Duration and Funding Amount per Round Controlling for Firm and Industry Factors

The sample is 2143 funding rounds for 794 venture capital-backed firms for the period 1961 to 1992. The dependent variables are the time in years from funding date to the next funding date and the logarithm of the round's funding amount in thousands of 1992 dollars. Independent variables include a dummy variable that equals 1 if the funding round is either seed or startup (early stage) and a dummy variable that equals 1 if the round is either early, first, or other early (middle stage). Liquidity in the venture capital industry is controlled using new capital commitments to venture capital partnerships in the previous year in constant 1992 dollars. Tangibility of assets is measured by the average ratio of tangible assets to total assets for company's in the firm's industry. Market-to-book is the average industry ratio of market value of equity to book value of equity. Research and development intensity is proxied by the average industry ratios of R&D to sales or R&D to assets. The age of the venture capital-backed firm is months from incorporation to financing date. Panel A are maximum-likelihood estimates for Weibull distribution duration models. Panel B estimates are ordinary least squares. *t*-statistics for coefficients are in parentheses.

Panel A: Regressions for Duration of Financing Round

	Dependent Variable: Duration of Financing Round					
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.030	0.361	0.407	0.417	0.070	0.082
	(−0.19)	(2.50)	(2.86)	(2.93)	(0.39)	(0.42)
Investment was in an early stage firm?	0.051	0.040	0.037	0.047	0.036	0.031
	(0.63)	(0.49)	(0.44)	(0.56)	(0.44)	(0.38)
Investment was in a middle stage firm?	−0.054	−0.058	−0.103	−0.094	−0.102	−0.106
	(−0.93)	(−1.00)	(−1.72)	(−1.55)	(−1.71)	(−1.75)
Capital committed to new venture funds in previous year	−0.60 × E-04	−0.56 × E-04	−0.52 × E-04	−0.55 × E-04	−0.54 × E-04	−0.56 × E-04
	(−4.97)	(−4.56)	(−4.10)	(−4.41)	(−4.22)	(−4.36)
Industry ratio of tangible assets to total assets	0.405				0.400	0.398
	(4.01)				(3.84)	(3.23)
Industry market-to-book ratio		−0.047			0.000	−0.019
		(−1.87)			(0.00)	(−0.41)
Industry ratio of R&D expense to sales			−3.390		−2.268	
			(−2.52)		(−1.79)	
Industry ratio of R&D expense to total assets				−0.795		−0.194
				(−2.69)		(−1.67)
Age of the firm at time of venture financing round	0.016	0.016	0.016	0.017	0.016	0.017
	(3.58)	(3.68)	(3.49)	(3.56)	(3.52)	(3.60)
Logarithm of the amount of venture financing this round	0.011	0.012	0.016	0.011	0.010	0.009
	(0.71)	(0.73)	(0.68)	(0.65)	(0.59)	(0.52)
Pseudo-R^2	0.045	0.037	0.045	0.046	0.053	0.051
Model χ^2	56.00	42.25	48.64	49.47	62.74	60.38

Table VI—*Continued*

Panel B: Regressions for Size of Each Financing Round

Independent Variables	Dependent Variable: Logarithm of the Financing Amount in the Round					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	6.580	6.756	6.902	6.929	6.379	6.108
	(38.00)	(39.02)	(46.39)	(46.27)	(26.97)	(22.39)
Investment was in an early stage firm?	−0.635	−0.608	−0.703	−0.703	−0.748	−0.760
	(−4.14)	(−4.22)	(−4.83)	(−4.83)	(−5.14)	(−5.23)
Investment was in a middle stage firm?	−0.224	−0.216	−0.308	−0.309	−0.314	−0.328
	(−2.29)	(−2.20)	(−3.06)	(−3.06)	(−3.13)	(−3.26)
Capital committed to new venture funds in previous year	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	(3.94)	(4.21)	(3.91)	(3.98)	(3.10)	(3.08)
Industry ratio of tangible assets to total assets	0.352				0.612	0.810
	(2.23)				(3.64)	(4.16)
Industry market-to-book ratio		−0.051			0.041	0.084
		(−0.64)			(0.49)	(1.03)
Industry ratio of R&D expense to sales			1.578		3.618	
			(0.72)		(1.56)	
Industry ratio of R&D expense to total assets				−0.099		1.372
				(−0.21)		(2.43)
Age of the firm at time of venture financing round	−0.019	−0.019	−0.014	−0.014	−0.014	−0.014
	(−2.58)	(−2.58)	(−1.82)	(−1.86)	(−1.90)	(−1.89)
R^2	0.031	0.028	0.039	0.031	0.041	0.044
F-statistic	9.33	8.40	8.50	8.40	8.03	8.55

ongoing financing round or firms might not receive another investment because they went bankrupt, went public, or were acquired. Models of unemployment (Lancaster (1979, 1985)) deal with similar censoring. I utilize duration data techniques used in unemployment estimation, surveyed in Kiefer (1988).

A firm is assumed to have a certain probability of receiving financing in each period. The instantaneous probability of receiving financing is called the hazard rate, $h(t)$. $h(t)$ is defined as:

$$h(t) = \frac{\text{Probability of receiving funding between t and } t + \Delta t}{\text{Probability of receiving funding after } t} \quad (1)$$

To estimate the duration model, assumptions about the distribution of the hazard rate must be made. The two most common distributions used in duration models are the Weibull and exponential distributions. The Weibull distribution offers two advantages. First, the time dependency of the hazard rate can be estimated. Second, the likelihood function for the Weibull model can be easily modified to allow for censored data. Other distributional assumptions (e.g., exponential or normal) were estimated and did not affect the

qualitative results, although the Weibull model gave better fit. The model estimated in Tables VI and VIII is:

$$h(t) = h_0(t)e^{\beta_0+\beta_1X_1+\cdots+\beta_KX_K} \qquad h_0(t) = t^{1/(\sigma-1)} \tag{2}$$

where $h_0(t)$ is the baseline hazard function.

Coefficients β_0, β_1, $\cdots$ are estimated via maximum likelihood estimators. These coefficients yield estimates of the probability that the firm receives financing in a particular month given values of the independent variables (including time from last investment). The resulting estimates from the Weibull regressions can be presented in multiple ways. Table VI and Table VIII present the model in log expected time parameterization, i.e., for given values of the independent variables, the model gives the logarithm of the expected time to refinancing. The interpretation of coefficients is straightforward, positive coefficients imply longer financing duration on average. Conversely, negative coefficients imply shorter expected durations.

The results of Table VI are generally consistent with the implications of an informational and agency cost explanation for staged venture capital infusions. In Panel A, financing duration declines with decreases in the industry ratio of tangible assets to total assets, increases in the market-to-book ratio, and greater R&D intensity. The coefficients are significant between the seven and one percent confidence levels. These factors are associated with greater agency costs of investment and liquidation and therefore lead to tighter monitoring.

The age of the venture-backed firm at the time of financing is positively and significantly related to financing duration. More information may be available for venture capitalists to evaluate older projects. One might also expect that larger financing rounds lead to longer funding duration. That is not the case. None of the coefficients on amount of venture financing are significant. The results indicate that industry- and firm-specific factors are important in determining the financing duration independent of the investment size.

Finally, in regressions (5) and (6), I include all industry accounting variables together to determine which of the asset measures are relatively more important. The ratio of tangible assets to total assets remains the most significant variable. Market-to-book drops out completely. Higher R&D intensities still reduce funding duration, but size and significance of the coefficients are reduced when the other asset measures are included. The results indicate that tangible assets may be particularly important in lowering expected agency costs.

Panel B examines factors affecting the size of the venture round. The dependent variable is the logarithm of the size of the financing round, in thousands of 1992 dollars. The ratio of tangible assets to total assets has the greatest effect on the amount of financing. Increases in tangibility increase the amount of financing per round. More R&D intensive industries also appear to receive more financing per round controlling for tangibility.

Panel A also shows that the duration of early and middle stage financings are not significantly different from late stage financings. The stage of development does, however, affect the amount of financing per round. Results from regressions in Panel B show that average early stage investments are between \$1.30 and \$2.03 million smaller than comparable late stage investments. Similarly, middle stage investments are on average \$0.70 to \$1.21 million smaller than late stage investments. The increasing size of investment per round reflects the growing scale of a firm. Greater investment is needed to expand the firm.

The duration of financing and the amount of funding per round is also sensitive to the growth in the venture capital industry. Greater commitments of capital to new venture funds reduces duration of financing and increases financing amount per round. A one standard deviation increase in new commitments to venture capital funds decreases funding duration by two months and increases the average funding by almost \$700,000.

If venture capitalists are capital rationed, larger cash commitments allow venture capitalists to invest more often in positive NPV projects and with larger cash infusions. If venture capitalists are susceptible to free cash flow agency costs, they might waste the extra cash by investing more, and more often, in bad projects. Similarly, the growth in new and inexperienced fund managers during the mid-1980s could have led to a deterioration in investment quality and monitoring. Sahlman and Stevenson's (1987) case study of the computer disk drive industry shows that venture capital investment in certain industries during the early and middle 1980s might have been excessive. This period coincides with the dramatic increase in commitments to venture capital funds and might indicate that either free cash flow agency costs or venture capitalist inexperience is a more likely explanation for the investment sensitivity to fundraising during this period of rapid entry.

B. Total Venture Financing and Number of Rounds

Data on total venture capital invested and the number of rounds provide another measure of monitoring intensity. Table VII presents results for both variables. Included in the regressions are three dummy variables for the outcome of venture financing: a dummy variable that equals one if the firm went public, another dummy variable that equals one if the firm was liquidated or filed for bankruptcy, and a third dummy variable that takes the value one for all firms that are acquired or merge with another company. Coefficients on these dummies provide information about the impact of monitoring for projects of varying success.

The dependent variable in Panel A is the logarithm of the total amount of venture financing that the firm received. The results show that firms that go public receive between \$3.36 and \$5.67 million more venture capital financing than firms that remain private. There is no difference in the total funding for those firms that are acquired and those that are liquidated compared to firms

that remain private. Even controlling for the number of financing rounds, firms that eventually go public receive more total financing.

The results in Panel B for the number of financing rounds confirm these results. Because the dependent variable is non-negative and ordinal, I estimate Poisson regressions for the number of rounds received. Firms that go public receive more financing rounds than those that remain private, while firms that are acquired or go bankrupt do not receive more rounds on average than those that remain private.

Table VII

Regression for Total Venture Capital Funding and Number of Rounds of Financing

The sample is 794 venture capital-backed firms for the period 1961 to 1992. The dependent variables are the total venture capital funding that the firm received in thousands of 1992 dollars and the number of distinct rounds of venture financing. Independent variables include a dummy variable that equals 1 if the firm completed an initial public offering, a dummy variable that equals 1 if the firm filed for bankruptcy, and a dummy variable that equals 1 if the firm was acquired by or merged with another company. Tangibility of assets is measured by the average ratio of tangible assets to total assets for companies in the firm's industry. Market-to-book is the average industry ratio of market value of equity to book value of equity. Research and development intensity is proxied by the average industry ratios of R&D to sales or R&D to assets. Estimates in Panel A are from ordinary least squares regressions. Estimates for equations in Panel B are from Poisson regressions. *t*-statistics for regression coefficients are in parentheses.

Panel A: Regressions for Total Funding

	Dependent Variable: Logarithm of Total Venture Financing Received					
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	11.017	7.075	7.290	7.427	4.714	4.771
	(12.38)	(38.22)	(67.40)	(68.38)	(4.41)	(4.47)
Firm exited via an IPO?	1.043	1.018	0.882	0.905	0.664	0.666
	(6.18)	(6.01)	(4.88)	(4.96)	(4.31)	(4.32)
Firm went bankrupt or was liquidated?	−0.023	−0.024	−0.102	−0.047	−0.085	−0.077
	(−0.11)	(−0.12)	(−0.49)	(−0.22)	(−0.48)	(−0.44)
Firm exited via merger or acquisition?	−0.125	−0.129	−0.003	−0.009	0.124	0.123
	(−0.76)	(−0.78)	(−0.02)	(−0.05)	(0.84)	(0.83)
Industry ratio of tangible assets to total assets	−3.660				1.118	1.036
	(−3.90)				(1.12)	(1.04)
Industry market-to-book ratio		0.311			0.402	0.420
		(2.90)			(3.52)	(3.69)
Industry ratio of R&D expense to sales			13.033		3.600	
			(4.02)		(1.24)	
Industry ratio of R&D expense to total assets				5.709		2.540
				(1.95)		(1.02)
Number of rounds of venture financing received					0.396	0.399
					(15.19)	(15.43)
R^2	0.073	0.064	0.067	0.048	0.337	0.336
F-statistic	13.40	11.60	11.05	7.82	44.37	44.26

Table VII—*Continued*

Panel B: Poisson regressions for number of rounds

Independent Variables	Dependent Variable: Number of Financing Rounds Received (1)	(2)	(3)	(4)
Constant	2.904	0.945	0.796	0.888
	(10.51)	(13.88)	(18.82)	(21.55)
Firm exited via an IPO?	0.255	0.239	0.186	0.203
	(4.35)	(4.06)	(2.91)	(3.18)
Firm went bankrupt or was liquidated?	0.054	0.052	0.017	0.052
	(0.71)	(0.68)	(0.23)	(0.68)
Firm exited via merger or acquisition?	0.027	−0.006	−0.010	−0.004
	(0.43)	(−0.09)	(−0.16)	(−0.06)
Industry ratio of tangible assets to total assets	−2.054			
	(−6.96)			
Industry market-to-book ratio		0.021		
		(0.54)		
Industry ratio of R&D expense to sales			7.416	
			(6.25)	
Industry ratio of R&D expense to total assets				2.907
				(2.73)
Pseudo-R^2	0.020	0.006	0.019	0.007
Model χ^2	60.25	18.55	50.07	18.81

A plausible explanation for these results is that venture capitalists gather information about the potential profitability of projects over time. If venture capitalists receive favorable information about the firm and it has the potential to go public, the venture capitalist continues to fund the project. If the project is viable but has little potential to go public, the venture capitalist quickly searches for a corporate buyer. Firms that have little potential are liquidated.

Industry factors appear to have an important impact on total funding received. Panel A shows that firms in industries with more tangible assets receive less total financing. Firms in industries with high market-to-book ratios receive more total financing. Similarly, R&D intensive industries receive significantly greater amounts of financing.

The most important factor influencing total venture financing is the number of financing rounds the firm has received. In fact, when the number of financing rounds is included in regressions with industry variables, tangibility of assets and R&D intensity are no longer significant. The coefficient on industry market-to-book ratio is unchanged, however. Even controlling for the number of financing rounds, firms in industries with high market-to-book ratios receive more total venture funding. If market-to-book measures the potential profitability of investment and growth opportunities, investment should be relatively higher in industries that have more growth opportunities. Similarly,

firms in high market-to-book industries may have less access to debt financing and may therefore rely more on venture capital.

Panel B shows that tangibility of assets and R&D intensity do indeed work through the number of financing rounds. Firms in industries with a greater fraction of tangible assets receive fewer rounds of venture financing. Similarly, firms in R&D intensive industries receive more rounds of financing.

Overall, the evidence suggests that venture capitalists are concerned about the lack of entrepreneurial incentive to terminate projects when it becomes clear that projects will fail. Venture capitalists minimize agency costs by infusing capital more often. As asset tangibility and liquidation value increase, venture capitalists can recover more of their money if liquidation occurs, and the need to monitor declines. By gathering information, venture capitalists determine whether projects are likely to succeed and continue funding only those that have high potential.

IV. Alternative Explanations

While the results from Section III are consistent with predictions from agency theory, alternative explanations may explain the results. Cost of monitoring may affect investment structure through the efficacy of interim monitoring. Tangible assets may be easy to monitor without formal evaluation. A venture capitalist can tell if a machine is still bolted to the floor. If costs of monitoring are very low, the venture capitalist may choose to have long financing rounds to avoid costs of writing new contracts. At the same time, venture capitalists could monitor the firm more often between capital infusions. Easier interim monitoring would reduce expected agency costs between financing rounds and, hence, increase funding duration.

Both monitoring and agency costs are important. Conversations with practitioners, however, indicate that they normally make continuation decisions when a new financing round occurs. Venture capitalists evaluate a firm based upon performance progress, not whether a machine is still bolted down. Future work should examine the importance of monitoring costs in determining investment structure and the frequency of monitoring.

The relation between funding duration and the nature of firm assets may also be driven by differences between high technology and low technology firms. High technology firms may naturally pass through more milestones. Because industry measures like the ratio of tangible assets to total assets, market-to-book, and R&D intensity are highly correlated with high technology and low technology status, shorter funding duration may be correlated with these measures. The coefficients in Table VI would measure the amount of information revealed over time and the number of benchmarks used to evaluate the firm. The more information that is revealed, the more often the project is reevaluated.

If the alternative of technology-driven milestones is true, then coefficients on asset measures would be driven by the difference between high technology and low technology industries. If we rerun the duration regressions within tech-

nology groups, the effect of asset tangibility, industry market-to-book ratios, and R&D intensities should be much less important. Table VIII presents Weibull distribution maximum likelihood estimates for each technology cohort. In Panel A, the sample is high technology firms which include communications, computers, computer related, software, electronic components, other electronics, biotechnology, and medical equipment companies. The sample in Panel B is low technology firms, which include medical services, energy, consumer products, industrial products, transportation, and other (primarily services) companies.

The coefficients on industry asset measures are surprisingly similar for the high technology and low technology cohorts and both have estimates that are close to the estimates for the entire sample. It is impossible to reject the hypothesis that the coefficients for the tangibility of assets, market-to-book ratio, and the R&D intensity are equal across types of industries. The similarity of the coefficients shows that the relation between duration and asset measures is consistent within industrial classifications as well. In unreported regressions, finer industry divisions had no qualitative effect on the coefficients.

The one major difference between the two groups is the effect of firm age. The age of the firm receiving financing does not have an effect on the financing duration for high technology firms but has a significantly positive effect in the low technology cohort. Firm age may be more important in measuring potential asymmetric information for low technology firms but may have only a small impact on asymmetric information for high technology companies.

While alternative explanations may help explain some of the results, conversations with venture capitalists indicate that they are concerned about the entrepreneur's continuation decisions and strategy choices. Results in Section III are consistent with venture capitalists' stated concern that entrepreneurs have private information about future viability of the firm, that they always want to continue, and that entrepreneurs may want to enrich their reputation through activities at investors' expense.

V. Conclusion

Corporate control is a fundamental concern of investors. If individuals knew all potential outcomes, state-contingent contracts would be able to solve any potential agency cost. But such complete knowledge does not exist, and investors must minimize potential agency costs. Mechanisms in financial contracts between venture capitalists and entrepreneurs directly account for potential agency costs and private information associated with high-risk, high-return projects.

This paper has demonstrated that the staging of venture capital investments can be understood in an agency and monitoring framework. Results from a sample of venture capital-backed companies are consistent with the predictions presented. Venture capitalists are concerned that entrepreneurs with private information and large private benefits will not want to liquidate a project even if they have information that the project has a negative net

present value for shareholders. Entrepreneurs may also pursue strategies that enrich their reputation at shareholders' expense. Agency costs increase with declining asset tangibility, increasing growth options, and greater asset specificity. Venture capitalists monitor entrepreneurs with increasing frequency as expected agency costs rise.

Table VIII

Regressions for Duration Controlling for Firm and Industry Factors with the Sample Split into High Technology and Low Technology Companies

The sample is 2143 funding rounds for 794 venture capital-backed firms for the period 1961 to 1992. The dependent variable is the time in years from funding date to the next funding date. Independent variables include a dummy variable that equals 1 if the funding round is either seed or startup (early stage) and a dummy variable that equals 1 if the round is either early, first, or other early (middle stage). Liquidity in the venture capital industry is controlled using new capital commitments to venture capital partnerships in the previous year in constant 1992 dollars. Tangibility of assets is measured by the average ratio of tangible assets to total assets for company's in the firm's industry. Market-to-book is the average industry ratio of market value of equity to book value of equity. Research and development intensity is proxied by the average industry ratios of R&D to sales or R&D to assets. The age of the venture capital-backed firm is months from incorporation to financing date. All regressions are maximum-likelihood estimates for Weibull distribution duration models. *t*-statistics for coefficients are in parentheses.

Panel A: Regressions for Duration of Financing Round for High Technology Industries

	Dependent Variable: Duration of Financing Round					
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.036	0.464	0.542	0.549	0.022	−0.056
	(−0.17)	(2.56)	(2.99)	(3.03)	(0.09)	(−0.22)
Investment was in an early stage firm?	0.066	0.065	0.042	0.046	0.036	0.029
	(0.68)	(0.66)	(0.42)	(0.45)	(0.36)	(0.30)
Investment was in a middle stage firm?	−0.022	−0.009	−0.085	−0.084	−0.101	−0.109
	(−0.32)	(−0.13)	(−1.15)	(−1.14)	(−1.38)	(−1.48)
Capital committed to new venture funds in previous year	−0.63 × E-04	−0.59 × E-04	−0.54 × E-04	−0.57 × E-04	−0.59 × E-04	−0.61 × E-04
	(−4.50)	(−4.01)	(−3.59)	(−3.82)	(−3.81)	(−3.93)
Industry ratio of tangible assets to total assets	0.514				0.553	0.633
	(3.47)				(3.60)	(3.55)
Industry market-to-book ratio		−0.059			0.037	−0.003
		(−0.66)			(0.39)	(−0.03)
Industry ratio of R&D expense to sales			−2.418		−0.986	
			(−1.83)		(−0.51)	
Industry ratio of R&D expense to total assets				−0.541		−0.315
				(−1.88)		(−1.68)
Age of the firm at time of venture financing round	−0.001	−0.001	−0.005	−0.005	−0.006	−0.005
	(−0.17)	(−0.09)	(−0.70)	(−0.70)	(−0.74)	(−0.64)
Logarithm of the amount of venture financing this round	0.001	0.003	−0.002	−0.002	−0.004	−0.005
	(0.07)	(0.13)	(−0.08)	(−0.08)	(−0.21)	(−0.22)
Pseudo-R^2	0.036	0.029	0.032	0.032	0.041	0.040
Model χ^2	31.07	20.75	21.85	21.99	33.63	33.81

Table VIII—*Continued*

Panel B: Regressions for Duration of Financing Round for Low Technology Industries

	Dependent Variable: Duration of Financing Round					
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.078	0.399	0.382	0.400	0.130	0.208
	(−0.29)	(1.50)	(1.54)	(1.62)	(0.45)	(0.62)
Investment was in an early	−0.050	−0.095	−0.087	−0.068	−0.093	−0.098
stage firm?	(−0.35)	(−0.66)	(−0.61)	(−0.48)	(−0.65)	(−0.69)
Investment was in a middle	−0.148	−0.194	−0.210	−0.179	−0.196	−0.195
stage firm?	(−1.45)	(−1.88)	(−2.03)	(−1.72)	(−1.89)	(−1.88)
Capital committed to new venture	−0.43	−0.38	−0.37	−0.40	−0.38	−0.38
funds in previous year	× E-04	× E-04	× E-04	× E-04	× E-04	× E-04
	(−1.86)	(−1.89)	(−1.68)	(−1.72)	(−1.68)	(−1.62)
Industry ratio of tangible assets	0.433				0.393	0.337
to total assets	(2.90)				(2.55)	(2.17)
Industry market-to-book ratio		−0.076			−0.053	−0.078
		(−1.41)			(−0.91)	(−1.43)
Industry ratio of R&D expense			−4.270		−2.006	
to sales			(−2.18)		(−1.89)	
Industry ratio of R&D expense				−1.067		−0.388
to total assets				(−2.41)		(−1.66)
Age of the firm at time of	0.026	0.028	0.030	0.031	0.029	0.030
venture financing round	(4.07)	(4.34)	(4.44)	(4.54)	(4.34)	(4.41)
Logarithm of the amount	0.022	0.018	0.017	0.014	0.019	0.017
of venture financing this round	(0.79)	(0.63)	(0.61)	(0.50)	(0.66)	(0.59)
Pseudo-R^2	0.086	0.075	0.088	0.091	0.100	0.100
Model χ^2	39.27	33.29	39.38	40.34	46.19	45.82

The evidence indicates that venture capitalists use their industry knowledge and monitoring skills to finance projects with significant uncertainty. Venture capitalists concentrate investment in early-stage companies and high technology industries. Results also demonstrate that the duration of financing is related to the nature of the firm's assets. Higher industry ratios of tangible assets to total assets, lower market-to-book ratios, and lower R&D intensities are associated with longer funding duration. Firms that go public have received significantly more financing and a greater number of rounds than have firms that are acquired or liquidated.

This paper raises several interesting questions for future research. Because large firms also engage in projects that compete with investments by venture capitalists, comparing the structure and timing of investment of large corporations with those of venture capitalists might shed light on the comparative advantage of each. What implications does the structure of venture capital investment have on the future performance of new business and established firms? Can the structure of investment increase the probability that an entrepreneurial project ends up like Apple Computer, Genentech, or Microsoft? Cross-sectional and time series effects of firm- and industry-specific factors on

the outcome of investment (e.g., IPO, merger, bankruptcy, or remaining private) need to be examined.

The effect of growth in the venture capital industry on investment should be investigated further. Do free cash flow costs, liquidity constraints, or the entry of inexperienced venture capitalists better describe venture capitalists' response to changes in capital commitments to new funds through the 1980s? Does the fund raising ability of the venture capitalist affect only the size of the investment or does it lead to softer benchmarks as well?

The data in this paper is limited because it examines only venture capital equity financing. Most venture capital-backed firms receive some financing before they tap venture capital. What are these sources and how significant are they? "Angels," wealthy individuals that invest in entrepreneurial ventures, are one source. Family and friends are also major contributors. Bank lending may be important in certain industries, but very high risk companies might not have access to debt financing. Future work should examine appropriate sources of capital for new firms and how those sources change as the firm evolves. Determining the relationship among sources of capital for startup enterprises would be pivotal in understanding the genesis of new firms.

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