The Burden of the Nondiversifiable Risk of Entrepreneurship *

Robert E. Hall
Hoover Institution and Department of Economics
Stanford University
National Bureau of Economic Research
rehall@stanford.edu stanford.edu/∼rehall
Susan E. Woodward
Sand Hill Econometrics, Inc.
swoodward@sandhillecon.com sandhillecon.com

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Abstract

In the standard venture capital contract, entrepreneurs have a large fraction of equity ownership in the companies they found and are paid a sub-market salary by the investors who provide the money to develop the idea. The big rewards come only to those whose companies go public or are acquired on favorable terms, forcing entrepreneurs to bear a substantial burden of idiosyncratic risk. We study this burden in the case of high-tech companies funded by venture capital. Over the past 20 years, the typical venture-backed entrepreneur earned an average of $4.4 million from companies that succeeded in attracting venture funding. Entrepreneurs with a coefficient of relative risk aversion of two and with less than $0.7 million would be better off in a salaried position than in a startup, despite the prospect of an average personal payoff of $4.4 million and the possibility of payoffs over $1 billion. We conclude that startups attract entrepreneurs with lower risk aversion, higher initial assets, preferences for entrepreneurship over employment, and optimistic beliefs about the payoffs from their products.

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1 Introduction

An entrepreneur's primary incentive is ownership of a substantial share of the enterprise that develops the entrepreneur's idea. An inescapable consequence of this incentive is the entrepreneur's exposure to the idiosyncratic risk of the enterprise. Diversification or insurance to ameliorate the risk would necessarily weaken the incentives for success.

We study this issue in the case of startup companies backed by venture capital. These startups are mainly in information technology and biotechnology. They harness teams comprising entrepreneurs (scientists, engineers, and executives), venture capitalists (general partners of venture funds), and the suppliers of capital (the limited partners of venture funds). During the startup process, entrepreneurs collect only sub-market salaries. The compensation that attracts them to startups is the share they receive of the value of a company if it goes public or is acquired.

We make use of a rich body of data on payoffs to entrepreneurs. Our most important finding is that the reward to the entrepreneurs who provide the ideas and long hours of hard work in these startups is zero in almost three quarters of the outcomes, and small on average once idiosyncratic risk is taken into consideration.

Standard venture deals involve three parties—entrepreneurs, general partners, and limited partners. The entrepreneurs have leveraged positions; that is, they receive no payoff until other claimants have received prescribed payoffs. The general partners arrange financing and supervise the startup company by holding board seats. Part of their compensation is proportional to the amount invested and the rest depends on the startup's return in excess of that amount. The limited partners are passive investors who hold debt and equity claims on the startup. General partners are somewhat diversified across investments and the limited partners are highly diversified. The burden of specialization falls mainly on the entrepreneurs.

Although the average ultimate cash reward to an entrepreneur in a company that succeeds in landing venture funding is $4.4 million, most of this expected value comes from the small probability of a great success. An individual with a coefficient of relative risk aversion of 2 and assets of $0.7 million would choose employment at a market salary over becoming an entrepreneur. With lower risk aversion or higher initial assets, the entrepreneurial opportunity is worth more than alternative employment. We infer that entrepreneurs are drawn differentially from individuals with lower risk aversion and higher assets or with more optimism. Other types of people that may be attracted to entrepreneurship are those with preferences for that role over employment and those who exaggerate the likely payoffs of their own products.

We focus on the joint distribution of the duration of the entrepreneur's involvement in a startup—what we call the venture lifetime—and the value that the entrepreneur receives when the company exits the venture portfolio. Exits take three forms: (1) an initial public offering, in which the entrepreneur receives liquid publicly-traded shares or cash (if she sells her own shares at the IPO) and has the opportunity to diversify; (2) the sale of the company to an acquirer, in which the entrepreneur receives cash or publicly-traded shares in the acquiring company and has the opportunity to diversify; and (3) shutdown or other determination that the entrepreneur's equity interest has essentially no value. Most IPOs return substantial value to an entrepreneur. Some acquisitions also return substantial value, while others may deliver a meager or zero value to the entrepreneur.

The joint distribution shows a distinct negative correlation between exit value and venture lifetime, especially in information technology. Highly successful products tend to result in IPOs or acquisitions at high values relatively quickly. These outcomes are favorable for entrepreneurs in two ways. First, the value arrives quickly and is subject to less discounting. Second, the entrepreneur spends less time being paid a low startup salary and correspondingly more time with higher post-startup compensation, either in the public version of the original company, in the acquiring company, or in another job. A fraction of entrepreneurs launch new startups after exiting from an earlier startup.

We develop a unified analysis of the factors affecting the entrepreneur's risk-adjusted payoff, based on a dynamic program. The analysis takes account of the joint distribution of exit value and venture lifetime and of salary and compensation income. We use it to calculate the certainty-equivalent value of the entrepreneurial opportunity—the amount that a prospective entrepreneur would be willing to pay to become a founder of a venture-backed startup. For a risk-neutral individual, the certainty-equivalent is \$4.4 million. With mild risk aversion, however, the amount is only \$1.9 million and with normal risk aversion, the amount is only slightly positive.

We are not aware of any earlier research that quantifies the rewards on a per-company basis or per-entrepreneur-year basis, the focus of our work. Earlier research on venture-backed startups has focused on the returns to venture investors. An extensive theoretical literature considers the implications of idiosyncratic risk for entrepreneurs and managers—see Heaton and Lucas (2004) for a recent contribution and many references.

2 The Startup Process

At the outset, startups are usually operated and financed by the entrepreneurs themselves. Friends and family may invest as founding shareholders. Unless the founders are wealthy, they need outside financing, so a main task early in a startup is to find investors. Some are individual investors called angels. But venture funds are capable of investing more at the outset than is available from these other sources, and venture can invest large amounts later in the development of a startup with a promising product. Our concern is with the companies that succeed in obtaining venture funding by convincing some venture capitalists that the new business has a positive net present value, which, given the skewness of the distribution of value at outcome, implies at least some chance of becoming highly profitable.

Venture funds seldom give a company all of the money it will need to get from startup to exit in a single investment. Instead, a syndicate of venture funds will provide financing in rounds, anticipating future rounds of funding, possibly including different investors, if the startup makes reasonable progress but still lacks the revenue to be self-sustaining, and denying the startup further funding otherwise. An early round typically gives a startup a few million dollars, while later rounds, if they occur, often involve much larger investments.

General partners are the organizers of venture funds. They recruit financing commitments from limited partners—usually pension funds, endowments, and wealthy individuals—and choose the companies that will receive financing. Compensation to general partners comprises an annual fraction of committed capital (typical is two percent) plus *carry*—a fraction of the profits (20 to 30 percent) from successful exits. The limited partners receive most of the cash returned by venture investments when a company undergoes a favorable exit event—an IPO or acquisition.

Venture funds generally hold convertible preferred shares in their portfolio companies. The preference requires that the funds receive a specified amount of cash back before the common shareholders (the entrepreneurs, angels, and employees) receive any return. In a successful outcome, the convertible preferred shares convert shares to common stock. Instead of convertible preferences, venture funds may hold debt claims, in which case they receive the repayment of the debt even in the best outcomes. Both arrangements put the common shareholders, including the entrepreneurs, in a leveraged position, increasing their exposure to the idiosyncratic risk of the startup.

A huge literature portrays the standard venture financial contract as the constrained optimum of a challenging mechanism design problem. This research explains key features, including the assignment of a share of the ultimate value to the entrepreneurs, multiple stages of financing, and debt instruments (preferences) that convert to equity. Some of the more prominent contributions include Admati and Pfleiderer (1994), Schmidt (2003), Casamatta (2003), and Repullo and Suarez (2004). Wilmerding (2003) and Bagley and Dauchy (2003) explain the terms of venture contracts from the perspective of venture capitalists and their lawyers.

The dominant factor in this literature is moral hazard. Venture investors and their agents, the general partners of venture funds, are unable to monitor or specify the efforts of entrepreneurs to commercialize their ideas. Consequently, the entrepreneurs are paid in proportion to the actual commercial success of their companies. This alignment of incentives comes at the cost of a substantial diminution in the value of the enterprise because of the idiosyncratic risk that entrepreneurs are unable to insure. Alternatives with less risk, such as paying entrepreneurs salaries in place of equity, apparently provide such weak incentives that the relationship based on equity incentives weakened by idiosyncratic risk is still optimal for some products and some entrepreneurs.

Venture capitalists face a daunting problem evaluating proposals for startups. One of the reasons that entrepreneurs receive sub-market salaries during the startup phase is to induce self-selection among applicants for venture funding. Only entrepreneurs with beliefs in the commercial values of their ideas will seek funding if the entrepreneur's payoff from an unsuccessful startup is negative.

Most of the expected return to entrepreneurs comes from low- probability large gains. About three-quarters of venture-backed companies expire without returning any cash to their entrepreneurs. The largest returns generally come from IPOs, but acquisitions sometimes provide high returns as well. On the other hand, many acquisitions occur at low prices and are effectively liquidations. Some venture-backed companies remain for many years as stand-alone operations, able to pay their employees out of revenue, but generating no returns for shareholders.

The free-standing startup company is one of the ways that ideas for new products are developed and marketed. It provides powerful incentives for its entrepreneurs, but at the cost of exposing them to the idiosyncratic risks of their companies. Most scientists and engineers working on new products work as employees for established—often very large—companies. Their employment contracts isolate them from the most of the idiosyncratic risks of the products they develop. Incentives are not as powerful as in startups. We discuss the sorting of potential entrepreneurs into startups and established companies in a later section. We note that the market for scientists and engineers has not developed any intermediate contract, though one could imagine such a contract. It would pay a higher salary than the standard venture contract does, but provide less exit value, for example, by putting a ceiling on the payout. We believe that such contracts are rare. The two successful contract forms in the market technical talent are polar opposites. The intermediate contract appears not to be viable.

3 Data

3.1 Data on venture transactions

We use a database compiled by Sand Hill Econometrics on venture investments in startups and on the fates of venture-backed companies. The data are drawn from a variety of sources, including several commercial data vendors. The vendors concentrate on reporting funding events and valuations for venture investments and successful outcomes (IPOs and high-value acquisitions)and are less likely to report shutdowns and acquisitions at low values. Sand Hill Econometrics has used a wide range of sources to augment coverage of these adverse termination events. Hall and Woodward (2007) describe the data in more detail and documents the technique we use to track the evolution of the entrepreneurs' ownership of a company through successive rounds of funding, each of which dilutes the entrepreneurs' claims.

One important source of valuation data is S-1 statements filed by venture-backed companies when they go public. These statements often give a funding history for the company. Because an IPO is a favorable event, the back-filling of round values from S-1s is a source of return-based selection in the data. Our earlier paper describes how we adjust for selection bias.

Our data include 20,961 venture-backed companies, the great majority of all such companies in the United States starting in 1987. Among the exit values used in the analysis, 2,010 are IPOs, 5,329 are acquisitions, and 3,180 are confirmed zero-value exits. Of the remaining companies, we treat those more than 5 years past their last rounds of venture funding as having exited at some time with zero value; 3,904 companies fall into this category. We randomly assign these companies exit dates by drawing from the empirical distribution of time past funding of companies with known zero-value exit dates. The remaining 6,538 companies have not yet achieved their exit values.

3.2 Number of entrepreneurs per company

Our basic data sources do not contain information about the number of entrepreneurs in each startup company. We use an estimate from a sample of companies that underwent IPOs. The sample is a random draw from all IPOs reported in our data. The SEC form S-1 filed prior to an IPO contains a description of the major shareholders, which includes the founders. Our estimate of the average number of entrepreneurs is 2.02 with a standard error of 0.15 .

4 The Joint Distribution of Startup Lifetime and Exit Value

The lifetime of a startup—the time from inception to the entrepreneurs' receipt of cash from an exit event—plays a key role in our analysis. Entrepreneurs prefer short lifetimes for two reasons. First, their salaries at a venture-backed startup are modest; they forego a full return to their human capital during the lifetime. Second, the time value of money places a higher value on cash received sooner.

Lifetimes and exit values are not distributed independently. In particular, a substantial fraction of startups linger for many years and then never deliver much cash to their founders. And some of the highest exit values occurred for companies like YouTube that exited soon after inception. We work with the joint distribution, $f(\tau, v)$, of startup lifetime, τ, and value received by the entrepreneurs, v. We take a flexible view of the joint distribution, as appropriate for our rich body of data. We place lifetimes τ and values v in 9 and 11 bins respectively and estimate the 99 values of the joint distribution defined over the bins.

Estimation of the joint distribution needs to take account of the fact that many companies in our data have not completed their lifetimes as startups. To account for the right-censoring of lifetimes, we let $I_{t,\tau}$ be an indicator function for whether a company started in month t

could have been observed to exit at lifetime τ. We denote the month where we gather our data as T. Thus

$$\begin{aligned} I_{t,\tau} &= 1 \text{ if } T - t \geq \tau \\ &= 0 \text{ otherwise.} \end{aligned} \tag{1}$$

We further let $N_{v,\tau}$ be the number of companies observed in the sample with entrepreneurial exit value in bin v and lifetime in bin τ. Non-exited companies are not included in N. We let L_t be the number of companies launched in month t. Then

$$N_{v,\tau} = \sum_t L_t I_{t,\tau} f_{v,\tau}, \tag{2}$$

where f is the joint distribution defined over the bins. We let

$$\tilde{N}_\tau = \sum_t L_t I_{t,\tau}, \tag{3}$$

so

$$f_{v,\tau} = \frac{N_{v,\tau}}{\tilde{N}_\tau}. \tag{4}$$

Our method for estimating the joint distribution is equivalent to estimating a hazard function showing the probability of exit at a given age conditional on no earlier exit, using all available data on the hazard at each age.

This approach to estimating the joint distribution does not constrain it to sum to one. In our data, the sum is 0.88 . Any reasonable approach to imposing that constraint could be rationalized as the minimization of some weighted distance function. We choose the obvious one, which is to divide the distribution from (4) by the sum of all of its values. Figure 1 shows the estimated joint distribution. The left row, with literally zero exit value to the entrepreneurs, dominates the probability. Most of the remaining probability goes to moderate exit values with relatively brief lifetimes. Exit values above \$100 million are quite rare.

Figure 2 and Figure 3 together provide a useful alternative view of the joint distribution. Figure 2 shows the marginal distribution of exit value, summed across all the lifetime categories. It shows that 73 percent of all startups deliver zero exit value. Categories of low but positive exit value account for most of the rest of the outcomes. Only a tiny fraction deliver more than \$100 million in value to their entrepreneurs. Figure 3 shows the conditional distribution of lifetime given exit value. Each row sums to one. Note that the two axes on the

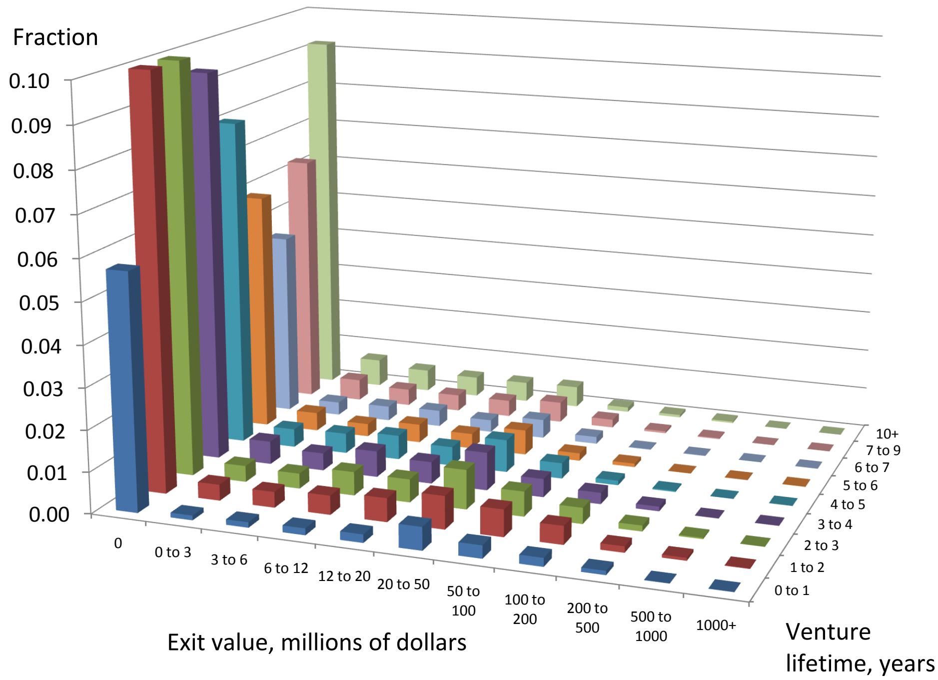

Figure 1: Joint Distribution of Venture Lifetime and Exit Value

floor are reversed relative to Figure 1 to make it easier to see the shape of the distribution. This figure shows the negative correlation of lifetime and exit value. At the front, the figure shows that zero-value exits tend to have long lifetimes. At the back, it shows that high-value exits tend to have short lifetimes. The conditional distributions of the high-value exits are irregular because there are few of them, though they account for a significant fraction of the total exit value.

Figure 4 shows the distribution of total exit value by exit-value category. Each bar shows the fraction of the total arising within the category. The category contributing the greatest fraction of value is \$100 to \$200 million. Many IPOs fall into this category, which corresponds to a few hundred million dollars in total equity value for the company.

Figure 5 shows the marginal distribution of venture lifetimes. The modal lifetime is between one and three years. The median is somewhat above 4 years. We do not calculate a mean lifetime, because the mean is sensitive to the extreme values, which are difficult to measure. Figure 5 shows the distribution of exit value by lifetime. More than a quarter of the total value arises from companies with venture lifetimes between one and two years. Not only is this range of lifetimes common, but exits that soon tend to have higher values.

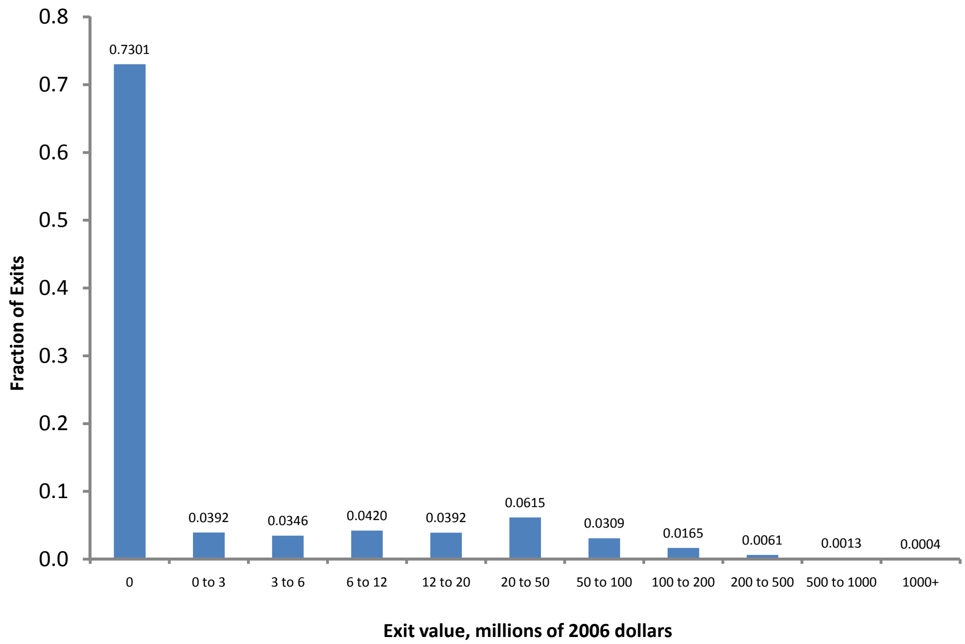

Figure 2: Marginal Distribution of Exit Value

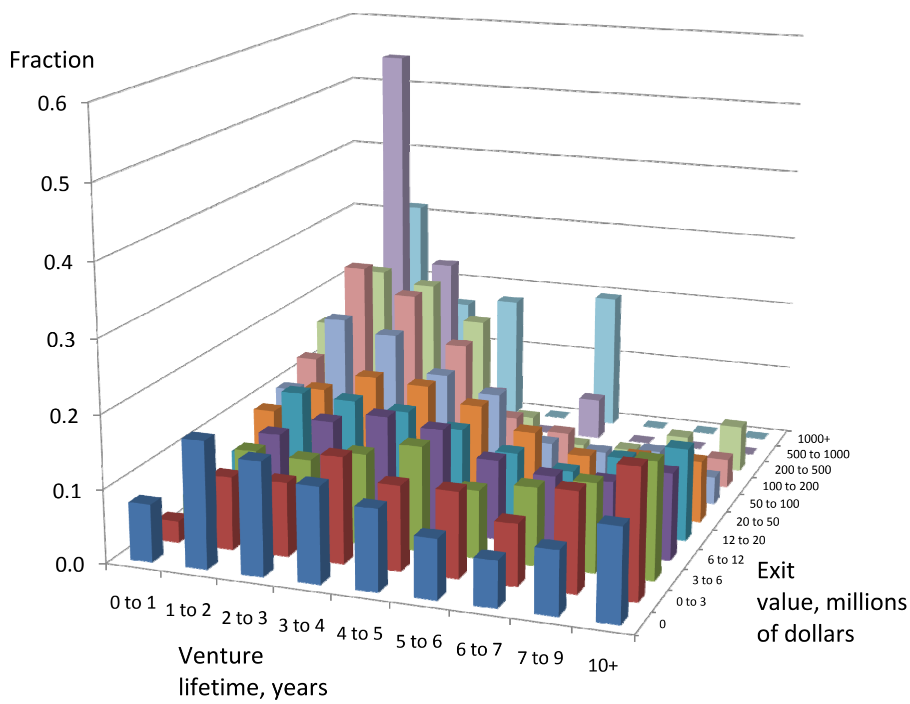

Figure 3: Conditional Distribution of Venture Lifetime Given Exit Value

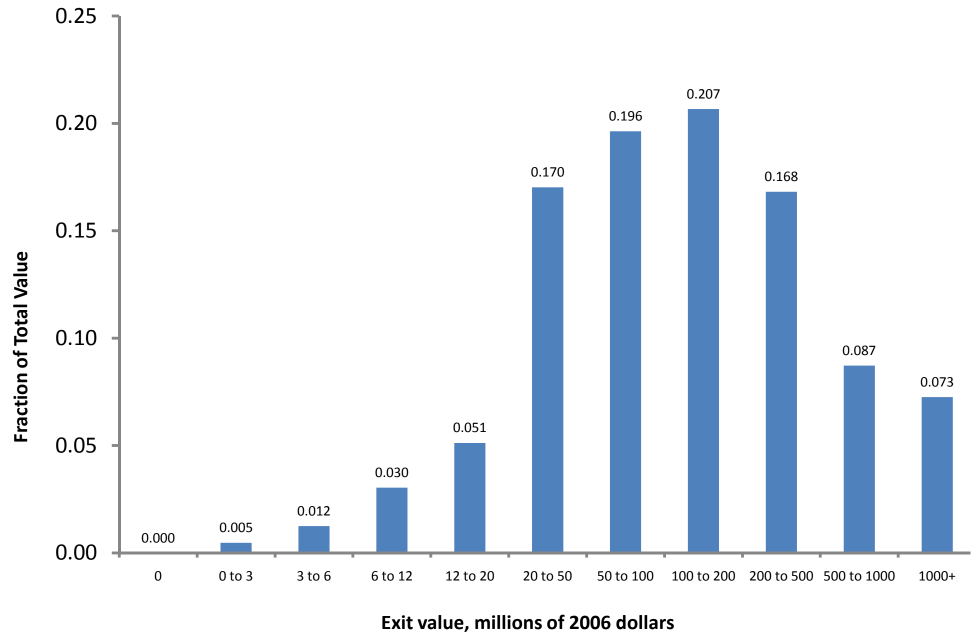

Figure 4: Fractions of Total Exit Value by Exit-Value Category

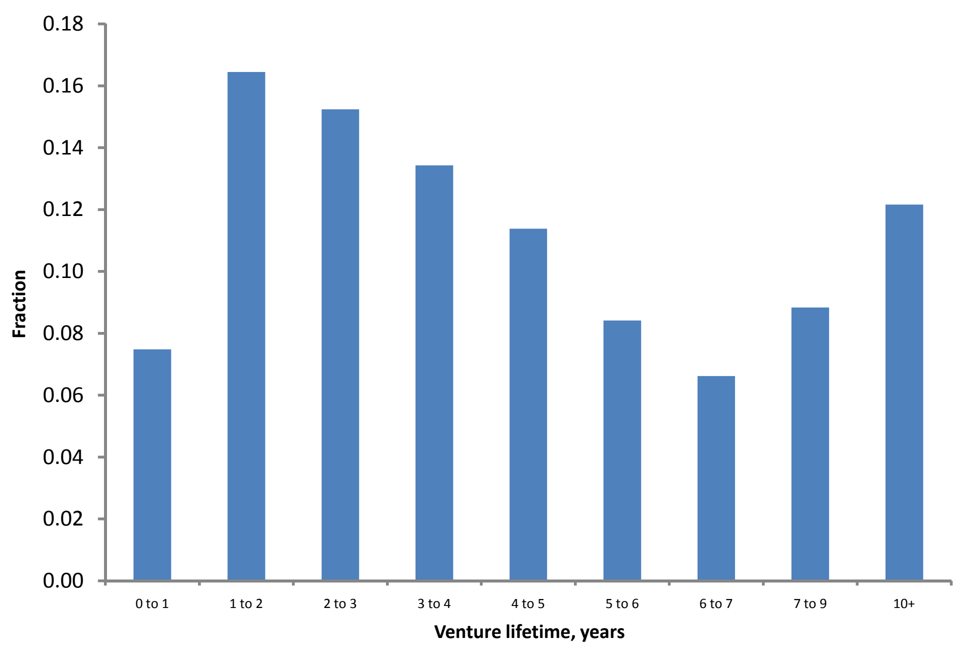

Figure 5: Marginal Distribution of Venture Lifetime

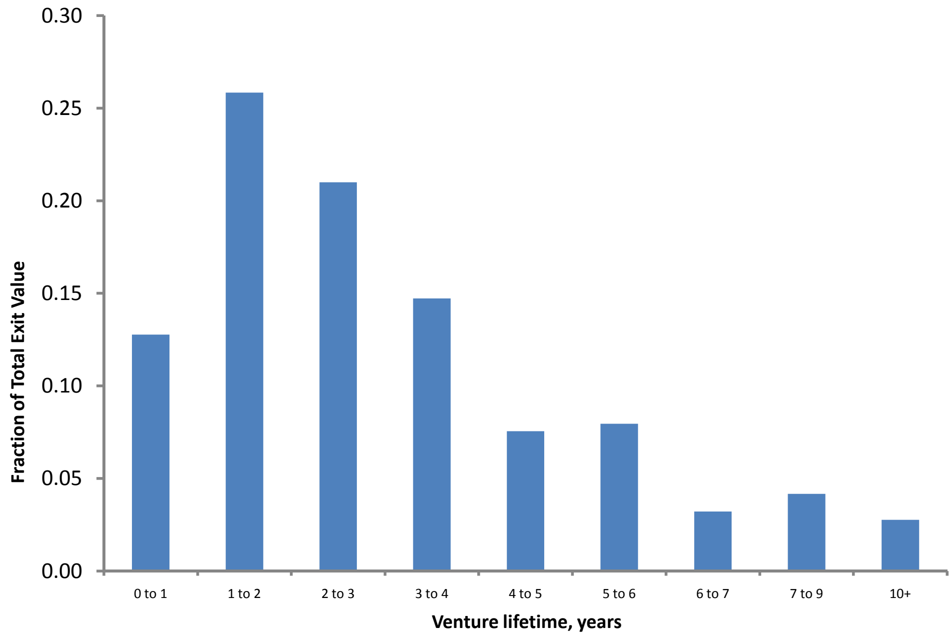

Figure 6: Fractions of Total Exit Value by Venture Lifetime

5 Economic Payoffs to Entrepreneurs

Venture-backed companies typically have a pair of scientists or similar experts, or a small group, who supply the original concept, contribute a small amount of capital, and find investors to supply the bulk of the capital. These entrepreneurs, together with any angels, own all of the shares in the company prior to the first round of venture funding.

The entrepreneurs are specialized in ownership of the venture-stage firm. Our approach to valuation takes account of the heavy exposure of the entrepreneur to the idiosyncratic volatility of the company. We also take account of the modest salaries that entrepreneurs generally receive during the venture phase of the development of their companies and of the lifetime of the company, which affects the discounting applied to the exit value and the burden of the low salary.

Our framework starts from a standard specification of intertemporal preferences for entrepreneurs—they order random consumption paths according to

$$\mathbb{E} \sum_t \left(\frac{1}{1+r}\right)^t u(c_t). \tag{5}$$

Here r is the entrepreneur's rate of time preference and the rate of return on assets; $u(c)$ is a concave period utility. We define the function $U(W)$ as the utility from a constant path of consumption funded by wealth W:

$$U(W) = \frac{1+r}{r}\, u\left(\frac{r}{1+r}W\right) \tag{6}$$

The multiplication by $\frac{1+r}{r}$ turns flow utility into discounted lifetime utility. The quantity $\frac{r}{1+r}W$ is the flow of consumption to be financed by the return on the wealth at rate r.

We distinguish between *wealth*, W_t, which measures the entrepreneur's total command over resources, and so incorporates the expected value of future compensation (human wealth), and *assets*, A_t, by which we mean holdings of non-human wealth such as securities. A_t does not include the entrepreneur's holdings of shares in the startup, which we classify as human capital. For an entrepreneur in year t of a startup that has not yet exited, we define $W_t(A_t)$ as the *wealth-equivalent* of the entrepreneur's command over resources, counting what remains of the entrepreneur's original non-human wealth, A_t, and the entrepreneur's random future payoff from the startup, conditional on not having exited to this time. Our definition is implicit: $U(W_t(A_t))$ is the expected utility from maximizing equation (5) over consumption strategies.

Now we let $U(W_t(A_t))$ be the value, in utility units, associated with an entrepreneur in a non-exited company t years past venture funding, as a function of current non-entrepreneurial assets A_t. We could have defined a value function $U_t(A_t)$ without interposing the function $W_t(A_t)$. Instead we let $W_t(A_t)$ be the value function, which means that we need to take the concave transformation $U(W_t(A_t))$ so that the Bellman equation adds up utility, according to the principle of expected utility. The slightly roundabout approach of stating our findings in terms of the wealth-equivalent $W_t(A_t))$ makes the units meaningful, whereas the units of utility are not. Further, in our benchmark case, utility is negative, a further source of confusion. Note that W captures initial assets, venture salary, venture exit value, and subsequent compensation in a post-venture position, when it is calculated at time zero for an entrepreneur.

The company has a conditional probability or hazard π_t of exiting at age t. At exit, it pays a random amount X_t to the entrepreneur. Upon exiting, the entrepreneur's value function is $U(W^*(A))$, where A now includes the cash exit value. The entrepreneur's consumption is limited by assets left from the previous year—no borrowing against future earnings may occur. The entrepreneur's dynamic program is

$$U(W_t(A_t)) = \max_{c_t < A_t} [u(c_t) + \frac{1}{1+r} \; (1-\pi_{t+1}) U(W_{t+1}((A_t - c_t)(1+r) + w)) \\ + \frac{1}{1+r} \pi_{t+1} \; \mathbb{E}_X \; U(W^*((A_t - c_t)(1+r) + X_{t+1}))] \quad (7)$$

The post-venture value function is

$$U(W^*(A)) = \frac{1+r}{r} \; u\left(\frac{rA + w^*}{1+r}\right). \tag{8}$$

Here w^* is post-venture compensation, including employee stock options, at the non-venture continuation of this company or another company. From equations (6) and (8), we have

$$W^*(A) = A + \frac{w^*}{r}. \tag{9}$$

Note that this is additive in A. But when future earnings are random, the entrepreneur's risk aversion enters the calculation of the wealth-equivalent.

We represent each of the value functions $U(W_t(A_t))$ as piecewise linear with 500 knots between zero and \$49 million, spaced exponentially. We calculate them by backward recursion (value function iteration). We assume power utility with constant relative risk aversion, γ. We take as our base case $\gamma = 2$, a venture salary of $w = \$150,000$, post-venture compensation of $w = \$300,000$, and starting assets of $A_0 = \$1$ million.

A useful feature of the wealth-equivalent is that the difference between its value for an entrepreneur with given initial assets and its value for an individual who holds a non-venture position paying w^* and with the same initial assets is the amount that the second would be willing to pay to become an entrepreneur. We call this the *certainty-equivalent value of the entrepreneurial opportunity* and denote it $\tilde{A}$. This property follows from the additivity of the non-entrepreneurial wealth-equivalent we noted earlier.

Figure 7 shows $W_0(A_0)$, the wealth-equivalent for an entrepreneurial experience as of its beginning and $W^*(A_0)$, the wealth-equivalent for a non-entrepreneur, both as functions of the common value of their initial assets, shown on the horizontal axis. The certainty-equivalent value of the venture opportunity is the vertical difference between the two curves. The non-entrepreneurial value is a straight line with unit slope—a dollar of extra initial assets becomes a dollar of wealth, because the non-venture individual faces no uncertainty. On the other hand, a dollar of extra initial assets becomes more than a dollar of equivalent wealth, because initial wealth has no uncertainty and thus dilutes the uncertainty from the

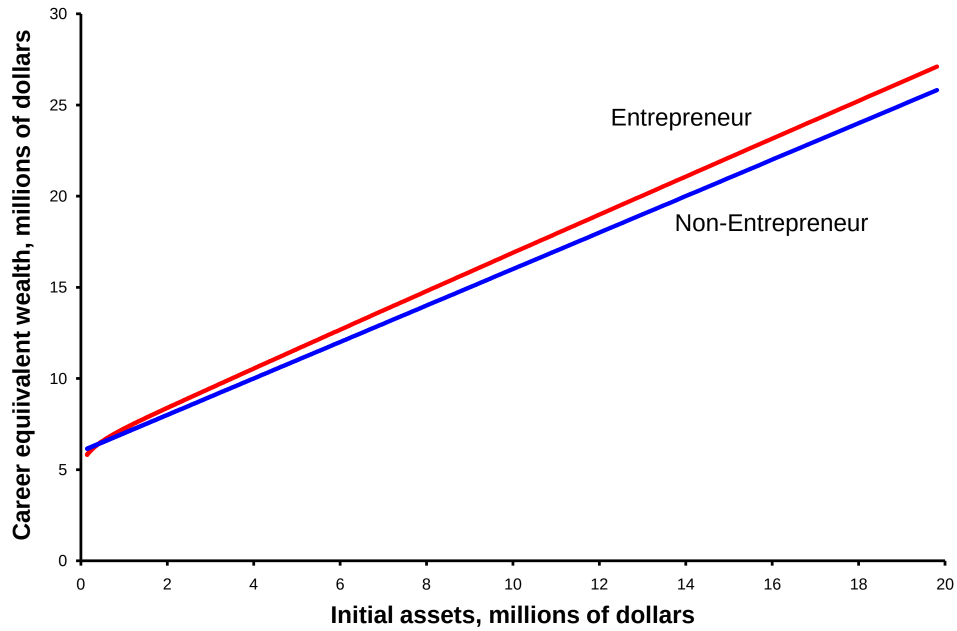

Figure 7: Certainty-Equivalent Career Wealth for Entrepreneurs and Non-Entrepreneurs

venture outcome. This finding is a cousin of the principle that people should treat risky outcomes as if they were worth essentially their expected values, when the outcomes are tiny in relation to their wealth. The slope of the entrepreneur's value is more than three at low levels of assets but declines to 1.03 at assets of $20 million.

The figure shows that, despite the chance of making hundreds of millions of dollars in a startup, the economic advantage of entrepreneurship over an alternative career is not substantial. The burden of the idiosyncratic risk of a startup falls most heavily on those with low initial assets. The entrepreneur with less than a million dollars of initial assets faces a heavy burden from the risk and has a lower career wealth than the non-entrepreneur.

Table 1 gives the certainty-equivalent value of the entrepreneurial opportunity for nine combinations of the three determinants: the coefficient of relative risk aversion, the compensation at an alternative, non-entrepreneurial job, and the entrepreneur's assets at the beginning of entrepreneurship. The first three lines take the entrepreneur to be risk-neutral, so the values are just present values at the 5-percent annual real discount rate. In this case, the value is the same for any level of initial assets. The value is $4.4 million. The value is $3.3 for an individual with a non-entrepreneurial opportunity to earn $600,000 per year. If the non-entrepreneurial opportunity pays $2 million per year, the venture opportunity has negative value. A typical startup cannot attract an established top executive from a large

Coefficient of relative risk aversion, γ	Compensation at non-entrepreneurial job, thousands of dollars per year	Certainty-equivalent of entrempreurial opportunity, millions of dollars		
		Assets at beginning, millions of dollars		
		1	5	20
0	300	4.4	4.4	4.4
0	600	3.3	3.3	3.3
0	2,000	-1.9	-1.9	-1.9
0.9	300	1.2	1.6	2.3
0.9	600	0.1	0.7	1.3
0.9	2,000	-9.0	-5.5	-3.7
2	300	0.2	0.6	1.3
2	600	-1.7	-0.3	0.3
2	2,000	-20.7	-10.2	-4.9

Table 1: Certainty-Equivalent Value of the Venture Opportunity

public corporation, even if the executive is risk-neutral, as their earnings are generally even higher than $2 million.

The conclusions from the table are similar if the individual is mildly risk-averse, with a coefficient of relative risk aversion of 0.9. The advantage of the entrepreneurial opportunity, stated as a wealth-equivalent, is only $1.2 million for an entrepreneur with $1 million in assets and only $2.3 million for an entrepreneur with $20 million. These figures become only slightly greater than zero if the non-entrepreneurial opportunity pays $600,000 per year.

At the standard value of the coefficient of relative risk aversion, 2, the advantage of the entrepreneurial opportunity is generally small or negative—deeply negative if the non-entrepreneurial opportunity pays $2 million per year. In our base case, with non-entrepreneurial compensation of $300,000 per year and $1 million in assets, the advantage of the entrepreneurial opportunity is only $0.2 million. The incentive is not impressive for larger asset holdings. With higher compensation at the non-entrepreneurial job, the advantage disappears unless the individual is quite rich.

6 Entrepreneurs in Aging Companies

Our discussion so far has focused on the risk-adjusted payoff to a potential entrepreneur at the decision point when venture funding first becomes available. In this section, we consider the same issue at later decision points, as the startup ages. Our discussion is conditional on the company not having exited.

The dynamic program of equation (7) assigns a value $W_t(A_t)$ to the entrepreneur's position in each year t that the company has not exited. Under our assumptions, the path is the same for all companies. The entrepreneur's value falls as the company ages for two reasons. First, the entrepreneur generally consumes out of assets, so assets decline. Second, early exits are the most valuable exits, so aging another year means that the remaining potential exit values are not as valuable. Figure 8 shows the path of $W_t(A_t)$. It declines from \$7.2 million at the outset to \$6.1 million at age 10, conditional on no exit. From that point, the value rises, because the distribution of exit values becomes more favorable, though not as favorable as for young startups.

The figure also shows the individual's value of a non-entrepreneurial job, $W^*(A_t)$. It declines as well, but only for the first reason, the draw-down of assets to finance consumption in excess of the low startup salary. In year 9, the entrepreneur would gain by leaving the startup and taking the non-entrepreneurial job. The prospect of a high-value exit has dimmed to the point that it no longer makes up for the difference between non-entrepreneurial compensation and the startup salary. What happens? Our dynamic program does not consider the possibility that the entrepreneur might resign at this point. It shows that it would be rational for the entrepreneur to agree, as of the inception of the startup, to stay with it until an exit occurred (we assume that every surviving company exits at age 17).

Although many disappointed entrepreneurs may stay with startup companies past the point where it pays off personally, the law does not permit enforcement of a contract requiring such loyalty. If it is collectively rational for all of the parties to a venture-backed startup (venture capitalists and investors) to keep the company in operation, they might increase the entrepreneur's salary sufficiently to keep the entrepreneur's value $W_t(A_t)$ equal to the non-entrepreneurial value, $W^*(A_t)$. The necessary amount of this salary augmentation appears at the bottom of Figure 8. It is tiny, never exceeding \$19,000 per year. Because the augmented salary arrives at a time when the entrepreneur's assets are depleted, it adds \$3 to W for each dollar of expenditure.

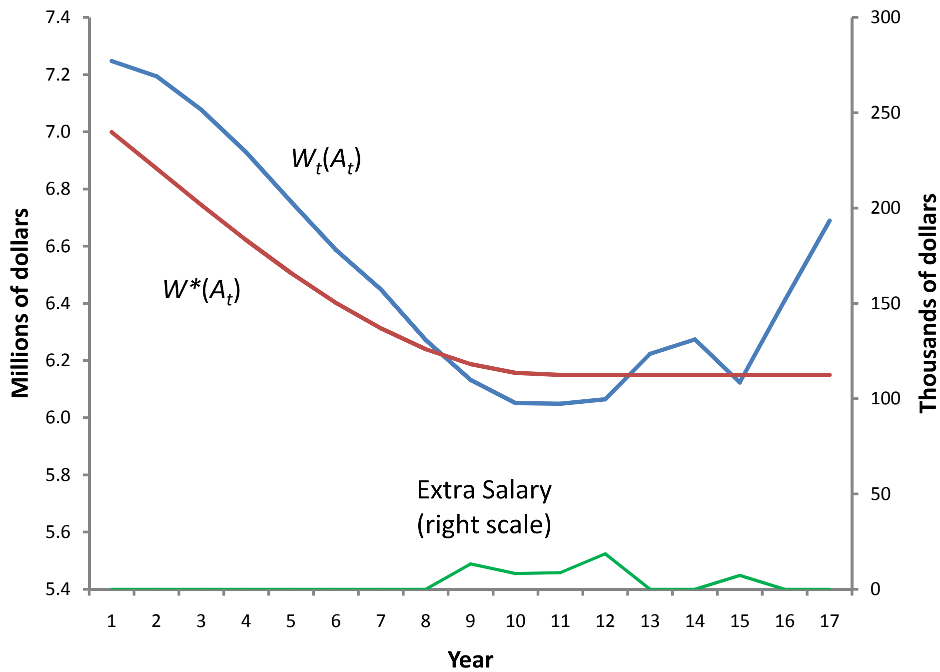

Figure 8: Entrepreneurial Value and Non-Entrepreneurial Value Prior to Exit

Figure 9 shows the paths of assets and consumption as a company ages. For the first decade, assets decline because consumption exceeds the modest startup salary and the entrepreneur has no other source of current cash, pending a favorable exit. During this period consumption declines, because, as an exit fails to occur during the early years, the entrepreneur learns that risk-adjusted well being, as measured by $W_t(A_t)$, has declined. Eventually assets fall to the point of consumption. From this point until exit, the entrepreneur lives on the salary and maintains assets only as a way to spread consumption between paychecks (we assume, for simplicity, that the entrepreneur receives the salary at the end of each year and we measure assets at the beginning of the year). The line labeled $c(W_t)$ shows the level of consumption that a consumer without a cash-flow constraint would choose, given lifetime prospects as measured by W_t. Consumption starts out only slightly below this level, but as the entrepreneur depletes assets, consumption falls toward the cash-flow limit. In the event that the startup ages into its second decade, the cash-flow constraint keeps consumption far below its unconstrained level.

Figure 10 shows the paths of assets, consumption, and unconstrained consumption for an entrepreneur who receives extra salary as needed to keep $W_t(A_t)$ at least as high as $W_t^*(A_t)$ in every year, thus removing the temptation to depart the startup while it may still be

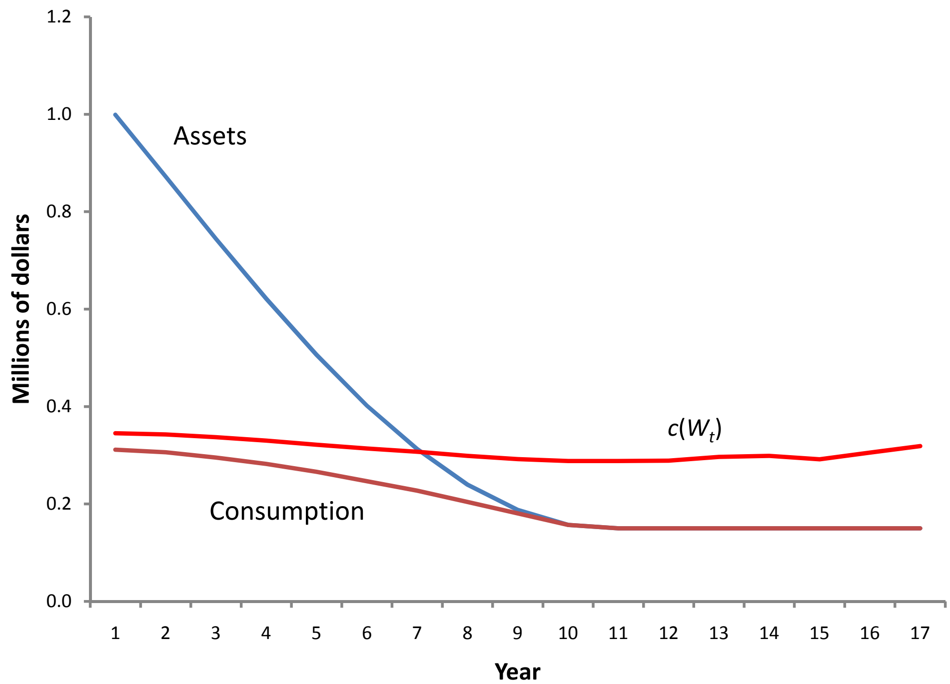

Figure 9: Consumption and Assets prior to Exit, No Extra Salary

viable. The entrepreneur with this assurance consumes more in years 4 through 9, when the promise begins to matter, and thus becomes cash-flow-constrained sooner. Consumption in the second decade is more irregular because of the uncertainty about exit year.

Keeping the entrepreneur's consumption low prior to exit is a key feature of the venture financing contract. The entrepreneur's incentive to make the startup successful depends on the entrepreneur's marginal utility. Keeping the entrepreneur hungry is an essential feature of the venture relationship. Our results show that entrepreneurs are hungry—in the sense that actual consumption is below the level they would choose given their certainty-equivalent wealth—at all times during the startup, but especially as the startup ages.

7 Sorting between Entrepreneurship and Employment

The coexistence of the entrepreneurial and employment contract forms for bringing new high-tech products to market presumably reflects heterogeneity on both sides of the market. Where powerful incentives are less important, large organizations will dominate because they can insure their workers. In this section, we examine sorting among individuals by deriving the crossover point for the choice of an individual between entrepreneurship and employment. We divide the three-dimensional space defined by risk aversion, alternative

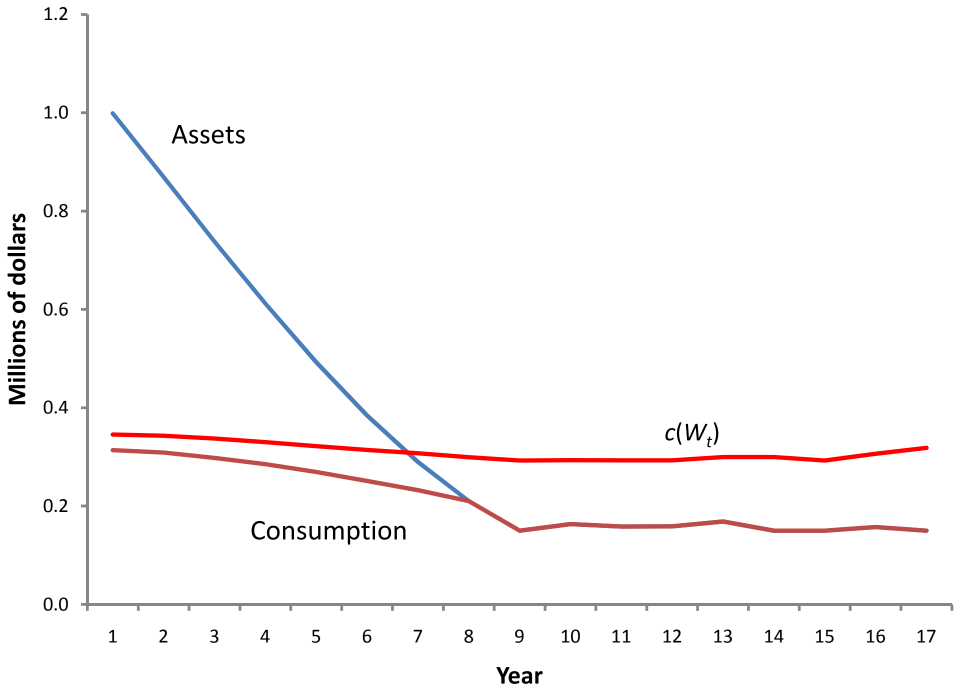

Figure 10: Consumption and Assets prior to Exit, with Extra Salary

employment compensation, and initial assets into two subspaces, one where the individual prefers to be an entrepreneur and the complement where the individual prefers to be an employee.

Figure 11 shows the surface separating the two subspaces, as a set of lines in the risk aversion-starting assets plane. Each line shows the dividing line in the plane corresponding to a different value of the compensation available at alternative employment. The area in the lower right of the figure describes individuals who opt for employment rather than entrepreneurship as long as employment pays \$300,000 per year or more. These people have high risk aversion and low starting assets. The region up and to the left contains people who are more inclined to be entrepreneurs because they are less risk-averse or have higher starting assets. It takes compensation of at least \$500,000 to attract them to employment rather than entrepreneurship. Similarly, the next region to the left has people even more inclined to entrepreneurship who require compensation of \$700,000 to overcome that inclination. The last region on the left contains those with very low risk aversion or low aversion and higher starting assets. These individuals require compensation above \$700,000 to choose employment over entrepreneurship.

Other characteristics may affect the sorting of engineers and scientists into entrepreneur-

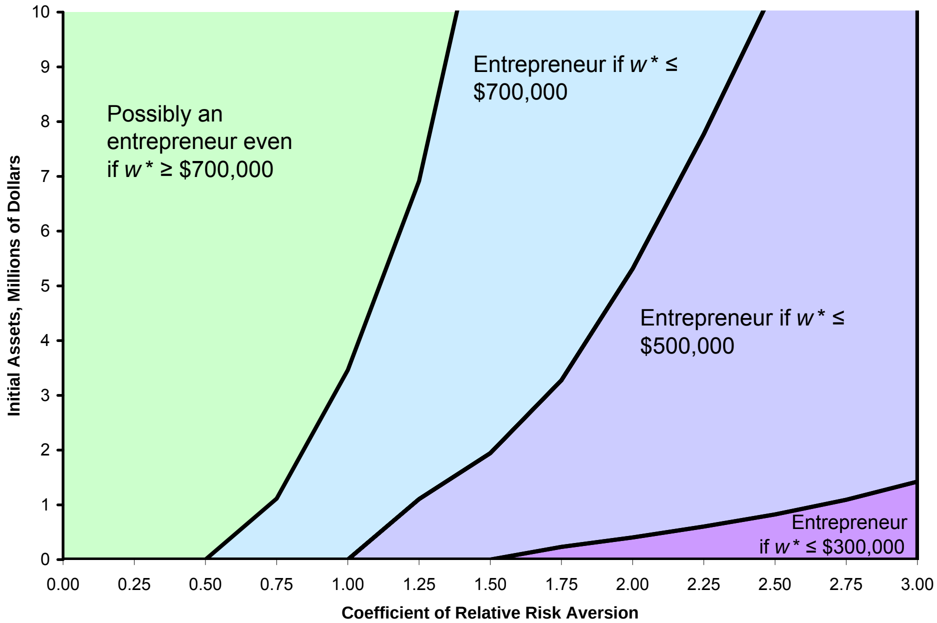

Figure 11: Sorting of Individuals into Entrepreneurship and Employment

ship and employment. Those with a preference for working in an organization they help manage or a distaste for an employment hierarchy will choose entrepreneurship even if they are located clockwise of the relevant line in Figure 11. Another possibility is that entrepreneurship attracts individuals who overestimate the likely payoffs from their ideas.

8 Discounting

We stress that the parameter r in our analysis is the rate of time preference and also the return earned on the entrepreneur's savings. It is not the financial discount rate or cost of funds of the startup company. Financial discounting is implicit in the dynamic program. We can illustrate the high implicit discount by a simple thought experiment. Suppose that an entrepreneur learned in year t that an exit would occur in the following year, and the entrepreneur were a security that paid off ϵX_{t+1} in year $t+1$, where ϵ is a small amount. Any individual trades off small values in one period against another period at the marginal rate of substitution. Thus the value the entrepreneur would ascribe to the security would be

$$\epsilon \, \mathbb{E}_X \, \frac{u'(c_{t+1})}{(1+r)u'(c_t)} X_{t+1} \tag{10}$$

The discount factor D_t is the ratio of this value to the expected value,

$$D_t = \frac{\mathbb{E}_X \ \frac{u'(c_{t+1})}{(1+r)u'(c_t)} X_{t+1}}{\mathbb{E}_X \ X_{t+1}} \tag{11}$$

In our base case, with coefficient of relative risk aversion of two, the discount factor D_t varies from 0.09 to 0.22 over the age of the company. Thus a claim that had an expected payoff of one dollar next year, in proportion to the distribution of the exit value next year, would be worth only \$0.09 to \$0.22 this year. Conceptually, the discount breaks down into a pure time element and an element relating to the fact that the amount of the exit value will become known next year. The pure time discount is just the 5 percent in $\frac{1}{1+r}$. All the rest of the discount comes from the uncertainty in the exit value. The reason that the entrepreneur puts such a low value on the payoff ϵX_{t+1} is that it delivers almost all its value in circumstances where the entrepreneur is rich and has low marginal utility. Notice that $D = \frac{1}{1.05}$ for a risk-neutral entrepreneur with constant marginal utility.

9 Serial Entrepreneurship

Gompers, Kovner, Lerner and Scharfstein (2008) report that about 12 percent of venture-backed entrepreneurs have served in that role in an earlier venture-backed startup. Our dynamic program, equation (7), does not consider that possibility. We could alter the program to include the 12 percent likelihood of future entrepreneurship, though this alteration would come at a considerable complication in calculating the value functions, because the same function would appear after the exit in the future and at time zero. The effect would be a slight increase in the value of entrepreneurship relative to employment. None of our conclusions would be significantly affected, because the probability of repeating as an entrepreneur is relatively small.

Our results have an interesting implication for serial entrepreneurship. Figure 11 shows that the choice between entrepreneurship and employment is sensitive to assets. A successful exit will give an entrepreneur a substantial level of assets, far up the vertical axis in the figure. Hence further entrepreneurship becomes far more attractive relative to employment after a success. Wealth from a successful earlier exit relieves the burden of the idiosyncratic risk of a second startup.

10 Concluding Remarks

The contract between venture capital and entrepreneurs does essentially nothing to alleviate their financial extreme specialization in their own companies. Given the nature of the gamble revealed in Figure 2, entrepreneurs would benefit by selling some of the value that they would receive in the best outcome on the right, when they would be seriously rich, in exchange for more wealth in the most likely of zero exit value, on the left. It would be hard to find a more serious violation of the Borch-Arrow optimality condition—equality of marginal utility in all states of the world—than in the case of entrepreneurs.

A diversified investor would be happy to trade this off at a reasonable price, given that most of the risk is idiosyncratic and diversifiable. But venture capitalists will not do this—they don't buy out startups at the early stages and they don't let entrepreneurs pay themselves generous salaries. They use the exit value as an incentive for the entrepreneurs to perform their jobs. Moral hazard and adverse selection bar the provision of any type of insurance to entrepreneurs—they must bear the huge risk shown in Figure 2.

The venture capital institutions of the United States convert ideas into functioning businesses. We show that the process contains an important bottleneck—for good reasons based mainly on moral hazard, the venture contract cannot insure entrepreneurs against the huge idiosyncratic risk of a startup. Risk-adjusted payoffs to the entrepreneurs of startups are remarkably small. Although our results are based entirely on the venture process, we believe that no other arrangement is much better at solving the problem of getting smart people to commercialize their good ideas.

The approach to the measurement of the burden of non-diversifiable risk developed in this paper applies to many other settings as well. Executives of large companies often have employment contracts exposing them to their employer's idiosyncratic risk. Employees in general are exposed to the idiosyncratic risks of their jobs and of their human capital. The self-employed, including authors, composers, and inventors, bear large amounts of undiversifiable idiosyncratic risk. Given panel data on the cash receipts of these people, one could apply the method of this paper directly.

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