Title
An Index for Venture Capital

Authors
Quigley, John M.
Woodward, Susan E.

Publication Date
2003-07-11

UNIVERSITY OF CALIFORNIA AT BERKELEY

Department of Economics

Berkeley, California 94720-3880

Working Paper No. E03-333

An Index for Venture Capital

John M. Quigley

University of California, Berkeley

Susan E. Woodward

Sand Hill Econometrics, Menlo Park, California

July 2003

Keywords: Private Equity, Price Index

JEL Classification: G2, E3, C4

Abstract

In this paper we build an index of value for venture capital. Our approach overcomes the problems of intermittent, infrequent pricing of private company deals by using a repeat valuation model to build the index, and it corrects for selection bias in the reporting of values. We use a unique data set from Sand Hill Econometrics. The index measures the return and risk for venture capital. Its covariance with other asset classes from 1987-1999 enables us to explore the role of venture capital in diversified portfolios during a period of increased importance of venture capital in the economy.

Previous versions of this paper were presented at the Financial Markets Conference sponsored by the Atlanta Federal Reserve Bank and the NYU Stern School of Business, Sea Island Georgia, May 2002, and at the Conference on Price Indices and Quality Change sponsored by the Zentrum für Europaïsche Wirtschaftsforschung, Mannheim, April 2002. An early version of this paper (Quigley, 2001) was prepared for Offroad Securities. We are grateful for the assistance of Shawn Blosser, Min Hwang, and Zach McRenolds and for the comments of Robert Gary-Bobo, Bruce Lehmann, and Robert Hall.

I. Introduction

Over the past decade, venture capital has grown from a tantalizing sideshow to a serious function of US capital markets. It is estimated that in 1990 about $3 billion flowed into venture funds, while in 2000 the corresponding figure was $103 billion. In 2000, the outstanding total value of such firms was roughly $500 billion; in comparison, the market value for companies listed on US stock exchanges was roughly $10 trillion. The economic importance of the privately held companies that seek financing from outside investors probably exceeds their current share of business value, because some of today's private companies will become high-value public companies in the future.

Some of the ownership interests in private companies are held directly as stock in the issuing company, and some are held as limited partnerships in venture capital funds. Holders are primarily pension plans, endowments, corporations, and wealthy individual investors. Companies funded by venture capital funds and those funded directly by primary investors find their way to the public markets. During the late 1990s, roughly two-thirds of the companies making initial public offerings had backing from venture capital funds and many of the others had substantial funding from outside primary investors. Investment in pre-public companies is no longer experimental or exploratory, but is a permanent feature of the U. S. financial landscape. Private equity,[1] the domain of venture capital, is here to stay.

There is little systematic information on the results of venture investments. By contrast, for publicly traded holdings, quantitative performance evaluation is straightforward. Standard

[1] By private equity we mean equity in *pre-public* companies. These firms raise money from outside investors with the hope and intention of becoming public corporations. We do not include leveraged buy-outs (LBOs), management buy-outs (MBOs), or private placements in otherwise public companies (PIPEs) in our analysis, although they are private in the sense that there are restrictions on the sale of these types of securities to the general public. Further, by common usage, "venture capital" refers to investments in pre-public companies both made through venture capital funds and made directly by primary investors. We thus use venture capital and private equity as synonyms.

indices, such as the S&P500 and the Wilshire 5000, provide measures of overall market returns. For non-traded holdings, such as venture capital, investors have no similar benchmark.

This paper builds an index for venture capital to provide a clear benchmark. Such a benchmark is useful for evaluating the performance of particular venture holdings, for evaluating the performance of specific funds, including venture capital limited partnerships, corporate venture funds, and venture holdings of pension and endowment funds that invest both directly and indirectly in private deals, for comparing the performance of venture capital with that of other asset classes, for determining the appropriate portfolio allocations of different asset classes; and for other applications as well.

There are two major problems in constructing such an index. First, pricing events for private companies are intermittent and infrequent, not regular and almost continuous as for traded securities. A price is set for stock in an individual company when it raises new money, when it sells shares to the public (through an IPO), when it is acquired, or when it ceases operations. These companies are "private" — their stock is not registered with the Securities and Exchange Commission (SEC), they do not report financial results to the SEC or to the public unless they choose to, and their stock is not traded in any organized market. Nearly all such companies are organized as C-corporations (and are thus themselves taxable entities). These companies may be valued only a handful of times during the interval between establishment and IPO, acquisition, or ceasing operations[2]. Moreover, because they are private, disclosures are voluntary. Hence, even when they are valued, they need not reveal the price at which they sold stock in their most recent round. More important for our analysis is the fact that companies may

[2] Private companies that raise money from outside investors and cease operations can do so either through windup or shutdown (in principle creditor's bills are paid) or through Chapter 7 bankruptcy liquidation. If there is no hope for a company, the board of directors is obliged to wind it up rather than continue struggling until remaining assets can no longer satisfy creditors. Windups (or shutdowns) are far more frequent than bankruptcies.

simply forgo an opportunity to raise money if they find the available terms unappealing. In other words, some trades happen and the prices at which they occur are reported, some trades occur but price is not reported, and some potential trades do not occur at all.

To measure movements in the value of these privately held firms over time, we develop a method for creating a standardized price index for such firms. We build the index using a modern hybrid version of the repeat-sales technique introduced by Bailey *et al*. (1963) for measuring housing prices, and we correct it for selection bias. There are two steps to building the index. In the first step, to measure the degree of bias in the transactions that do reveal value, we use all of the pricing events for all of the companies for which we have data (both those that reveal value and those that do not) to estimate the probability that a company will reveal value (through an IPO, acquisition, private funding, or by ceasing operations). We then use this estimated probability in constructing the index by a repeat-sales method that uses only the transactions for companies which revealed value at least twice, thus creating an observable return in some interval. The approach is similar to that used to construct price indices for residential real estate by government agencies (OFHEO), government-sponsored enterprises (Freddie Mac and Fannie Mae), and private firms such as MRAC, Inc, and to construct quality-adjusted measures used by the U.S. Department of Commerce in reporting the prices of other durable goods. The novelties in our application lie in the extension of the repeat sales approach to private companies, the correction for selection bias made necessary by the non-random nature of the reporting of transactions, and the analysis of a timely and unique data set.

The unit of observation is a pricing event for a private company. This includes any private round of fund raising, which necessarily produces a company value (reported or not) determined by negotiation between the issuing company and its investors (which may include venture capital limited partnerships, individuals, and corporations). Pricing events also include

IPOs, acquisitions, and windups or bankruptcies. The index thus reflects gross returns from direct investments in the companies, not the returns to venture fund limited-partner investors after the fees and expenses of their funds.[3]

Others have acknowledged the importance and difficulty of estimating returns for private equity investments. Bygrave and Tymmons (1992) calculated average internal rates of return for completed venture funds; they reported an average annual return of 13.5 percent from 1974 to 1989, using an approach that provides no risk measurement. Reyes (1997) used a set of 175 completed venture capital funds to calculate betas, and found them to lie between 1 and 3.8. Gompers and Lerner (1997) reported an arithmetic average annual return of 30.5 percent on completed venture funds from 1972 to 1997. Long (1999) calculated risk by inferring the shorter-term standard deviation from variations in longer-term returns, and reported an estimate of the annual standard deviation of 8.23 percent per year for completed venture funds. This analysis was based upon nine unidentified, successful VC investments. Moskowitz and Vissing-Jorgenson (2000) measured returns to all private equity, conceived very broadly to include closely held businesses with no intention of going public and no money from outside investors. They used data from the Survey of Consumer Finances, including self-reported valuations. They were puzzled that the returns were so low.[4] Chen, Baierl, and Kaplan (2000) examined completed venture funds to calculate average annual arithmetic and geometric returns, standard deviations, and correlations with market indices. They reported a geometric average return of 13 percent, an annual standard deviation per fund of 115.6 percent, and a correlation with the public stock market of 0.04. None of this work considers selection bias.

[3] Venture capital funds typically charge their limited partner investors an annual management fee of two to three percent of net asset value, and then also take 20 to 35 percent of the gains (20 percent is a standard "carry," while 35 percent is a "premium carry") on the companies with positive returns when they are acquired or go public.

Two pieces of research on venture risk and return that do address the selection issue are Cochrane (2001) and Peng (2001). Both use a subset of our data that was available earlier. These data are for venture-backed firms only, primarily from the VentureOne database (described below). Both analyze returns only for rounds of funding for firms that have exited, that is, gone public, been acquired, or been wound up (perhaps through bankruptcy). Cochrane uses a maximum likelihood approach to estimate return, standard deviation, and correlation with the market. His approach thus estimates risk and return directly only for firms which have exited and without building an index. Peng builds an overall index by first building two indices, one for exits that arise from windup and one for all others that have exited. He corrects for selection bias crudely, by assigning weights to the two sub-indices based on the likelihood that companies will go out of business or will succeed (estimated from observable characteristics). His results using this simple approach indicate that the beta for private equity is high (2.4), even though its correlation with the S&P500 is very low (0.04). He also finds that the beta on the NASDAQ is higher still (4.7), and the correlation with the NASDAQ is substantial (0.52). Peng and Cochrane measure returns gross of venture expenses and carry.

In Section II we describe the economic problem and review the models that have been employed in analogous settings to develop price indexes. Section III provides a detailed description of data on start-up firms used to estimate a price index for this sector of the economy. Section IV reports our principal empirical results, measurement of a price index corrected for selection bias. Section V explores an application of this analysis to portfolio allocation. Section VI is a brief conclusion and discussion of future work.

---

[4] Companies issuing pre-public private equity are a tiny fraction of private businesses. There are more than 20 million companies that file income tax returns. Roughly 5 million have a payroll. Of these, roughly 1.5 million are organized as C corporations.

II. Indices of Price and Valuation

Methods for estimating market prices for heterogeneous goods or for items traded infrequently have received considerable attention among applied econometricians and finance professionals. Methods to account for the heterogeneity of goods were extended in the early 1970s (Kain and Quigley, 1970, Griliches, 1971) and have been applied quite widely in the analysis of durables, such as automobiles (Otha, 1971), housing (Kain and Quigley, 1975), and home appliances (Hausman, 1979). Hedonic price models account for the heterogeneity of commodities by regressing the observed transaction prices or market values, V_t, (or sometimes, in the case of automobiles, list prices) on a vector, $X_t=(x_{1t}, x_{2t}, \ldots, x_{nt})$ describing the qualitative and quantitative attributes of the goods. The estimated coefficients, b, represent the implicit marginal prices of each attribute.

$$(1) \qquad V_{\mathrm{t}} = b_0 + \sum_{i=1}^{n} b_i x_{it} + \sum_{\tau=1}^{t} p_\tau \delta_\tau + \varepsilon_{\mathrm{t}} \qquad ,$$

where δ_τ is an indicator variable with a value of one for all time periods up to t, and p_τ is the change in prices during period τ. ε_t is a random error with mean zero.

It is often assumed that the statistical relationship is semi-logarithmic. The underlying logic is that market value V is the product of price P times quantity X, i.e.,

$$(2) \qquad V_t = X_t P_t \ .$$

The logarithm of the transaction price is regressed upon variables measuring the physical characteristics of the commodities x_{it} and dummy variables representing time δ_t. In this formulation, $\exp\left(\sum_{\tau=1}^{t} p_\tau \delta_\tau\right)$ is the price index at t.

Despite the popularity of the semi-log form, it has been shown that few economically meaningful restrictions can be placed on the form of the hedonic relationship (Rosen, 1974). Because theory provides little guidance in the formulation of statistical models of hedonic prices and because many durables are traded infrequently in thin markets, repeat-sales methods have been developed to abstract from measuring the hedonic characteristics of these goods.

Consider the difference between transaction prices measured at t and T.

$$(3) \qquad V_t - V_T = \sum_{i=1}^{n} b_i\left(x_{it} - x_{iT}\right) + \sum_{\tau=T}^{t} p_\tau \delta_\tau + \left(\varepsilon_t - \varepsilon_T\right) \ .$$

If the form of the hedonic price function is semi-logarithmic and if the characteristics of the commodity are unchanged between sales, the model reduces to

$$(4) \qquad V_t - V_T = \sum_{\tau=T}^{t} p_\tau \delta_\tau + \left(\varepsilon_t - \varepsilon_T\right) \ ,$$

where the left hand side is a logarithmic difference.

The advantage of this formulation is that, for repeat sales of unchanged commodities, it is not necessary to measure the detailed characteristics of the commodities to estimate the price index implied by equation (1). In the forty years since they were introduced (Bailey, *et al.*, 1963), these models have been applied extensively to the housing market, and they form the basis for most commercially developed measures of local housing price variation (for example, indexes marketed by MRAC, Inc., and by CSW, Inc.) as well as the regional housing price information produced by the Federal Government (the OFHEO house price series for states and metropolitan areas). Goetzmann (1993) applied the same technique to valuing.

The repeat-sales method encounters two major challenges. First, multiple sales may be non-random samples of the underlying population (Englund, *et al.*, 2000). If the objective is to estimate the value of the stock of the asset, rather than merely the value of those units that have been sold in any period, this selection bias may be important. In an application to private companies, it seems clear that firms receiving financing at any point in time are those whose prospects are more promising than are those of other firms. Thus, bias in sample selection is potentially quite important. Second, characteristics of the product may change.

To address these issues, a variety of hybrid models have been developed. These models combine the desirable properties of hedonic and repeat sales estimators. For example joint estimation of equations (1) and (3) for single sales and repeat sales combine hedonic adjustments with changes in market value.

$$V_t = b_o + \sum_{i=1}^{n} b_i x_{it} + \sum_{\tau=1}^{t} p_\tau \delta_\tau + \varepsilon_t \tag{5a}$$

$$V_t - V_T = \sum_{i=1}^{n} b_i^* (x_{it} - x_{iT}) + \sum_{\tau=T}^{t} p_\tau^* \delta_\tau + (\varepsilon_t - \varepsilon_T) \tag{5b}$$

(5c) $b_i = b_i^*$ for all i , and

$p_\tau = p_\tau^*$ for all τ .

More general hybrid specifications with more realistic specifications of the error structure are also possible. (See Englund, *et al*., 1998, for a survey and application.)

A sensible specification of the error structure in (5) may be a first-order autogressive process,

$$\varepsilon_{it} = \lambda \varepsilon_{i,t-1} + \eta_{it} \quad , \tag{6}$$

where η_{it} is a white-noise innovation.

$$\begin{aligned} & E(\eta_{it}) = E(\varepsilon_{it}) = E(\eta_{it}\varepsilon_{it}) = 0 \\ & E(\eta_{it}^2) = \sigma_\eta^2 \\ & E(\varepsilon_{it}^2) = \sigma_\eta^2 \end{aligned} \tag{7}$$

The original Bailey, *et al*. (1963) model assumes the $\lambda = 0$ while the Case-Shiller (1987) model assumes $\lambda = 1$.

In this formulation, the error variances in equations (5a) and (5b) are:

$$(8a) \qquad Var(\varepsilon_{it}) = \frac{\sigma_\varepsilon^2}{1-\lambda^2} + \sigma_\eta^2 \qquad .$$

$$(8b) \qquad Var(\varepsilon_{it} - \varepsilon_{i\tau}) = \frac{2\sigma_\varepsilon^2(1-\lambda^{t-\tau})}{1-\lambda^2} + 2\sigma_\eta^2 \qquad .$$

Estimation of the model can be accomplished in a three-step procedure. First, equation (5a) is estimated using the sample of repeat valuations. Second, the squared residuals are used to estimate λ. This is a straightforward nonlinear estimation that can be accomplished by a grid search, yielding a consistent estimate. Third, equation (5) is re-estimated by weighted least squares. The weights are the reciprocals of the square roots of the right-hand side of equation (8) using the λ from the second stage.

Now consider selection bias. The bias arises because successful firms are more likely to attract additional rounds of private equity finance, are more likely to reveal value when they do attract money, are more likely to be acquired by publicly traded firms, and are more likely to raise capital through an initial public offering. In any period, we observe that firm *j* reveals its value, if the revelation index of that firm, F_{it}, exceed some threshold, F_{tj}^o . Let

$$(9) \qquad F_{tj} = \gamma_o + \sum_{i=1}^{m} \gamma_i z_{itj} + \eta_{tj} \qquad ,$$

where $Z_{tj} = (z_{1tj}\,,\ z_{2tj}\,, \ldots, z_{mtj})$ are the characteristics of firm *j* at time *t* that affect funding and other aspects of value revelation, and η_{tj} is a random error. The revelation index depends positively on the firm's need to obtain funding and negatively on the firm's value in relation to its earlier value. We observe a firm's value only at the time of a revelation event, $F_{tj} > F_t^o$. Thus, the expectation of equation (1) for firm *j* is

$$(10) \qquad E\left(V_{tj}\right) = b_o + \sum_{i=1}^{n} b_i x_{itj} + \sum_{\tau=1}^{t} p_\tau \delta_\tau + E\left(\varepsilon_{tj} \middle| F_{tj} > F_t^o\right) .$$

Similarly, from equation (3)

$$(11) \qquad E\left(V_{tj} - V_{Tj}\right) = \sum_{i=1}^{n} b\left(x_{itj} - x_{iTj}\right) + \sum_{\tau=T}^{t} p_\tau \delta_\tau = E\left(\left[\varepsilon_{tj} \middle| F_{tj} > F_t^o\right] - \left[\varepsilon_{Tj} \middle| F_{Tj} > F_T^o\right] \right) \quad .$$

Clearly, the coefficients estimated from equation (10) or (11) are biased if the conditional expectation of the error term is not zero. Following Heckman (1979), we model the process that selects firms into the set of observations of those funded.

Let I_{tj} be an indicator variable with a value of 1 if firm *j* reveals its value at time *t* and zero otherwise, and let

$$(12) \qquad prob\left(I_{tj} = 1\right) = prob\left(F_{it} > F_t^0\right) = \Phi\left(\gamma_o + \sum_{i=1}^{m} \gamma_i z_{itj} \right) ,$$

where Φ is the standard normal distribution, and γ is a set of parameters. Further assume that the correlation of the random element of this selection model, η, and the random element of value, ε, is ρ. Without loss of generality, we can assume that the variance of η is one. Then the bias term in equation (10) becomes:

$$(12A) \qquad E\left(\varepsilon_{tj} \middle| F_{tj} > F_t^o\right) = \rho\sigma \frac{\phi(\gamma Z_{tj})}{1 - \Phi\left(\gamma Z_{tj}\right)},$$

where ϕ is the standard normal density and $\omega_{tj} = \dfrac{\phi\left(\gamma Z_{tj}\right)}{1 - \Phi\left(\gamma Z_{tj}\right)}$ is the inverse Mills ratio. Its inclusion in the valuation regression yields unbiased estimates of the parameters in the presence of non-random sample selection. The selection bias-corrected valuation model associated with equation (11) is

$$V_{tj} - V_{Tj} = \sum_{i=1}^{n} b\left(x_{itj} - x_{iTj}\right) + \sum_{\tau=T}^{t} p_{\tau}\delta_{\tau} + \theta\left(\omega_{tj} - \omega_{Tj}\right) + \left(\varepsilon'_{tj} - \varepsilon'_{Tj}\right) \tag{13}$$

where θ is a parameter. We can thus obtain unbiased estimates of the price movement of private equity firms using the non-random sample of firms whose valuations are actually observed.

III. Data

The data used to estimate the venture index come from the Sand Hill Econometrics database and cover the period from January 1, 1987 through March 31, 2000 – the period covering the rise in the importance of private equity and ending just before the market declines of the second quarter of 2000. Construction of this database began with data purchased from proprietary data vendors and has since been substantially augmented by Sand Hill's own research. Substantial effort was invested to make the data suitable for analytical purposes – eliminating duplicate rounds of funding (by matching company names, dates of funding, and amounts raised, both electronically and by consolidating multiple closings of the same round) and obtaining precise exit dates for companies that have been shut down, been acquired, or gone public.

As reported in Table 1, the data contain 5,607 unique firms with financing data for a total of 12,553 rounds of funding, including 9,706 rounds of private-equity financing, plus 1,307 IPOs, 896 acquisitions, and 644 shutdowns. The average valuation of private firms rises with each round of funding through round 3, but is lower for the small fraction of firms, about five percent, which report funding in rounds 4 through 9. At rounds designated "later," the average firm valuation is higher than at round 4, \$110.5 million versus \$96.6 million; at the mezzanine round, the average firm valuation is $124.8 million. For those firms acquired by publicly traded corporations, the average valuation is $125.6 million, and it is almost double that for IPOs.

Appendix Table A2 reports the status of development of these firms at the time of financing. More than half of the financing rounds occurred when the firms were delivering product, goods or services, to customers. Almost a quarter of the rounds occurred while the product was in development. In another 6 percent of the cases, the product was in beta testing or clinical trials, and in another 6 percent of the cases, the firm was a new startup. It is clear from the table that later rounds of financing are associated with more advanced stages of product development.

Seventy-seven percent of those rounds labeled mezzanine took place after the firm was shipping products to customers. Eighty-two percent of the acquisitions took place after the firm was shipping product to customers. More than a third of the companies were profitable at the time of their IPO.

Table 2 reports more detail on the firms that exited from the data set via IPO, acquisition, or shutdown. For each of these exits, the table reports the type of the preceding financing round, the average firm valuation, and the amount raised at that previous round. The table also reports the average valuation at exit. The table documents the enormous growth in the value of firms exiting through an IPO (and it points out the one firm that went from a $3M seed-round firm to a $1.6B IPO. This firm retains an exclamation point in its corporate name.)

Equally stunning is a comparison of the amount raised in the penultimate private round for different exit types. For firms exiting via IPO, the penultimate round raised about $10 million on average. The average time interval between the penultimate around of financing—between the last round of private equity finance and the exit is also quite short—a year or two for IPOs, and two or three years for acquisitions. The table also reports the substantial declines from the average value in the previous round for those firms that are shut down. The volatility in the valuation of these firms is quite striking.

IV. Empirical Analysis

We estimate the probability that a firm will undergo a new round of private equity financing, an IPO, an acquisition or a bankruptcy by analyzing the event histories of all firms in our data. We observe each firm each half year, beginning in 1987 or when the firm is first recorded in the data set. During each half-year, we observe whether it was valued through a new round of private equity finance, an IPO, an acquisition or a bankruptcy. We observe its business group in one of four categories. We record its development status at the last round of financing and the round class at the last round. We compute the elapsed time between the last round of private equity finance and the beginning of the funding period. We also measure the S&P Index for public equity at the beginning of the funding period.

Table 3 reports separate probit models for these four types of valuation based upon these valuation events. The coefficients relate the probabilities of observing private equity finance, an IPO, an acquisition, or a bankruptcy to firm characteristics: business group, current development status, and current round class.

Most of the coefficients are precisely estimated. Firms in the healthcare, IT, retail and service sectors are less likely to receive private equity funding than other firms. Healthcare firms are less likely to be involved in an IPO, but firms in the retail and service sectors are more likely to be acquired, other factors equal.

Firms that are already profitable are much more likely to receive additional private equity funding, but are much less likely to receive funding through an IPO. Conversely, firms in the product development or beta testing phases are less likely to receive funding than companies at other stages, while firms in beta testing are more likely to receive funding through an IPO. Not surprisingly, in any given half-year, firms which had been reported to be unprofitable in the previous half year are more likely to shut down or go bankrupt.

Firms are more likely to receive private equity financing (and to cease operations) at earlier funding rounds, but are much more likely to do an IPO or be acquired after later rounds of financing. Firms are more likely to receive external funding from any source when the elapsed time to the last injection of funds is longer, but they are also more likely to cease operations. IPOs and windups are more likely when stocks (the S&P500) are at higher values.

We use these models to estimate the probability that each firm will experience each of these events in each period. The sum of these four probabilities estimates the probability that a firm will be valued and will thus appear as an observation in the analysis sample in each period. The inverse Mills ratio, calculated from this probability, performs the role of correcting selection bias.

Table 4 reports the coefficient estimates for the valuation models. For comparison, the simple repeat valuation model, equation (3), is presented as well as the hybrid model, equation (5), estimated by generalized least squares. Results are reported both with and without the bias correction factor.[5] For all models the dependent variable is expressed in logarithms; the coefficient can thus be interpreted as the percentage change in firm valuation associated with a one-unit change in each independent variable.

As the table indicates, later rounds of financing are generally associated with higher firm valuations. In particular, mezzanine round of private finance, acquisitions, and IPOs are associated with higher valuations. Firms reporting profits are valued substantially higher, by about 25 percent, than other firms at the same round in the same line of business.

The importance of sample selection bias in the statistical models is quite large indeed. The difference in valuation between a firm that has a 10 percent probability of having a pricing event in the sample (ω=0.1/0.9=0.11) and one that has a 90 percent probability (ω=0.9/0.1=9.0) is more than 50 percent. Correcting for selection bias influences both the level and precision of the measure of the value of the stock of private equity which we impute from the sample of firms receiving funding in any period. The coefficients of the selection bias-corrected models are more precisely estimated, and the coefficients of the more efficiently estimated hybrid model differ from those of the uncorrected model.

Each valuation model also includes a set of variables representing time in half years beginning with the first half of 1987. Figure 1 graphs the nominal price index derived from these variables as well as the 95 percent confidence interval of that index. The figure is based upon the preferred specification: the bias-corrected hybrid model of valuation reported in Table 4, column 4. The index tracks the valuation of a "standardized" venture firm (where firms are standardized by the characteristics reported in Table 3). The figure reports that this index of venture company prices remained stable between 1987 and 1992 in nominal terms (from an index value of 100.00 to 104.52), before increasing steadily until 1998 (to 181.60) and then increasing abruptly in 1999 (to 444.37).

---

[5] The estimates of σ_ε^2, σ_η^2, and λ associated with the hybrid models are 0.1752, 0.0958, and 0.9190 respectively for the model reported in column 3 and 0.1748, 0.0964, and 0.9150 for the model reported in column 4.

V. An Application

The price index derived in the previous section facilitates some suggestive *ex post* comparisons between investment in venture capital and investment in other financial instruments such as common stocks. Of course, with current institutional arrangements, it is quite easy to invest in a pool of common stocks, for example in a mutual fund or derivative of the S&P500. While venture capital was growing in importance during the 1990s (measured by the amounts outstanding), it is directly accessible as an investment for individuals only if they are "accredited" investors, while indirect investments for individuals are possible through pension funds. In this section, we illustrate the potential role for private equity funds in investment portfolios and assess the possible improvements in the risk/return frontier made possible by including venture capital in a portfolio. Specifically, we consider a fund or an index whose experience tracks the value of firms in the Sand Hill database during the period 1987-2000. As noted above, this database is the nearest thing to a comprehensive inventory of the venture capital sector.

We consider the allocation of an investment portfolio among three types of equities whose prices are indexed by: the S&P500; the NADAQ index; and the private equity index (PEI) derived in the previous section. We also consider investors' opportunities to invest in long-term bonds or T-bills.[6] We ignore holdings of human capital and owner-occupied housing. Figure 2 indicates the course of real returns to investments in the S&P500, the NASDAQ Index, private equity, and long-term bonds during the period 1987-2000. Returns are measured semi-annually, as of June 30 and December 31. Returns on private equity are measured by the change in the PEI minus the consumer price index, in percent. Returns on other equities are measured

---

[6] We use the average rates on 90-day T-bills and 30-year bonds from the CRISP database.

similarly by the real percentage change in the relevant index. For bond returns we use the average real return for US Treasury 30-year bonds, and T-bills are measured by the average 90-day rate.

Table 5A reports the means, standard deviations, and the correlations among real returns during the period. The average return on T-bills is 1.23 percent per year, while for bonds it is over two percent. Real returns on private equity averaged more than five percent, substantially less than the S&P500. Returns to the NASDAQ index averaged 9.66 percent. Private equity is substantially more volatile than the S&P500, and slightly more volatile than the NASDAQ. These are gross returns, not adjusted for transactions costs. The venture capital returns are not adjusted for the expenses or carry of the venture general partners.

Returns on T-bills and bonds are moderately correlated while returns to investment in the S&P500 index and the NASDAQ index are more highly correlated. In contrast, there is essentially no correlation between the return on private equity investment and the return on other assets. This suggests that there is some role for private equity investment in the portfolios of qualified investors. The estimated beta between the venture deals and the S&P500 is 0.04, and between the venture deals and the NASDAQ it is 0.30. About a third of the variance in the Private Equity Index is "explained" by the S&P500 and the NASDAQ. These regressions are reported in Table 5B.

Table 6 compares the weights on these five asset classes in optimal portfolios with varying risk and return characteristics. The portfolios, derived by standard Markowitz techniques, represent the weights on a portfolio of these five assets that minimize the variance in the total return at a given level of the expected return. Panel A presents the portfolio allocations in the absence of investment opportunities in private equity. In the left side of the table, the portfolios place no restrictions on short sales, but they do restrict the portfolio weights so that investors place no more than +/- 300 percent of their wealth in any single asset. Panel B indicates the portfolio allocations when private equity is included as an investment asset. In the absence of private equity, the optimal strategy, based on the experience of the 1990s, was to go long in the S&P500 and to finance the investment through borrowing in bonds and T-bills. At higher risks, the S&P Investment is at the constraint, 300 percent of wealth, and the portfolio shifts to greater reliance upon NASDAQ.

When investments in venture capital are permitted, a large fraction of the portfolio is shifted into the PEI at the highest levels of risk. The reliance upon the NASDAQ is reduced substantially as the portfolio of assets shifts to the PEI, and the short position on T-bills (borrowing) falls.

It is worth noting that, except at the lowest level of risk, the optimal portfolios never include short positions on equities. Investors borrow by selling short T-bills and bonds and using the proceeds to buy equities. The decade of the 1990s was an unusually good period to have invested in equities, in case you had not noticed.

The right side of Table 6 presents comparable information when no short positions are permitted on any asset. Again, Panel A presents the portfolio allocations in the absence of investment opportunities in private equity. When borrowing is not permitted, the risk-return profile is substantially affected. At low levels of risk, investors' portfolios include T-bills and the S&P500. At higher levels of risk, investors' portfolios are concentrated in the NASDAQ index.

When private equity investment is permitted, in Panel B, investment in common stocks is reduced modestly, and investments in venture capital are not negligible. At moderate levels of risk, the portfolio includes a 10-15 percent allocation to venture capital. At higher levels of risk, all investment is concentrated in the NASDAQ.

Figure 3 illustrates the effect of venture investment upon the efficient frontier linking risk and return. As indicated in Figure 3A, when borrowing against bonds and T-bills is allowed, the introduction of venture capital into the portfolio increases investor returns by about one percentage point (per half year) for risky portfolios, and by much less for safer portfolios. When short sales are not permitted, Figure 3B, average risks and returns to any portfolio are sharply reduced. At moderate levels of risk, the introduction of private equities increases the risk-adjusted rate of return by as much as a quarter percent (per half year). At higher levels of risk, however, venture capital plays no role, as the optimal investment portfolio is a pure NASDAQ play.

VI. Conclusion

This paper reports a method for building an index of venture capital that can be used in much the same manner that the NASDAQ and the S&P500 are used as indices of the prices of common stocks. Because venture capital is traded infrequently in thin markets, the technique uses a repeat-sales approach plus a correction for the selection bias present in the observations on value for private equities.

The approach is used to estimate an index for venture capital using the Sand Hill database, a comprehensive database of pricing events for venture companies' private rounds of funding and ultimate disposition. The estimated price index is rather flat in nominal terms between 1987 and 1995, after which it rises steadily until 1998, and abruptly through 1999. It falls sharply in the last half year, 1999 II, for which we have data. The confidence interval widens considerably in 1999.

The price index does permit some investigation of the role of private equity in diversified portfolios. An analysis of the optimal allocation among T-bills bonds, common stocks, and private equity indicates some role for private equity investment. In very risky portfolios, in which investors sell short T-bills and bonds, optimal investment shares are 20-50 percent of wealth in venture capital and 200-300 percent of wealth in the S&P500 and the NASDAQ. In more realistic portfolios, in which short positions are not permitted, the portfolios of risk-tolerant investors may allocate 10-15 percent of wealth to venture capital. The inclusion of venture capital in a portfolio could increase returns at the same levels of risk by something less than one percentage point.

References

Bailey, Martin H., Richard F. Muth, and Hugh O. Nourse, 1963, "A Regression Method for Real Estate Price Index Construction," *Journal of the American Statistical Association*, 4, 1963: 933-942.

Bygrave, William D., and Jeffrey A. Timmons, 1992, *Venture Capital at the Crossroads*, Boston: Harvard Business School Press.

Case, Bradford and John M. Quigley, 1991, "The Dynamics of Real Estate Prices," *Review of Economics and Statistics*, 73(1): 50-58.

Case, Karl E. and Robert J. Shiller, 1987, "Prices of Single-Family Homes Since 1970: New Indexes for Four Cities," *New England Economic Review*, September/October, 45-56.

Cochrane, John H., 2001, "The Risk and Return of Venture Capital," NBER Working paper.

Englund, Peter, John M. Quigley and Christian Redfearn, 1998, "Improved Price Indexes for Real Estate: Measuring the Course of Swedish Housing Prices," *Journal of Urban Economics*, 44: 171-196.

Englund, Peter, John M. Quigley and Christian L. Redfearn, 1999, "Do Housing Transactions Provide Misleading Evidence about the Course of Housing Prices?" *Journal of Real Estate Finance and Economics*, 19(2): 91-112.

Fenn, George W., Nellie Liang, and Stephen Prowse, 1995, "The Economics of the Private Equity Market," Board of Governors of the Federal Reserve, Staff Report #168, November.

Goetzmann, William N., 1993, "Accounting for Taste: Art and the Financial Markets over Three Centuries," *American Economic Review*, 83(5): 1370-77.

Goetzmann, William N. and Liang Peng, 2000, "The Bias of the RSR Estimator and the Accuracy of Some Alternatives," *Real Estate Economics*, forthcoming.

Gompers, Paul A. and Josh Lerner, 1997, "Risk and Reward in Private Equity Investments: The Challenge of Performance Assessment," *Journal of Private Equity* (Winter): 5-12.

Gompers, Paul A. and Josh Lerner, 2000, "Money Chasing Deals? The Impact of Fund Inflows on Private Equity Valuations," *Journal of Financial Economics*, 55: 281-325.

Griliches, Zvi, 1971, *Price Indexes and Quality Change*, Cambridge, MA: Harvard University Press.

Hausman, Jerry A., 1979, "Individual Discount Rates and the Purchase and Utilization of Energy Using Durables," *Bell Journal of Economics*, 1-(1): 33-54.

Kain, John F. and John M. Quigley, 1970, "Measuring the Value of Housing Quality," *Journal of the American Statistical Association*, 65(44): 532-548.

Kain, John F. and John M. Quigley, 1975, *Housing Markets and Racial Discrimination*, New York: Columbia University Press, for NBER.

Long, Austin M. III, 1999, "Inferring Period Variability of Private Market Returns as Measured by λ from the Range of Value (Wealth) Outcomes over Time," *Journal of Private Equity*, 5: 63-96.

Otha, Makoto, and Zvi Griliches, 1975, "Automobile Prices Revisited: Extensions of the Hedonic Price Hypothesis," in *Household Production and Consumption*, N.E. Terleckyj, ed., Chicago, IL: University of Chicago Press.

Moskowitz, Tobias J., and Annette Vissing-Jorgenson, 2000, "The Private Equity Puzzle," working paper, University of Chicago.

Peng, Liang, 2001, "Building a Venture Capital Index," working paper, Department of Economics, Yale University. liang.peng@yale.edu

PriceWaterhouseCoopers, LLP, 2000, "Venture Capital Investment Level," *Moneytree U.S. Report: Full Year and Q4: 1999 Results*, www.pwcmoneytree.com.

Reyes, Jesse E., 1997, "Industry Struggling to Forge Tools for Measuring Risk," *Venture Capital Journal*, Venture Economics, *Investment Benchmarks: Venture Capital.*

Rosen, Sherwin S., 1974, "Hedonic Prices and Implicit Markets," *Journal of Political Economy*, 82(1): 34-55.

VentureOne, 2000, "State of the Market," *Venture Edge*, Winter.

Venture Economics, 2001, press release at http://www.ventureeconomics.com

Zellner, Arnold, 1962, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests of Aggregation Bias," *Journal of the American Statistical Association*, 57: 500-509.

Table 1

Summary of Private Financing Information By Round of Financing

Round	Number of Observations[a]	Mean Value of Firms
Seed	566	3,554,028
1st Round	3,353	32,636,252
2nd Round	2,522	50,141,038
3rd Round	1,450	96,650,060
4th Round	414	89,391,308
5th Round	151	38,379,338
6th Round	50	28,416,800
7th Round	10	26,380,000
8th Round	2	14,700,000
9th Round	1	24,400,000
"Later" Round	794	110,418,606
"Mezzanine" Round	387	124,592,831
"Restart"	38	10,751,579
IPO	1,318	241,668,350
Acquisition	899	125,185,462
Bankruptcy	644	1[b]
Total:	12,599	

Notes:

a. Observations include those financing rounds with information on post-round valuation of the company and the date of the financing round, for January 1, 1987 through March 31, 2000.

b. Value at bankruptcy is assumed to be negligible and is assigned a value of $1.

c. Rounds that occurred after a "re-start" for a given company are included in the numbered rounds above (i.e., the first round after a re-start is included in the "1st Round" figures above).

Source: See text for details of data assembly.

Table 2

Summary of Private Financing Information
Final Financing Round Information for Firms that have Exited

	Number of Firms	Mean number of Days Between Exit & Preceding Round	For Preceding Round: Mean Valuation Pre-Round	For Preceding Round: Mean Valuation Post-Round	At Exit: Mean Valuation
IPOs whose Preceding Financing Round was…					
Seed	1	371	2,000,000	3,000,000	300,300,000
1st Round	120	756	21,834,500	29,874,917	204,016,583
2nd Round	207	601	41,936,570	53,867,729	324,817,072
3rd Round	192	557	64,504,479	76,564,375	265,026,833
4th Round	67	679	66,395,224	73,031,194	177,428,806
5th Round	24	720	49,375,000	55,724,167	173,611,667
6th Round	8	627	23,091,250	26,612,500	89,705,000
7th Round	1	68	63,500,000	67,000,000	161,100,000
8th Round	0				
9th Round	0				
"Later" Round	194	450	106,765,722	123,886,856	323,741,495
Mezzanine	247	317	69,976,883	81,002,632	200,925,951
"Re-start"	2	620	18,185,000	26,935,000	190,650,000
Acquired Firms whose Preceding Financing Round was…					
Seed	18	784	2,952,222	4,597,222	28,063,889
1st Round	155	766	10,624,065	14,807,548	119,188,194
2nd Round	145	701	25,331,379	33,091,241	140,007,241
3rd Round	112	721	36,005,625	43,430,625	88,616,875
4th Round	45	985	23,383,333	28,145,333	42,118,000
5th Round	13	1,011	29,756,154	33,565,385	43,676,923
6th Round	10	795	23,210,000	28,320,000	50,704,000
7th Round	0				
8th Round	0				
9th Round	0				
"Later" Round	48	818	33,514,792	39,476,250	202,685,417
Mezzanine	40	724	56,834,750	67,346,500	87,495,250
"Re-start"	2	1,271	5,300,000	8,500,000	14,180,000
Windup Firms whose Preceding Financing Round was…					
Seed	26	1,745	1,196,154	1,909,615	1
1st Round	119	1,649	7,301,261	10,962,353	1
2nd Round	102	1,786	9,862,647	14,399,902	1
3rd Round	85	1,852	20,879,412	27,279,412	1
4th Round	27	2,024	20,970,370	25,472,222	1
5th Round	18	2,524	24,055,556	28,933,333	1
6th Round	3	2,786	23,600,000	33,000,000	1
7th Round	3	2,714	15,666,667	18,833,333	1
8th Round	1	3,232	7,600,000	8,300,000	1
9th Round	0				
"Later" Round	25	1,396	22,739,600	27,638,400	1
Mezzanine	11	1,838	40,772,727	49,190,909	1
"Re-start"	7	1,292	2,535,714	5,028,571	1

Source: See text for details of data assembly.

Table 3
Probit Models of the Probability of New Private Equity Finance, IPO, Acquisition and Bankruptcy by half year, 1987-2000
(t-ratios in parentheses)

	Private Equity	IPO	Acquisition	Bankruptcy
Business Group				
Healthcare	-0.170 (4.15)	-0.172 (2.35)	0.053 (0.83)	0.119 (1.31)
Information Technology	-0.207 (5.24)	-0.060 (0.85)	-0.069 (1.14)	0.078 (0.92)
Retail & Services	-0.188 (4.44)	-0.071 (0.93)	0.235 (3.45)	0.048 (0.52)
Development Status[a]				
Product Development	-0.208 (8.28)	-0.103 (1.53)	0.103 (2.18)	-0.159 (2.54)
Beta Testing	-0.256 (5.66)	0.324 (2.42)	0.097 (1.19)	-0.156 (1.42)
Clinical Trials	-0.055 (0.92)	-0.332 (3.37)	0.303 (2.51)	-0.084 (0.57)
Product Shipping	-0.036 (1.43)	-0.226 (3.63)	-0.025 (0.58)	-0.088 (1.50)
Profitable	0.313 (8.13)	-0.615 (9.08)	-0.073 (1.30)	-0.334 (3.33)
Restart	0.111 (1.39)	0.054 (0.35)	-0.077 (0.69)	-0.271 (1.89)
Round Class[a]				
Round 1	0.263 (9.88)	-0.588 (4.21)	-0.201 (3.32)	0.231 (3.30)
Round 2	0.333 (11.45)	-0.886 (6.33)	-0.353 (5.63)	0.129 (1.76)
Restart	0.505 (17.33)	-1.254 (9.04)	-0.426 (6.91)	-0.051 (0.72)
Later Round	0.323 (4.15)	-0.665 (3.10)	-0.264 (2.02)	-0.086 (0.54)

Table 3 (Continued)
Probit Models of the Probability of New Private Equity Finance, IPO, Acquisition and Bankruptcy by half year, 1987-2000
(t-ratios in parentheses)

	Private Equity	**IPO**	**Acquisition**	**Bankruptcy**
Interval[b] (thousands)	0.5471 (37.20)	0.229 (10.14)	0.028 (1.78)	0.343 (21.31)
S&P Index ($x10^3$)	0.007 (1.42)	0.052 (5.12)	0.014 (1.48)	0.200 (6.17)
Time[c]	-0.008 (3.31)	-0.030 (5.80)	-0.024 (5.05)	-0.168 (8.60)
Constant	0.589 (12.18)	3.280 (20.73)	2.547 (28.52)	4.963 (18.70)
Number of zeros	42282	50032	49869	50708
Number of ones	9070	1320	1483	644

Notes

a. Development Status and Round Class are recorded for the round of financing immediately preceding the current half-year.
b. Interval is the number of days (in thousands) from the last round of financing to the beginning of the current half-year.
c. Time is measured in half years, beginning in 1987.

Table 4
Valuation of Private Equity Firms

	Uncorrected Models		Selection bias-corrected Models	
	Repeat	**Hybrid**	**Repeat**	**Hybrid**
Financing Round :				
Seed				
	15.130	15.026	15.317	14.868
	(174.19)	(271.13)	(176.13)	(263.15)
Round 1	15.868	15.979	15.971	15.821
	(234.08)	(395.60)	(237.06)	(376.52)
Round 2	16.392	16.739	16.506	16.572
	(263.52)	(429.39)	(267.06)	(405.07)
Round 3	16.392	17.211	16.825	17.032
	(263.52)	(430.19)	(277.80)	(403.82)
Round 4	16.716	17.402	16.972	17.235
	(274.24)	(356.81)	(253.79)	(343.05)
Round 5	16.849	17.435	17.048	17.260
	(250.37)	(270.60)	(209.32)	(263.31)
Round 6	16.900	17.346	17.122	17.188
	(206.37)	(175.57)	(148.41)	(173.42)
Round 7	16.945	16.762	16.763	16.701
	(146.17)	(92.95)	(77.39)	(93.00)
Round 8	16.646	17.146	16.597	16.991
	(76.48)	(39.48)	(35.41)	(39.29)
Round 9	16.372	17.583	16.791	17.431
	(34.75)	(28.80)	(28.22)	(28.67)
Later Round	16.599	17.449	16.962	17.285
	(27.75)	(395.82)	(264.05)	(378.45)
Mezzanine	16.834	17.761	17.128	17.594
	(260.39)	(359.07)	(257.63)	(345.61)
Restart	16.976	16.105	15.754	15.848
	(253.73)	(115.31)	(112.29)	(112.83)
IPO	15.619	18.278	17.545	18.116
	(110.71)	(428.44)	(277.61)	(409.33)
Acquisition	17.386	17.329	16.980	17.198
	(273.44)	(387.68)	(267.29)	(376.90)

Table 4

(Continued)

	Uncorrected Models		Selection bias corrected Models	
	Repeat	**Hybrid**	**Repeat**	**Hybrid**
Development Status:				
Startup	0.198 (1.26)	-0.189 (2.66)	0.174 (1.12)	-0.227 (3.21)
Product Development	0.346 (2.28)	0.074 (1.14)	0.376 (2.48)	0.015 (0.24)
Beta Testing	0.423 (2.71)	0.152 (2.10)	0.436 (2.81)	0.078 (1.07)
Clinical Trials	0.374 (2.33)	0.148 (1.91)	0.365 (2.28)	0.095 (1.23)
Product Shipping	0.419 (2.77)	0.206 (3.28)	0.415 (2.76)	0.151 (2.42)
Profitable	0.605 (3.95)	0.355 (5.23)	0.592 (3.88)	0.392 (5.79)
Restart	-0.256 (1.49)	-0.626 (6.51)	-0.182 (1.06)	-0.626 (6.54)
Business Group:				
Healthcare		0.276 (4.31)		0.195 (3.05)
Information Technology		0.487 (7.83)		0.400 (6.42)
Retail & Services		0.334 (4.97)		0.288 (4.30)
Mill's Ratio			-0.094 (6.82)	-0.082 (12.96)
R^2 adjusted	0.864	0.914	0.864	0.916
Number of Observations	12553	9263	12553	9263

Note: The hedonic model, equation (1) in the text, includes observations on 12,553 rounds of financing on 5,607 firms and is estimated by ordinary least squares. The hybrid model, equation (5a), (5b) and (5c) in the text, includes observations on 6,920 pairs of firm valuations and 2,343 individual valuations of firms. This model is estimated by generalized least squares. All models also include 26 dummy variables representing time in half years beginning with 1987 II.

Table 5

A. Means, Standard Deviations, and Correlations among Five Asset Returns

	T-bills	Bonds	Private Equity	S&P 500	NASDAQ
Mean	0.0125	0.0190	0.0406	0.0543	0.0651
Standard Deviation	0.0066	0.0799	0.1456	0.0911	0.1445
Correlations :					
T-bills	1.0000	0.3742	0.1604	0.2275	0.0779
Bonds		1.0000	-0.3154	0.3807	0.2079
Private Equity			1.0000	0.0439	0.2966
S&P 500				1.0000	0.8403
NASDAQ					1.0000

B. Regression of Private Equity Index on the S&P500 and NASDAQ indexes
(t-statistics in parentheses)

	1	2	3
S&P 500	0.029		-1.156
	(0.078)		(2.599)
NASDAQ		0.429	0.911
		(2.260)	(3.617)
Constant	1.039	0.598	1.299
	(0.394)	(2.840)	(3.944)
R^2	0.0003	0.1754	0.3627

Table 6

Optimal Portfolios

Four Financial Instruments and Private Equity

A. Unrestricted Portfolios

Four Financial Assets

Returns	Risk	T-bills	Bond	S&P500	NASDAQ	Private Equity
0.0121	0.0062	1.0302	-0.0211	-0.0206	0.0115	0.0000
0.0422	0.0631	0.4366	-0.2063	0.8778	-0.1082	0.0000
0.0722	0.1257	-0.1570	-0.3915	1.7763	-0.2279	0.0000
0.1022	0.1885	-0.7505	-0.5767	2.6747	-0.3475	0.0000
0.1323	0.2535	-1.3517	-0.6192	3.0000	-0.0292	0.0000
0.1623	0.3259	-1.9572	-0.5807	3.0000	0.5378	0.0000
0.1923	0.4022	-2.5626	-0.5422	3.0000	1.1048	0.0000
0.2224	0.4807	-3.0000	-0.6955	3.0000	1.6955	0.0000
0.2524	0.5639	-3.0000	-1.3478	3.0000	2.3478	0.0000
0.2824	0.6512	-3.0000	-2.0000	3.0000	3.0000	0.0000

Four Financial Assets and Private Equity

Returns	Risk	T-bills	Bond	S&P500	NASDAQ	Private Equity
0.0117	0.0058	1.0605	-0.0320	-0.0365	0.0264	-0.0184
0.0441	0.0621	0.1709	-0.0697	0.9568	-0.2558	0.1978
0.0766	0.1238	-0.7188	-0.1074	1.9501	-0.5380	0.4140
0.1091	0.1856	-1.6084	-0.1451	2.9434	-0.8201	0.6302
0.1416	0.2536	-2.4881	0.0352	3.0000	-0.3741	0.8270
0.1741	0.3307	-3.0000	-0.1271	3.0000	0.2233	0.9038
0.2066	0.4185	-3.0000	-0.7855	3.0000	0.9702	0.8153
0.2390	0.5126	-3.0000	-1.4439	3.0000	1.7171	0.7268
0.2715	0.6102	-3.0000	-2.1023	3.0000	2.4641	0.6382
0.3040	0.7137	-3.0000	-3.0000	3.0000	3.0000	1.0000

B. No Short Positions

Four Financial Assets

Returns	Risk	T-bills	Bond	S&P500	NASDAQ	Private Equity
0.0125	0.0066	1.0000	0.0000	0.0000	0.0000	0.0000
0.0184	0.0151	0.8602	0.0000	0.1398	0.0000	0.0000
0.0242	0.0269	0.7205	0.0000	0.2795	0.0000	0.0000
0.0300	0.0392	0.5807	0.0000	0.4193	0.0000	0.0000
0.0359	0.0516	0.4410	0.0000	0.5590	0.0000	0.0000
0.0417	0.0641	0.3012	0.0000	0.6988	0.0000	0.0000
0.0475	0.0766	0.1615	0.0000	0.8385	0.0000	0.0000
0.0534	0.0891	0.0217	0.0000	0.9783	0.0000	0.0000
0.0592	0.1109	0.0000	0.0000	0.5421	0.4579	0.0000
0.0651	0.1445	0.0000	0.0000	0.0000	1.0000	0.0000

Four Financial Assets and Private Equity

Returns	Risk	T-bills	Bond	S&P500	NASDAQ	Private Equity
0.0125	0.0066	1.0000	0.0000	0.0000	0.0000	0.0000
0.0184	0.0144	0.8512	0.0000	0.1213	0.0000	0.0274
0.0242	0.0254	0.7018	0.0000	0.2413	0.0000	0.0569
0.0300	0.0369	0.5524	0.0000	0.3613	0.0000	0.0863
0.0359	0.0484	0.4030	0.0000	0.4813	0.0000	0.1157
0.0417	0.0600	0.2536	0.0000	0.6013	0.0000	0.1452
0.0475	0.0717	0.1042	0.0000	0.7212	0.0000	0.1746
0.0534	0.0855	0.0000	0.0000	0.8339	0.0560	0.1101
0.0592	0.1109	0.0000	0.0000	0.5421	0.4579	0.0000
0.0651	0.1445	0.0000	0.0000	0.0000	1.0000	0.0000

Note : “Returns” are average semi-annual investment returns; “risks” is the standard deviation of returns. Entries are portfolio weights imposing the constraint that investment in no single asset can exceed |300 percent| of wealth.

Appendix Table A1

Summary of Private Financing Information By Firm and Type of Business

	Total Number of Firms[a]	Number of Firms with Usable Financing Data[b]
Business Group		
Healthcare	1,621	1,332
Information Technology	4,194	3,107
Retail & Cons/Bus Prod/Serv	1,736	1,016
Other	214	152
Total Business Group:	7,765	5,607
Business Segment		
Biopharmaceuticals	519	451
Healthcare	338	256
Medical Devices	556	471
Medical IS	207	153
Other Medical	1	1
Communications	930	690
Electronics	585	472
Information Services	643	397
Semiconductors	274	218
Software	1,755	1,327
Other IT	7	3
Consumer Products	206	127
Consumer Services	1,167	642
Retailers	360	245
Other Retail	3	2
Other Companies	214	152
Total Business Segment:	7,765	5,607

Notes:

a. Includes all companies in the merged V1-VE database between January 1, 1987-March 31, 2000.

b. Includes only companies that have had one financing round for which information on pre- and post-round valuation of the company is available.

Source: See text for details of data assembly.

Appendix Table A2

Status of Development by Financing Round for Firms Receiving Private Financing

	Start-Up	Product in Development	Product in Beta Testing	Product in Clinical Trials	Product Shipping	Firm Profitable	Firm Re-Starting	N/A	Total
Seed	342	156	5	3	58	0	0	2	566
1st Round	367	1,331	96	38	1,354	140	17	10	3,353
2nd Round	6	768	121	63	1,420	113	7	24	2,522
3rd Round	0	243	69	63	975	70	9	21	1,450
4th Round	0	52	11	18	257	41	10	25	414
5th Round	0	9	3	1	102	15	4	17	151
6th Round	0	2	0	2	32	10	1	3	50
7th Round	0	0	0	0	7	1	1	1	10
8th Round	0	0	0	0	2	0	0	0	2
9th Round	0	0	0	0	1	0	0	0	1
"Later" Round	0	56	16	23	575	111	13	0	794
Mezzanine	0	48	7	29	220	78	0	5	387
"Restart"	0	0	3	0	8	1	26	0	38
IPO	0	111	5	71	667	451	0	13	1,318
Acquisition	2	99	23	14	554	182	3	22	899
Bankruptcy	9	103	18	11	400	36	15	52	644
Total:	726	2,978	377	336	6,632	1,249	106	195	12,599

Source: See text for details of data assembly.

Figure 1

Price Index for Private Equities
(1987H1 = 100)

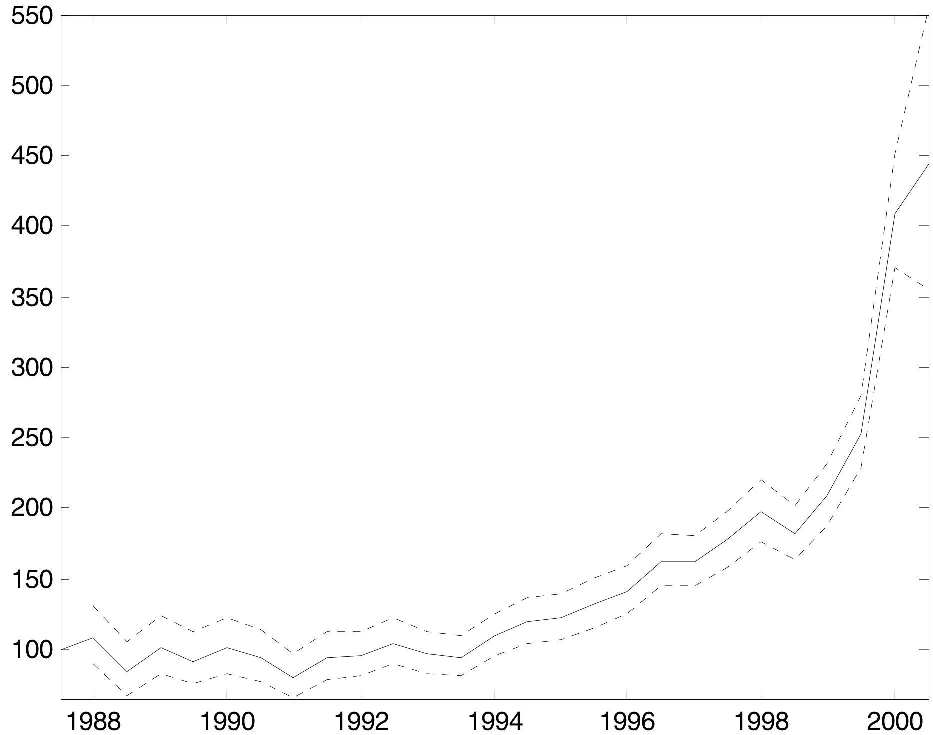
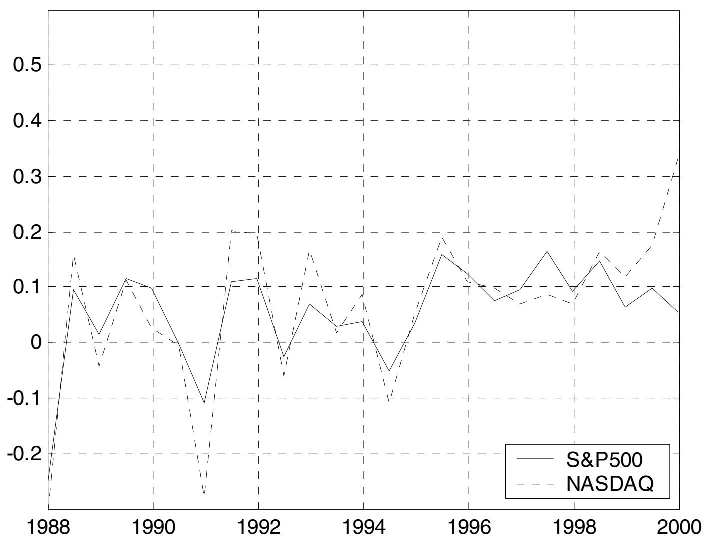


Figure 2
Semi-annual return for Private Equity, Long term Bonds, the S&P 500 and NASDAQ Index, 1997H1 – 1992H2

A. Returns on S&P 500 and NASDAQ



B. Returns on Long Term Bonds and Private Equity

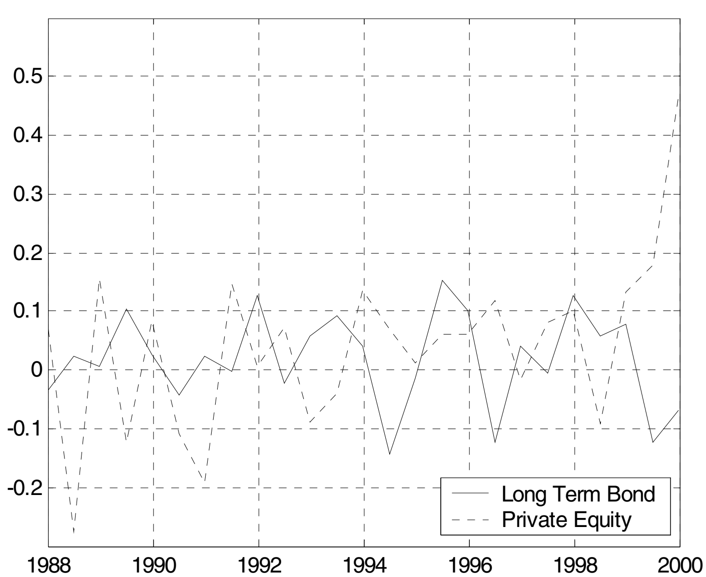
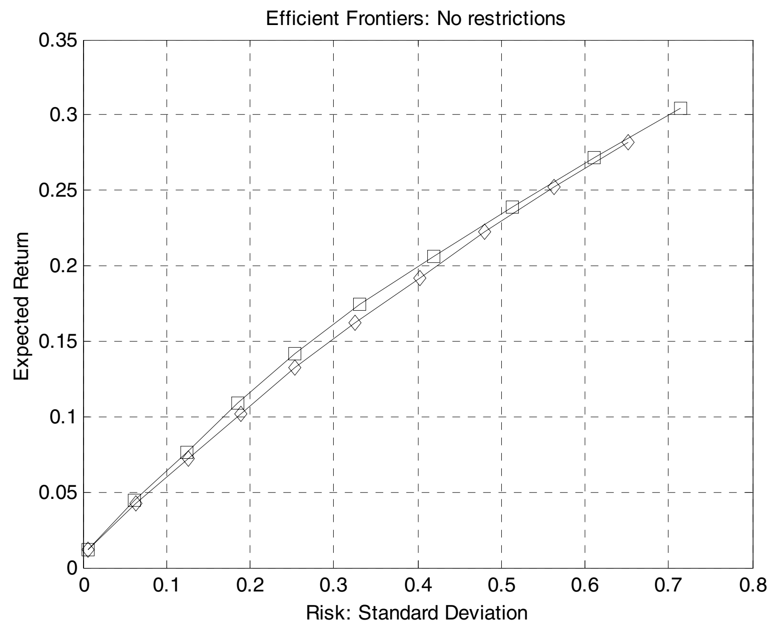


Figure 3

Efficient Frontiers

A. No Restrictions



B. No Short Sales