An empirical examination of factors that influence venture capital investment and the location of funds

Sandra Phillips Johnson

University of Nevada, Las Vegas

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AN EMPIRICAL EXAMINATION OF FACTORS THAT INFLUENCE VENTURE CAPITAL INVESTMENT AND THE LOCATION OF FUNDS

by

Sandra Phillips Johnson

Bachelor of Science
University of Nevada, Las Vegas
1995

A thesis submitted in partial fulfillment of the requirements for the

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Department of Economics
College of Business

Graduate College
University of Nevada, Las Vegas
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Master of Arts in Economics

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ABSTRACT

An Empirical Examination of the Factor That Influence Venture Capital Investment and the Location of Funds

by

Sandra Phillips Johnson

Dr. Nasser Daneshvary, Examination Committee Chair
Professor of Economics
University of Nevada, Las Vegas

Entrepreneurs who contribute to economic growth have looked to venture capital firms as a major source of financing. This thesis tests the significance of explanatory variables for investment in venture capital at both the national and regional levels. The explanatory variables predicting national new investment in venture capital include capital gains tax rates, stock market pricing, risk premiums, and regulations on pension fund investment. Further, this thesis examines whether the location of venture capital funds depends on research and development funds at universities within a state, state corporate income tax burdens, state unemployment rates, and average weekly earnings within a state.
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CHAPTER I

INTRODUCTION

The venture capital industry has emerged as an important component of America's private equity market. This market includes professional investment partnerships, such as venture capital firms, that acquire significant stock holdings of unregistered, private companies. Venture capital partnerships have provided hard-to-find financing for entrepreneurs. And, many entrepreneurs have been credited with fueling economic growth through the process of technological innovation.

Technological innovation, as the Office of the President noted, "is responsible for a significant portion of the increases in the standard of living." Indeed, Robert M. Solow, recipient of the 1987 Nobel Prize in economics, pointed to technological innovation as a critical source of a country’s economic growth. Venture capital investment has funded innovators such as Federal Express and many of today’s leading

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high technology firms, including Genetech, Microsoft and Intel. What, then, are the economic factors that impact this market?

Today's formal venture capital investment industry evolved during the late sixties. Therefore, much of the data necessary to study this industry covers a relatively brief time frame. However, research on venture capital has identified several economic variables thought to influence new investment flows. Minarik (1992), Proterba (1989), and Bygrave and Shulman (1988) have investigated the effects of capital gains taxation on venture capital investment. Studies have also examined the state of stock markets for small-capitalized companies as an explanatory variable of new venture capital investment. Additionally, the venture capital industry has been studied from a regional perspective. Among others, Green (1991), Florida and Kenney (1988b), and Leinbach and Amrhein (1987) have studied regional patterns of venture capital investment or high technology location factors. Their research identified several factors, including mature financial centers and proximity to large research and development universities, as attractors of venture capital to a state or region.

Although a wealth of research has focused on venture capital, many questions remain regarding the effects of capital gains taxation. The effects of risk premiums on

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venture capital investment also merits empirical examination. Further, a need exists for empirical scrutiny of economic factors that influence the location of venture capital funds.

Our national legislators frequently engage in debate on the effects of increases or decreases in capital gains tax rates upon businesses and economic growth. Empirical knowledge of how such changes impact venture capital can lead to better informed decisions. In addition, with knowledge of which economic factors in a state affect location and investment decisions of the venture capital industry, state legislators can better plan for economic development.

This study, therefore, examines national new investment in venture capital. It analyzes historical data from 1969 through 1995 to identify the effects of interest rates, stock market performance, pension plan legislation, and changes in capital gains tax rates on national venture capital investment. In addition, it investigates how total venture capital within a state is influenced by corporate tax burdens, university research and development, average weekly earnings, and unemployment rates. Data used for the regional analysis covers fifty states and the District of Columbia between 1993 and 1995.

This paper is composed of seven major sections. First, the introduction provides the background and purpose for this study. Next, a brief overview of the venture capital industry is given. The third section reviews the literature and empirical analyses consulted for this study. The forth section presents the econometric models adopted for this analysis. Then, the data and methodology used for this analysis are given in section five. Subsequently, section six presents the results of the econometric analyses. Finally, section seven details the conclusions reached as a result of this study.
THE VENTURE CAPITAL INDUSTRY

Since its formal emergence in 1946, the venture capital industry has fluctuated between periods of rapid expansion and periods of sharp contractions. This industry boomed in the early- and mid-1960s, only to shrink dramatically from 1969 to the mid-1970s. Venture capital investments surged again between the late 1970s and the 1980s. Then, after a brief downturn in the early nineties, venture capital investments grew to record levels of $4.3 billion of new investments in independent private firms during 1995. In that same year, $37 billion in total funds was under management by the total venture capital industry. As Figure 1 shows, total funds under management by the venture capital industry have maintained an upward growth trend since 1983.

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8 Total funds under management include funds invested by venture capital firms into portfolio firms as well as new investment funds received by venture capital firms.

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When studying the dynamics of venture capital investment, it is helpful to understand the industry structure, the roles of its key players, and the manner in which funds are invested and returns distributed. An understanding of the basic characteristics of the venture capital industry can lead to more accurate predictions on its responses to changes in economic variables.

This chapter will provide a brief overview of the venture capital industry. First, the history of venture capital investment will be reviewed. Next, the structure of the venture capital industry will be discussed, with an emphasis on independent private firms. And finally, the cycle of venture capital investment will be examined.
History of the Venture Capital Industry in the United States

The origins of today's venture capital industry in the US can be traced back to the founding of American Research and Development (ARD) in Massachusetts in 1946. This organization of MIT colleagues formed with the objective of investing in emerging ventures. Its investment of approximately $70 thousand in Digital Equipment Company (DEC) in 1957 reaped manifold returns when the firm went public in 1960. When DEC shares were offered to the public through an initial public offering (IPO), ARD's shares rose in value from $25 per share to $74.10 per share. The success of ARD's investment in DEC fueled growth in the venture capital industry in the 1960s and 1970s.

A major offshoot of ARD's success was the establishment of small business investment corporations (SBICs) by the US Small Business Administration (SBA). In 1958, SBICs were established to create pools of capital for the development and formation of new ventures. The SBICs were licensed and regulated by the government and were able to provide four-to-one leveraging for loans to emerging small businesses. They were at the forefront of the venture capital industry's early expansion and grew to approximately 700 firms by the mid-1960s.

However, a stock-market downturn in late 1969, along with recessionary pressures and Vietnam-War related tax increases almost yielded a deathblow to the SBICs. SBIC-funded new ventures, financed by debt as opposed to equity, faltered as their cash flows failed to support debt payments. Their troubles led to new SBA regulations that reduced the number of SBICs in the program. The influence of SBICs

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has continued to wane in the venture capital world. SBIC gross loans and investments outstanding for the 1990 fiscal year totaled only $2.6 billion.\textsuperscript{11} In comparison, private venture capital firms, exclusive of SBICs, managed $24.139 billion during the same calendar year.\textsuperscript{12}

Researchers have credited several factors for the emergence of private venture capital firms as the dominant segment of the industry. One such factor identified by Fenn, Liang, and Prowse was the organizational innovation of a limited partnership structure.\textsuperscript{13} This innovation reduced information search costs and risk for inexperienced investors in venture capital. These improvements were accomplished by partnering inexperienced investors with experienced venture capital firms that could make better selections of entrepreneurial firms in which to buy equity holdings. Venture capital firms, therefore, can be viewed as financial intermediaries between inexperienced investors and entrepreneurial firms. Yuk-Shee Chan also identifies venture capital firms as financial intermediaries who can reduce information and search costs.\textsuperscript{14}

Additionally, Fenn, Liang, and Prowse cited changes in legislation regarding pension fiduciaries as an augmenting influence on industry growth.\textsuperscript{15} For example, the

\begin{itemize}
\item\textsuperscript{10} Bygrave and Timmons, \textit{Venture Capital at the Crossroads} (1992), p. 21.
\item\textsuperscript{13} George W. Fenn, Nellie Liang, and Stephen Prowse, \textit{The Economics of the Private Equity Market} (Washington: Board of Governors of the Federal Reserve System, 1995), p. 4.
\item\textsuperscript{14} Chan, Yuk-Shee, "On the Positive Role of Financial Intermediation in Allocation of Venture Capital in a Market with Imperfect Information," \textit{The Journal Of Finance} 38.5 (December 1983), pp. 1543-1568.
\item\textsuperscript{15} Fenn, Liang, and Prowse (1995), pp. 13-14.
\end{itemize}

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“Prudent Man” Rule of 1979 altered the Employment Retirement Income Security Act (ERISA) by allowing pension managers to invest in higher-risk instruments such as venture capital. In addition, the “Safe Harbor” Regulation for ERISA in 1980 removed the fiduciary role for venture capital firms that accepted pension funds as limited partners.

The rate of taxation on capital gains is also thought to influence investment in venture capital. Dworsky hypothesized that reductions in capital gains taxation led to increases venture capital investment. In sum, many factors have been cited as contributing to the rise of independent private venture capital firms to a predominant position in the venture capital industry including: limited partnership structures; relaxed regulations for pension fiduciaries; and capital gains tax reductions.

Structure of the Venture Capital Industry

Today’s venture capital industry is composed of three major types of investment firms. These categories include independent private firms, corporate industrial groups, and venture capital subsidiaries of financial corporations. However, as seen in Figure 2, independent private firms have emerged as the dominant sector of this industry.

Because of their dominant position in the industry, as well as the availability of data,


independent private firms are evaluated in this study. The major characteristics of independent private firms are detailed in this section.

Figure 2. Venture capital industry segments in 1995

Independent Private Firms

Independent private firms represent the major source of organized venture capital funds.\(^{18}\) Between 1969 and 1995, these firms experienced high variability in inflows of new funds from investors. The path of new investment to independent private firms is exhibited in Figure 3.

Independent private firms controlled 83 percent of the $37 billion under management in the venture capital industry for 1995. One segment of this category is composed of family groups such as the Rockefellers, Phipps, and Whitney organizations. Independent private firms also include professional partnerships that invest funds received from pensions, major corporations, individuals and families, endowments and foundations, insurance firms, and foreign investors.

Pension funds were the largest source of new investment flows to independent private firms during 1995. Pensions provided approximately $1.656 billion, or 38 percent of the $4.227 billion total of new inflows to independent private firms in 1995.

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Endowments and foundations were the next largest source of new venture investment flows, committing 23 percent of total new funds in 1995. Insurance companies, individuals and families, and corporations provided approximately 19 percent, 18 percent, and 2 percent respectively of 1995 new funds for independent private firms. Figure 4 provides a graphical summary of the sources of new venture capital inflows to independent private firms in 1995.

![Graphical summary of sources of new investment flows to independent private firms in 1995]

Figure 4. Sources of new investment in venture capital

The Venture Capital Investment Process

Independent private firms act as financial and management intermediaries between entrepreneurs seeking capital and investors seeking new, high-return investments. Bygrave and Shulman identify three major stakeholders in the venture
capital process; limited partners, general partners, and portfolio firms.²¹

Limited partners consist of individuals and families, pension funds, corporations, insurance companies, foreigners, and endowments and foundations. They invest funds with venture capital firms. Next, venture capital firms, acting as general partners, use their business and management expertise to identify entrepreneurial firms with high-growth prospects. Equity positions are then purchased from selected entrepreneurs or portfolio companies. A graphical representation of this investment process is presented in Figure 5.

![The Venture Capital Investment Process](image)

Figure 5. An overview of the venture capital investment process

Many entrepreneurs tend to obtain equity financing from venture capital firms as opposed to debt financing. As Fenn, Liang, and Prowse noted, debt financing is usually not an alternative for entrepreneurs due to the high degree of risk associated with their business ventures. Further, new ventures tend to require a higher degree of interaction with experienced investors than is normally provided through debt financing.

Investors in venture capital earn their returns through the appreciation of their shares in the portfolio companies as opposed to dividend income. The appreciated value, or capital gain, is realized when the portfolio company advances to the initial public offering (IPO) stage. Under an IPO a portfolio firm, which has been privately owned, registers with the Securities and Exchange Commission and “accesses the public capital market through the sale of securities.” However, a high degree of risk is associated with a new venture successfully reaching the IPO stage. Alternately, venture investors may have their appreciated shares purchased through private mergers or as acquisitions by other firms.

Phillips and Kirchhoff tested the old adage that “four out of five new firms fail within the first five years.” Their results yielded a lower percentage—three out of five new firms—nevertheless, posing a high degree of uncertainty for investors in new ventures. This high degree of risk associated with venture capital investment leads the

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typically risk-averse investor to require a higher return from such investments.

Indeed, high returns are not unusual for this industry. To illustrate, Venture Economics cited returns at "astronomical levels of 1 year IRR of 54.2% for funds formed during 1969-1995." Such performance levels bode well for the continued growth of the venture capital industry.

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CHAPTER III

LITERATURE REVIEW

Economic research on the venture capital industry has expanded over the last three decades, concurrent with the industry’s growth. Most empirical studies have examined venture capital investment from 1969 onward, due to availability of data covering that period. Literature reviewed in this section falls into two categories: (1) studies of the economic variables predicted to affect national investment in venture capital, (2) and regional studies of the impact of locational and economic factors on venture capital.

This section will first present summaries of previous research and opinions regarding the effect of capital gains taxation on investment and the attendant implications for national venture capital investment. Subsequently, research examining the relationship between venture capital investment and variables such as stock market indices, interest rates, and the market for public offerings will be reviewed. Finally, the chapter will conclude with a review of regional and state economic conditions thought to influence both venture capital location and investment activity.
Capital Gains Taxation

The tax rate on long-term capital gains changed several times between 1969 and 1995, the period under consideration for this study. Long-term capital gains are defined as the appreciation on assets held by investors for more than 6 months up until 1976, and greater than 12 months thereafter. Jane Gravelle identified the following major movements of the maximum individual tax rate on long-term capital gains: an increase from 25 percent to 48 percent in 1969; a reduction to 28 percent in 1978; a further reduction to 20 percent in 1981; an increase to 33 percent in 1986; and a decrease to 28 percent in 1990.  

The literature expressed dichotomous opinions on the response of investment in venture capital to these tax rate changes. Some argued that increases in the marginal tax rate on capital gains would lead to significant reductions in venture capital investments. Yet, others posited minimal responses in venture capital investment due to changes in capital gains taxation. A key argument against rate hikes on capital gains taxes centered on the tendency of investors to hold appreciated equity in order to defer the payment of taxes on the appreciated value—the "lock-in" effect.

The "Lock-in" Effect of Capital Gains Taxation

Capital gains are not taxed until the appreciated equity is sold. Because of this interest-free deferment of taxation, investors are motivated to retain less than optimal stocks, which have appreciated over time. John C. Goodman, president and CEO for the

National Center for Policy Analysis, noted "Since selling is taxed and possessing is not, high capital gains taxes encourage investors to hold rather than sell—thereby avoiding the tax indefinitely."

Goodman's view was echoed by Auerbach, who noted the "lock-in" effect distorted efficiency in portfolio management. Consequently, if portfolio firms represented more efficient investment alternatives, the "lock-in" effect would impede the flows of investment dollars to venture capital.

Auten, Burman, and Randolph reviewed nine empirical studies which had evaluated the "lock-in" effect by estimating how sales of appreciated equity, or capital gains realizations, responded to changes in capital gains taxation. These studies yielded estimates, presented in Table 1 below, for the elasticity of capital gains realizations to changes in the marginal tax rates on the appreciation of investments held for more than six months.

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30 Long-term gains were defined as appreciation on securities held at least six months up until 1976. After 1976, securities held for at least one year qualified for long-term gains tax treatment.
Table 1. Long-Term Capital Gains Realization Elasticities

<table>
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<th>Data Type</th>
<th>Capital Gains Type</th>
<th>Realization Elasticity</th>
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<tr>
<td>Minarik (1981)</td>
<td>Cross-Section, High-Income Sample, 1983</td>
<td>Corporate Stocks</td>
<td>Range from -0.44 to -0.79</td>
</tr>
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<tr>
<td>U. S. Treasury (1985)</td>
<td>Time Series, 1954 to 1985, All Taxpayers</td>
<td>All Capital Assets</td>
<td>Short-Run: -1.3 Long-Run: -0.8</td>
</tr>
<tr>
<td>Congressional Budget Office (1988)</td>
<td>Time Series, 1954 to 1985, All Taxpayers</td>
<td>All Capital Assets</td>
<td>*Range from -0.79 to -0.99</td>
</tr>
<tr>
<td>Auerbach (1988)</td>
<td>Time Series, 1954 to 1986, All Taxpayers</td>
<td>All Capital Assets</td>
<td>*Long-Run Range: -0.06 to -1.08</td>
</tr>
</tbody>
</table>

*Derived at 25.4% average tax.

Source: Auten, Burman, and Randolph (1989) National Tax Journal, 355

The studies predicted from a .06 percent to almost a four percent decrease in capital gains realizations when the marginal tax rate increased by one percent. In other words, a one percent increase in the rate of capital gains taxation could, at most, result in up to a four percent decrease in sales of appreciated equities by investors. Moreover, even though researchers debated the magnitude of the lock-in effect, they generally found that increases in capital gains taxation could distort optimal portfolio decisions.
Although Auten, Burman, and Randolph examined all investments, not venture capital investment specifically, one could hypothesize that the lock-in effect might prevent funds from freely flowing into venture capital.

**Capital Gains Taxes and Investment Returns**

Some researchers also considered the depressing effects of such increased capital gains taxes on investment in stocks, which paid returns only through appreciation of equity. Bygrave and Timmons noted, “Within the venture capital industry, it is almost universally believed that the federal capital gains tax rate is the most important influence on the flows of venture capital.” Similarly, Rahn attributed a large drop in venture capital investment to the capital gains tax increase from 20 percent to 28 percent in 1986. He characterized the capital gains tax as “a direct levy on investment and entrepreneurship, punishing and discouraging these activities.”

Dworsky presented another viewpoint on the effects of capital gains tax rate cuts and venture capital investment. He argued that lower capital gains tax rates resulted in inefficient over-investment in venture capital funds. Dworsky noted the huge increases

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in venture capital funds from $39 million in 1977 to $11.5 billion in 1983.\textsuperscript{36} He contended that such heated investment produced declines in share values and investor losses because more new firms were created than the market could accommodate.

Other studies, however, have countered that capital gains taxes play no role in venture capital investment. Minarik found it unlikely that capital gains tax rate increases deterred entrepreneurs from forming new businesses.\textsuperscript{37} He stated, "An entrepreneur who believes that he has a million-dollar idea is unlikely to hold back because the capital gains rate is 28 percent instead of 22 percent."\textsuperscript{38} When he examined the influence of individual investor responses to capital gains taxation, he cited estimates that over 85 percent of formal venture capital was received from investors who were not subject to capital gains taxes including; endowments and foundations, foreign investors, and pension funds.

These assertions are supported by Proterba's research, which evaluated data on the capital structure of start-up firms, sources of venture capital, average tax rates on venture capital, and annual start-up activity.\textsuperscript{39} This study examined venture IPOs and realized capital gains to assess whether the statutory increase on capital gains tax rates in 1986 had diminished investment funding for new ventures. After analyzing data over the period of 1977 - 1988, Proterba concluded that the increase in marginal tax rates on capital gains for individuals did not have a major effect on the availability of investment

\textsuperscript{36} Dworsky (1986), p. 69.
\textsuperscript{38} Minarik (July 1992), p. 20.
funds for new ventures. This conclusion was based on finding that corporations, tax-exempt investors, and foreign investors who were not subject to individual capital gains tax rates contributed the majority of venture capital funding.

Therefore, competing views are presented by the literature on the effects of capital gains tax rate changes on venture capital investment. One body of research predicts marked decreases in venture capital investment in response to increases in the capital gains tax rate. Another body of literature predicts little or no response in venture capital investment when capital gains tax rates are increased.

Venture Capital Investment and Financial Markets

Econometric studies of new investment in venture capital have also included financial market variables. Bygrave and Shulman conducted empirical tests on annual variables expected to influence investment flows into venture capital funds. They analyzed 18 years of annual data from 1969 to 1987. The variables evaluated included; the S&P 500 and NASDAQ indexes, short- and long-term Treasury issues, a dummy variable for rate changes in capital gains taxes, and total dollar volumes of IPOs. The stock market indices and IPO level variables were chosen because rising stock index values were projected to lead to better prospects for IPOs, thereby increasing returns to venture capital investors. The stock market indices and IPO variables were expected to positively influence investment flows into venture capital funds.

Short-term Treasury bills and long-term Treasury bonds were predicted to have two directions of influence on venture capital investment. If they were viewed as "risk-free alternatives to investments in venture capital funds," venture capital investments could be expected to decrease when returns on Treasury bills or bonds increased. Bodie, Kane, and Marcus also identify the risk premium as an important variable when analyzing portfolio choice. On the other hand, if the rates on Treasuries were viewed as the cost of debt for entrepreneurs, venture capital investments could be expected to increase when return rates on Treasury bills and Treasury bonds increased.

The capital gains tax dummy was set to zero for high-tax years (1970-1977, 1986, and 1987) and set to one for low-tax years (1969, 1978-1985). These dummy values reflected increases in the rate of capital gains taxation from 25 percent to 48 percent in 1970, decreases in the rate to 28 percent in 1978, and increases in the rate to 33 percent in 1986. After correcting for serial correlation with the Hildreth-Lu technique, removing insignificant variables (IPO values), and eliminating variables with high multicollinearity (S&P 500 index, Treasury bills, and Treasury bonds), Bygrave and Shulman reached several findings.

First, the lagged NASDAQ index variable was the only statistically significant variable identified by this estimation. The coefficient for the capital gains tax dummy

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43 Zvi Bodie, Alex Kane, and Alan J. Marcus, Investments (Boston: Irwin, 1989), pp. 130-140. See Appendix A for further discussion on this theory.
44 Bygrave and Shulman designated 1969 and 1978-1985 as lower-tax years and set the dummy variable to one during these years.
was statistically insignificant. In addition, the coefficient on the dummy variable for capital gains tax rate changes multiplied by the lagged NASDAQ index, was insignificant. Bygrave and Shulman then concluded the evidence failed to support predictions that increases in the capital gains tax rate would significantly reduce new investment in venture capital.\(^{45}\) Instead, the value of the NASDAQ index, lagged by one year, was viewed as the most influential variable for predicting new venture capital investment. They cautioned, however, that the statistically insignificant results for the capital gains tax variable were not conclusive, and proposed that the relative importance of capital gains taxation on venture capital investment might be overstated by popular opinion.\(^{46}\)

Regional or State Influences on Venture Capital Investment

Venture capital investment has also been studied from a geographic viewpoint. The body of literature has identified characteristics of agglomeration in the location decisions of venture capital firms at a regional and state level. This section will first review research that focused on regional concentration tendencies in venture capital investment from a basic statistical or geographical viewpoint. Next, literature will be reviewed which applied econometric analysis to conditions in states or regions to determine the economic variables that influence location decisions of venture capital firms.

\(^{45}\) Bygrave and Shulman (1988) 335.
\(^{46}\) Bygrave and Shulman (1988) 335.
Regional Agglomeration Tendencies

Researchers have noted that venture capital activities are concentrated by region and within states. Both the location of venture capitalists and the location of venture capital investment in portfolio firms tend towards agglomeration. During the early 1970s, Milford B. Green observed a concentration of venture capital firms within large urban areas with mature financial centers. These early firms had spatial monopolies, which eroded over time as new venture capitalists and new investment opportunities in portfolio firms increased.

Green submitted that, over time, venture capitalists tended to develop market niches. These niches evolved around characteristics that concurrently influenced location and portfolio investment decisions. For example, when a venture capital firm chose to locate in a specific city, the types of firms seeking venture financing in that area would constrain the choice of industry in which investment dollars could be funneled. Alternately, if the venture capital firm sought to invest in a particular industry, its choice of location would be constrained by the location of entrepreneurial firms in that industry. Additionally, he noted that independent private venture capital firms were inclined towards investment in high-technology firms. Thus, the location of venture capital activities is related to the economic activity mix within the region.

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48 Underlying these choices was the requirement for close interaction and therefore, physical proximity, between venture capital firms and their portfolio companies.
49 Green included SBICs in his analysis and analyzed the difference in investment choices between private venture capitalists and SBICs.
The presence of high-technology firms is also considered an influence on location decisions for venture capital firms. Florida and Kenney identified two major locational characteristics of venture capital firms: (1) concentration in financial centers and; (2) concentration near high-technology firms. Using data on the sixty-one most active venture capital firms in 1985, they identified three major complexes. These major complexes, including California, New York, and New England, were each described as controlling greater than 15 percent of the $16.3 billion total U. S. venture capital pool in 1985. Two minor complexes, Texas and the Midwest were found to individually control between 5 to 15 percent of total venture capital resources. New York and Chicago were identified as mature financial centers that attracted venture capital resources. An extensive level of high-technology activity, likely to attract venture capital distinguished California and New England. Indeed, Florida, Smith, and Sechoka found that 50 percent of venture capital investment during 1986 went to the states of California and Massachusetts. Hence, the presence of mature financial centers and high technology firms are regional factors theorized to influence the location of venture capital resources and investment.

An additional economic factor considered likely to influence the location decisions of venture capital firms is the presence of large Research and Development (R&D) universities. Leinbach and Amrhein noted the relationship between venture

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capital activity and the presence of large research universities within a state or region.\textsuperscript{53} They cited the proximity of MIT, Cal-Tech, and Stanford universities as dominant factors in attracting the lion's share of U. S. venture capital resources to Massachusetts and California. The influence of R&D activity on location decisions of high technology firms, and therefore, venture capital firms, is examined in the next section of this paper.

**Empirical Studies of Regional Location Decisions**

Since high technology firms were cited as attractors of venture capital activity, literature regarding market factors that attract high technology firms to regions or cities was also consulted. Acs, FitzRoy, and Smith conducted empirical studies of the relationship between university research and development (R&D) spillovers and high technology employment in 37 American cities.\textsuperscript{54} They proposed that university research generated innovative knowledge which spread through personal interactions to local high technology firms, and that university R&D provided an experienced pool of trained labor for high technology firms. These factors, they argued, might influence the location decisions of high technology firms.

Based upon the empirical results, Acs, FitzRoy, and Smith concluded that a positive and statistically significant relationship existed between high technology employment and university R&D expenditures within a given location.\textsuperscript{55} Additionally,


they found a statistically significant and positive relationship between wages and high technology employment. This result was counter to the expected direction of influence for wages. However, the authors posited that the specialized skills required for the high technology industry might lead to a shortage of workers in the area. This shortage could then require higher bids for wages to attract and retain specialized workers.

Herzog and Schlottman also examined the location of high technology employment from the viewpoint of worker mobility and location factors which attracted high technology workers to certain Metropolitan Statistical Areas (MSAs) in the U. S.\textsuperscript{56} Although this empirical analysis focused on the factors influencing choice of residence for skilled workers, it did emphasize underlying conditions that impact the location decisions of high technology firms. Specifically, Herzog and Schlottman noted that:

In fact, although such surveys and case studies show high technology firms to be "footloose" in terms of the more traditional location factors (such as market access and transportation), they also provide evidence that these firms are dominated in their location decision by their ability to obtain and retain individuals with specific technical, scientific, and engineering skills.\textsuperscript{57}

Summary

This review of research on venture capital investment first summarized the body of literature regarding factors that could influence the national level of new investment in venture capital. The marginal rate of taxes on capital gains, and its effect on venture capital investment, has been widely discussed. One body of research predicted decreases

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in venture capital investment due to increases in capital gains taxation. This effect was expected because of the nature of venture capital investment returns. Since returns on venture capital are based purely on appreciation, the total return would be subject to capital gains taxes.

In contradiction, another body of research predicted little or no effect on national venture capital investment due to increases in capital gains taxation. This opposing research noted that most investors in venture capital enjoyed a tax-free status. Instead, pension legislation, which relaxed restrictions on venture capital investment by pension fiduciaries, was considered key to fueling new investment in venture capital.

Empirical research identified the state of the stock market for small equities as a significant statistical influence on national venture capital investment. Specifically, the NASDAQ index was found to be statistically significant for predicting new investment in venture capital. Capital gains taxes did not exhibit a statistically significant influence, although the researchers concluded that the effect of capital gains taxation on venture capital investment could not be wholly discounted.

A second body of literature on regional location decisions for venture capital investment was also reviewed. Agglomeration tendencies for the venture capital industries were noted in regions or states with mature financial centers, and in locations where high technology firms were present. Additionally, researchers cited the proximity of large R&D universities as a locational attractor for high technology firms.

The regional econometric studies reviewed found a statistically significant relationship between high technology employment and university R&D expenditures.

within a given location. Inasmuch as venture capital location decisions were considered to be influenced by the presence of high technology firms, the underlying presence of large R&D universities would be considered an economic factor attracting venture capital to a region or state.

Summaries of the literature reviewed on new investment in venture capital and on the regional location of venture capital funds are presented below in Table 2 and Table 3.

Table 2. Literature Summary: New Investment in Venture Capital

|---------------------------------------------------------------------------|-----------------|----------------------------------|----------------|

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## Table 3 Literature Summary: Regional Location of Venture Capital Funds

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Venture capital firms locate near mature or large financial centers.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. High technology firm’s location decision dominated by presence of labor force with scientific and engineering skills</td>
<td>Herzog &amp; Schlottman (1988)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER IV

THE EMPIRICAL MODELS

Venture capital investment will be examined in two distinct areas. First, the decisions made by limited partners (individuals, pension managers, etc.) to place new investment funds with independent private firms will be analyzed on a national level. Secondly, regional factors such as state corporate tax burdens and government R&D expenditures will be investigated for their impact on the location of venture capital investment funds.

Annual New Investment in Venture Capital

The empirical model used to evaluate annual new investment in venture capital firms incorporates variables identified by the existing literature and summarized in Table 2 of the preceding chapter. Specifically, this model incorporates the significant variables identified by the Bygrave and Schulman (1988) model, but modifies the equation as follows:\(^{38}\)

- The actual maximum individual capital gains tax rate is used instead of a dummy variable.

\[ \text{NEWVC}^*_t = \beta_1 + \beta_2 \text{NASDAQ}(-1)^*_t + \beta_3 \text{D} + \beta_4 \text{DNASDAQ}(-1)_t + \varepsilon. \]
A dummy variable (ERISA2) is added to capture the influence of the change in pension fund regulations, which permitted pensions to invest in venture capital firms. Bygrave and Schulman (1988) and Fenn, Liang, and Prowse (1995) cited pension investment relaxation as a major influence on venture capital investment.

Two variables reflecting a risk premium, (POSPREM and NEGPREM) are included based upon the literature of Bodie, Kane, and Marcus (1989), Bygrave and Schulman (1988), and Chan (1983).

After evaluating the movement of new venture capital investment over time, a logarithmic model was chosen for the time series regression.

The general equation constructed for annual new investment in venture capital (NEWVC) is:

$$\text{NEWVC} = f(\text{Stock market prices, capital gains tax rates, pension legislation, and risk premiums})$$

In particular, the model can be expressed as:

**Equation 1**: \[\ln(\text{NEWVC}_t) = \beta_1 + \beta_2 \ln(\text{NASDAQ}_t) + \beta_3 \text{LCGTRATE}_t + \beta_4 \text{ERISA2}_t + \beta_5 \text{POSPREM}_t + \beta_6 \text{NEGPREM}_t + \epsilon_t\]  

Addition models were evaluated prior to selecting this model. They included a semi-logarithmic model, a first differences model, and a linear model. Further, a variable for time was evaluated in all models, as well as a breakpoint variable for the year of 1980. Additional interest rates and stock market indexes were evaluated, but omitted due to multicollinearity. Also, consumption, new issues of securities, and changes in profits were considered.
where $\text{LNEWVC}_t$ is the natural log of new investment flows to independent private firms in year $t$;

$\text{LNASDAQ}_t$ is the natural log of the year-end closing value for the NASDAQ Index.

$\text{LCGTRATE}_t$ reflects the natural log of the maximum long-term capital gains tax rate for each year under consideration.

$\text{ERISA2}_t$ is a dummy variable, capturing the effects of ERISA legislative changes. It is set to zero for 1969 through 1978, and to one for all subsequent years. This allows the model to capture the influence of regulatory changes that allowed pensions to invest in venture capital.

$\text{POSPREM}_t$ reflects the difference between the annualized growth rates of the NASDAQ index and annualized Treasury bill returns. It denotes the risk premium between “risk-free” Treasuries and riskier equity investments. The value is set to the actual difference when positive, and to zero otherwise.

$\text{NEGPREM}_t$ reflects the difference between annualized Treasury bill returns and the NASDAQ growth rate when the difference is positive. It is set to the actual difference when positive, and to zero otherwise. This variable is included to capture whether venture capital investors exhibit a symmetrical response to risk premiums.

$\epsilon_t$ is the error term for the regression. An assumption of correct specification of the model anticipates independently distributed
error terms from a normal population, with zero expected value and constant variance.\textsuperscript{60}

The constant term of the equation, $\beta_1$, reflects an autonomous level of new investment in venture capital. The coefficients of the independent variables are expected, \textit{a priori}, to move in the following directions:

$\beta_2$ is expected to be positive. Many of the companies listed on the NASDAQ tend to be small capitalized, growth firms that are focused on high technology.\textsuperscript{61} As Bygrave and Shulman noted, an increase in its closing values or IPO volumes could trigger increased investor interest in high technology portfolio firms and venture capital investment.\textsuperscript{62} While the NASDAQ index is not viewed as causing venture capital investment, it does act as an indicator of demand for investment in small growth companies.\textsuperscript{63}

$\beta_3$ is expected to have a negative sign. Venture capital investment is projected to decrease when marginal tax rates on capital gains rise.

Venture capital is more severely affected by tax rate increases because its


\textsuperscript{62} Bygrave and Shulman (1988), 327.

\textsuperscript{63} Other securities market indexes were evaluated, including the S&P 500, AMEX, Dow-Jones Industrial Average, and the Russell 2000 before final selection of the NASDAQ.
returns are usually pure capital gains, not dividends.

\[ \beta_4 \]
is expected to be positive, reflecting the relaxation of regulations regarding pension fund investment in venture capital. \(^{64}\)

\[ \beta_5 \]
The direction is unknown. The Nasdaq growth rate was used for the “high-risk” return because yearly return data was not available for the venture capital firms considered in this study. The Portfolio Allocation model discussed in Appendix A predicts a positive direction for this coefficient. \(^{65}\) If the risk premium on small growth companies is positive, ceteris paribus, the optimal proportion of risky holdings in an investor’s portfolio would be expected to increase. \(^{66}\) However, if Nasdaq securities are viewed as substitutes to venture capital investment, this coefficient could take a negative direction.

\[ \beta_5 \]
The direction is also unknown. Again, the Portfolio Allocation model would predict an increase investment in Treasuries if their “risk-free” return is higher than “risky” returns. However, investors might substitute to investments with medium risk, or their tastes might be such that they always choose high-risk investments.

variable as the one that best fit the specification.

\(^{64}\) Bygrave and Timmons, Venture Capital at the Crossroads (1992), p. 262.

\(^{65}\) Bodie, Kane, and Marcus (1989), pp. 130-140.

\(^{66}\) Considering the optimal proportion of risky assets is given by \( y^* = \frac{\text{E}(r_p) - r_f}{\sigma_p} \). If the expected return on risky assets \( (r_p) \) increases, other things equal, \( y^* \) also increases.
Regional Location of Venture Capital Funds

The regional investment model examines total venture capital resources (both new inflows and fund holdings) within fifty states and the District of Columbia over a three-year period from 1993-1995. This pooled cross-section, time series model tests the influence of economic variables identified in Table 3 of the preceding chapter. While the literature did not empirically test for attractors of venture capital to a region or state, it did identify the variables included in this estimation as important to venture capital location.

The general equation constructed for the attraction of venture capital funds and firms (VCFUNDS) to a region or state is:67

\[ VCFUNDS = f(\text{research and development, corporate tax burdens, average weekly earnings, and unemployment rates}) \]

In particular, the functional form of the regression equation can be expressed as:

**Equation 2:** \[ VCFUNDS_{it} = \beta_1 + \beta_2 RD_{it} + \beta_3 CORPTAX_{it} + \beta_4 AWE_{it} + \beta_5 UNEMP_{it} + \beta_6 D_{it} + \varepsilon_{it} \]

67 Several additional variables identified by the literature were considered, but omitted from the model due to high multicollinearity. Total commercial bank assets by state were evaluated as an indicator of financial concentration. The number of advanced scientific and engineering degrees awarded by state was also considered as an indicator of a technically trained labor force. In addition, earnings by industries with high technology SIC codes were compiled by state. All of these variables were highly correlated with R&D.

68 Additional functional forms evaluated included a full logarithmic model, a model incorporating dummy variables for the years of 1994 and 1995, and a model with corporate tax dummies set to 1 for state with corporate income taxes and to zero otherwise.
where VCFUNDS are total venture capital funds, or the stock of venture capital, in state i during year t; i reflects state 1 – 51, and t reflects year 1 – 3:

RD$_{it}$ is the dollar amount of federal Research and Development funding committed to colleges and universities in state i during year t.

CORPTAX$_{it}$ is the ratio of corporate tax collections to total state government tax collections for state i during year t. It reflects the corporate tax burden of the state.

AWE$_{it}$ is the average weekly earning in the manufacturing industry for state i during year t. It reflects the cost of labor.

UNEMP$_{it}$ is the unemployment rate for state i during year t. It is a general measure of the economic growth in the state.$^{69}$

D$_{it}$ is a dummy variable for each state and the District of Columbia. Alaska is omitted from the dummy matrix. This variable is constructed to consider the intercept for each state.

$\epsilon$_$_{it}$ is the error term for the regression. An assumption of correct specification of the model anticipates independently distributed error terms from a normal population, with zero expected value and constant variance.$^{70}$

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$^{69}$ Herzog, Jr. and Schlottman (1991), p. 179 used employment growth as an indicator of the general economic condition of an MSA. The unemployment rate was selected as an alternate measure.

$^{70}$ Pindyck and Rubinfeld (1991), p. 224.
The coefficients of the independent variables, *a priori*, are expected to have the following signs:

\[ \beta_2 \] is expected to be positive, reflecting the influence of university research and development spending in attracting venture capital. The expected direction of influence is based upon research by Leinbach and Amrhein that cited large research universities as dominant factors in attracting venture capital resources to a state or region. 

\[ \beta_3 \] is expected to take a negative direction. Herzog and Schlottman cited the corporate tax climate as a location factor in attracting high technology firms to an MSA. This hypothesis can be extended to venture capital funds, which locate near, and invest in high technology firms. As the percentage of corporate tax collections increase, the amount of venture capital funds attracted to the state are expected, *ceteris paribus*, to decrease.

\[ \beta_4 \] is expected to take a negative direction. The *a priori* direction was theorized by Acs, FitzRoy, and Smith for the effect of wages upon high technology employment, and is extended to wages effect upon

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71 These expectations are based upon research cited in this paper by Florida and Kenney (1988b); Florida, Smith, and Sechoka (1991); and Milford B. Green (1991).
the location of high technology venture capital funds and firms. The coefficient will be added to the estimation’s constant term to determine the intercept for venture capital funds within the state. The intercept for Alaska, the omitted state, is provided by the constant term of the equation.

\[ \beta_5 \]

is expected to take a negative direction. As the unemployment rate increases, it reflects a decrease in the general economic condition of the state. Venture capital firms or funds, therefore, would not be attracted to states with high unemployment rates.

\[ \beta_6 \]

The direction is unknown. The coefficient will be added to the estimation’s constant term to determine the intercept for venture capital funds within the state. The intercept for Alaska, the omitted state, is provided by the constant term of the equation.

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\[ ^7 Acs, Fitzroy, and Smith (1995), p. 280. \]
CHAPTER V

DATA AND METHODOLOGY

This section of the paper presents the sources and construction of the data used for the empirical analyses of annual new venture capital investment and regional venture capital location factors. A discussion of the sources of data for both econometric models will first be presented. Subsequently, procedures used to construct the series will be summarized. These discussions will be followed by the presentation of descriptive statistics for the data and interpretations.

Sources of the Data

The dependent variable for the annual, new investment flow model is the yearly total dollar volume of new investment funds placed with independent private firms (NEWVC). Data for this series were obtained from the Venture Economics Annual Review: 1996. Venture Economics Investor Services, a division of Securities Data Company, compiled the data on this series. This firm maintains extensive databases on venture capital industry statistics based upon voluntary reporting and monitoring of the market.

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The independent variable for the National Association of Securities Dealers Automated Quotations (NASDAQ) series is the Nasdaq Composite Index. This index originated in 1971. Annual end-of-month, December closing values for this index from 1971 to 1995 were obtained from The NASDAQ Stock Market Fact Book. Percentage changes in the Nasdaq Composite Index data were used for the POSPREM and NEGPREM series.

The source for annualized rates of return on three-month US Treasury bills is the Economic Report of the President. The capital-gains tax rate variable (CGTRATE) reflects the maximum individual rates on capital gains. These rates were obtained from Jane Gravelle's history of capital gains taxation. The dummy variable constructed to capture the effects of Employee Retirement Income Security Act regulatory relaxations on investment by pension fund fiduciaries (ERISA2) is set to zero for years 1969 through 1978, and to one thereafter. The source for dates on ERISA modifications is the Federal Reserve System.

The source for the dependent variable (VCFUNDS) in the regional location of venture capital funds model is Venture Economics Annual Review: 1996.

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The source data for the independent variable reflecting annual, federal obligations for Research and Development to universities and colleges (RD) were obtained from the National Science Foundation. The source for the state corporate tax series data (CORPTAX) is the U. S. Bureau of the Census. State government tax collections were reported in nominal dollars for fiscal years 1993, 1994, and 1995. Source data for the Average Weekly Earnings series (AWE) and the unemployment rate series (UNEMP) were obtained from the Bureau of Labor Statistics.

Construction of the Series

In the model for annual new investment in venture capital, the data series were constructed as follows:

NEWVC The data is reported in annual, calendar-year volumes for the period of 1969 through 1995. Data were not available on this series prior to 1969. The nominal dollar values reflecting annual new investment in venture capital in million dollar increments were converted to a natural logarithmic form.

NASDAQ This variable reflects a market capitalization-weighted index

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covering all Nasdaq common stock, in addition to foreign stock, ADRs and the Nasdaq-100. The natural logarithms of year-end index values are used from the year of the Nasdaq Composite's conception (1971) to 1995.

CGTRATE The natural logarithms of the actual maximum individual tax rates on capital gains were used in this series.

ERISA2 is a qualitative, independent or dummy variable that takes values of zero or one.

POSPREM To construct this series, first the annual percentage changes in Nasdaq index values were calculated. Subsequently, the annualized percentage yield on three-month Treasury bills was subtracted from the Nasdaq percentage changes. Then, this variable was set to the actual value when the difference was positive, and to zero otherwise.

NEGPREM This series was constructed by subtracting the Nasdaq growth rate from the annualized yield on three-month Treasury bills. Actual positive values were used when they occurred, and the variable was set to zero otherwise.

The regional model's time series and cross-section data were ordered alphabetically by state, and then pooled by year from 1993 through 1995. The variables

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were constructed as follows:

**VCFUNDS**

VCFUNDS reflects total, nominal dollars in million dollar increments invested with all venture capital firms located within a given state for a given year during the period of 1993 through 1995.\(^6\) It includes both new investment funds from limited partners into venture capital firms, and venture capital funds that have been invested into portfolio firms under active management by venture capital firms located within the state. Fifty states and the District of Columbia are considered.

**RD**

Nominal dollar values in million dollar increments for federal research and development obligations to universities were given by state and by year.

**CORPTAX**

Nominal values for state corporate tax collections were ratioed to total state tax collections on an annual basis.

**AWE**

The 12-month average for weekly earnings in manufacturing are given in nominal, unadjusted dollar values.

**UNEMP**

Unemployment rates are expressed as percentages.

**STATE**

The state dummy variable is set to one for each of the three years that observations for that state are included and to zero otherwise.

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Summary Statistics on the Data

Summary statistics on data used in the annual new investment in venture capital model are presented in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>NEWVC</th>
<th>NASDAQ</th>
<th>CGTRATE</th>
<th>ERISA2</th>
<th>POSPREM</th>
<th>NEGPREM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1725.583</td>
<td>335.433</td>
<td>0.322</td>
<td>0.708</td>
<td>0.107</td>
<td>0.071</td>
</tr>
<tr>
<td>Median</td>
<td>1623.500</td>
<td>262.975</td>
<td>0.280</td>
<td>1.000</td>
<td>0.083</td>
<td>0.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>4227.000</td>
<td>1052.13</td>
<td>0.480</td>
<td>1.000</td>
<td>0.500</td>
<td>0.429</td>
</tr>
<tr>
<td>Minimum</td>
<td>15.000</td>
<td>59.820</td>
<td>0.200</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1501.649</td>
<td>261.396</td>
<td>0.102</td>
<td>0.464</td>
<td>0.127</td>
<td>0.130</td>
</tr>
</tbody>
</table>

Only 24 observations are included in the estimation covering the period of 1972 to 1995 because of the need for percentage changes in the NASDAQ variable. The Nasdaq Index originated in 1971 and thus constrains the number of observations. The average amount of new investment in venture capital over the 24-year period examined is $1,726 million with a standard deviation of $1,502 million. The large range of the NEWVC variable reflects the growth of investment in venture capital as well as the use of nominal dollar values.

The average value of the NASDAQ index over the 24-year period is 335.43. Its large range reflects the growth in investment in high technology, small-capitalized stocks over the period examined. The maximum rate on capital gains taxes for individuals (CGTRATE) was 48 percent during the period of evaluation, and the minimum rate was 20 percent. Additionally, for 71 percent of the years between 1969
and 1995, regulations were relaxed for investment in venture capital by pension fiduciaries (ERISA2).

The average positive premium (POSPREM) for NASDAQ investments compared to Treasury bill returns was ten percent during the period of observation. The maximum positive difference for NASDAQ growth rates was 50 percent. The average positive difference between Treasury bills and NASDAQ when Treasury returns were greater (NEGPREM) is 7.1 percent. The maximum positive difference for a Treasury bill return during the period of the study is 43 percent.

Correlations between the annual new investment variables are presented below in Table 5.

<table>
<thead>
<tr>
<th></th>
<th>NEWVC</th>
<th>NASDAQ</th>
<th>CGTRATE</th>
<th>ERISA2</th>
<th>POSPREM</th>
<th>NEGPREM</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEWVC</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NASDAQ</td>
<td>0.715</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CGTRATE</td>
<td>-0.551</td>
<td>-0.405</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERISA2</td>
<td>0.730</td>
<td>0.596</td>
<td>-0.832</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POSPREM</td>
<td>-0.066</td>
<td>0.327</td>
<td>-0.068</td>
<td>0.129</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>NEGPREM</td>
<td>-0.143</td>
<td>-0.266</td>
<td>0.213</td>
<td>-0.226</td>
<td>-0.484</td>
<td>1.000</td>
</tr>
</tbody>
</table>

New investment with independent private firms is positively correlated with the NASDAQ and ERISA2 variables, which meets the *a priori* expectations. Also, as theorized, NEWVC is negatively correlated with the capital gains tax rate variable. The POSPREM variable is negatively correlated with new venture capital investment. This direction indicates that the NASDAQ stock market might act as a substitute for venture capital investment, drawing away venture capital dollars when its "risk premium is high.
The NEGPREM variable is also negatively correlated with venture capital investment, revealing a potential asymmetry in investor responses. Also, ERISA2 and CGTRATE have a strong negative correlation, raising the possibility of multicollinearity.

The summary statistics on the data used for empirical tests on the regional location of venture capital funds are presented in Table 6.

<table>
<thead>
<tr>
<th>Table 6. Summary Statistics: Regional Investment Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCFUNDS</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Std. Dev.</td>
</tr>
<tr>
<td>Expected Sign</td>
</tr>
</tbody>
</table>

The average amount of venture capital funds across all thirty-five states (VCFUNDS) was $645 million between 1993 and 1995. This variable exhibits a large range and a large standard deviation because of the concentration of venture capital funds in some states, for example, California, Massachusetts, and New York.87

The average amount of research and development obligations (RD) to universities within a state was $227 million. Again, a large standard deviation and range exists for this series due to the concentration of large, research-oriented universities in some states.

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87 Richard Florida, Donald F. Smith, Jr., and Elizabeth Sechoka, "Regional Patterns of Venture Capital Investment," Venture Capital: International Comparisons, ed. Milford B. Green (New York: Routledge, 1991). The authors noted the concentration of venture capital funds within the Northeast and Pacific or West Coast regions.
The average proportion of corporate taxes to total state tax collections (CORPTAX) is 6.3 percent, with the maximum proportion being 39 percent for the state of Alaska in 1993.\textsuperscript{88}

The average weekly earnings in manufacturing (AWE) for the 50 states and the District of Columbia between 1993 and 1995 were $493. The unemployment rate (UNEMP) averaged 5.77 percent across the states during the period of observation. West Virginia experienced the highest unemployment rate of 10.9 percent in 1993. The lowest unemployment rate during the period was 2.6 percent in 1995 in the state of Nebraska.

The summary statistics for the state dummy (STATE) is the same for each state observed. Each of the 50 states and the District of Columbia contributed approximately two percent of the observations in the pooled, cross-section data.

Table 7 presents the correlation matrix for the variables in the regional estimation.

### Table 7. Correlation Matrix for the Regional Model

<table>
<thead>
<tr>
<th></th>
<th>VCFUNDS</th>
<th>RD</th>
<th>CORPTAX1</th>
<th>AWE</th>
<th>UNEMP</th>
<th>AK</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCFUNDS</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td></td>
</tr>
<tr>
<td>CORPTAX1</td>
<td>0.171</td>
<td>0.110</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AWE</td>
<td>0.147</td>
<td>0.237</td>
<td>0.219</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNEMP</td>
<td>0.281</td>
<td>0.258</td>
<td>0.053</td>
<td>0.114</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>AK</td>
<td>-0.053</td>
<td>-0.094</td>
<td>0.639</td>
<td>0.051</td>
<td>0.181</td>
<td>1.000</td>
</tr>
<tr>
<td>AL</td>
<td>-0.053</td>
<td>-0.022</td>
<td>-0.058</td>
<td>-0.104</td>
<td>0.085</td>
<td>-0.020</td>
</tr>
<tr>
<td>ARK</td>
<td>-0.053</td>
<td>-0.092</td>
<td>-0.023</td>
<td>-0.208</td>
<td>-0.030</td>
<td>-0.020</td>
</tr>
<tr>
<td>AZ</td>
<td>-0.048</td>
<td>-0.029</td>
<td>-0.023</td>
<td>-0.062</td>
<td>0.016</td>
<td>-0.020</td>
</tr>
<tr>
<td>CA</td>
<td>0.720</td>
<td>0.655</td>
<td>0.112</td>
<td>0.045</td>
<td>0.279</td>
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</tr>
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<td>CO</td>
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<td>0.001</td>
<td>-0.078</td>
<td>0.026</td>
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<tr>
<td>CT</td>
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<td>0.118</td>
<td>0.177</td>
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</tr>
<tr>
<td>DE</td>
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<td>-0.096</td>
<td>0.129</td>
<td>0.195</td>
<td>-0.093</td>
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<td>-0.049</td>
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<td>0.091</td>
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<td>-0.183</td>
<td>0.059</td>
<td>-0.020</td>
</tr>
<tr>
<td>GA</td>
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<td>0.002</td>
<td>-0.004</td>
<td>-0.126</td>
<td>-0.046</td>
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<tr>
<td>HI</td>
<td>-0.033</td>
<td>-0.082</td>
<td>-0.135</td>
<td>-0.040</td>
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<td>-0.020</td>
</tr>
<tr>
<td>IA</td>
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<td>-0.043</td>
<td>-0.056</td>
<td>0.068</td>
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<td>0.026</td>
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<td>-0.017</td>
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</table>
Table 7, continued

<table>
<thead>
<tr>
<th></th>
<th>VCFUNDS</th>
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<th>CORPTAX1</th>
<th>AWE</th>
<th>UNEMP</th>
<th>AK</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN</td>
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<td>0.040</td>
<td>-0.145</td>
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<td>-0.028</td>
<td>0.075</td>
<td>-0.020</td>
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<td>UT</td>
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<td>-0.046</td>
<td>-0.090</td>
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<td>-0.020</td>
</tr>
<tr>
<td>VA</td>
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<td>-0.008</td>
<td>-0.063</td>
<td>-0.059</td>
<td>-0.093</td>
<td>-0.020</td>
</tr>
<tr>
<td>VT</td>
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<td>-0.047</td>
<td>0.005</td>
<td>-0.096</td>
<td>-0.020</td>
</tr>
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<td>-0.022</td>
<td>0.042</td>
<td>-0.195</td>
<td>0.216</td>
<td>0.102</td>
<td>-0.020</td>
</tr>
<tr>
<td>WI</td>
<td>-0.035</td>
<td>0.014</td>
<td>0.011</td>
<td>0.075</td>
<td>-0.139</td>
<td>-0.020</td>
</tr>
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<td>WV</td>
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<td>0.037</td>
<td>0.054</td>
<td>0.342</td>
<td>-0.020</td>
</tr>
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<td>-0.195</td>
<td>-0.066</td>
<td>-0.056</td>
<td>-0.020</td>
</tr>
</tbody>
</table>

The amount of venture capital funds within a state (VCFUNDS) is positively and highly correlated with the federal research and development obligations to universities within the state (RD). The VCFUNDS variable is also positively correlated with the ratio of corporate taxes to total state taxes (CORPTAX), the average weekly earnings in manufacturing within a state (AWE), and the unemployment rate (UNEMP) counter to a priori expectations. States that exhibit a positive correlation with venture capital include California (72%), Connecticut (13%), Illinois (11%), Massachusetts (31%), Maryland (7%), New Jersey (4%), New York (51%), and Texas (2%). These positive correlations meet the literature’s findings that a major portion of U.S. venture capital tends to be concentrated in or attracted to the Northeast or to California, with smaller concentrations in the Midwest and Texas.* All states are correlated with each other at a negative 2 percent as demonstrated by Alaska (AK).

---

CHAPTER VI

Empirical Results

Empirical tests were conducted for both annual new investment in venture capital and regional location factors for venture capital funds. Leading this section is a presentation of the results of the estimation on annual new investment in venture capital. Afterward, the results of the regional estimation are discussed.

Annual New Investment in Venture Capital Estimation Results

The results of the initial, unrestricted estimation for annual new investment with independent, private firms are presented below in Table 8.
Table 8. Annual New Investment Estimation Results

Dependent Variable is LNEWVC
Included observations: 24

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-3.885</td>
<td>1.538</td>
<td>-2.526</td>
<td>0.021</td>
</tr>
<tr>
<td>LNASDAQ</td>
<td>1.326</td>
<td>0.272</td>
<td>4.870</td>
<td>0.000</td>
</tr>
<tr>
<td>LCGTRATE</td>
<td>-1.780</td>
<td>0.657</td>
<td>-2.735</td>
<td>0.014</td>
</tr>
<tr>
<td>ERISA2</td>
<td>1.360</td>
<td>0.630</td>
<td>2.160</td>
<td>0.045</td>
</tr>
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<td>POSPREM</td>
<td>-2.004</td>
<td>1.112</td>
<td>-1.802</td>
<td>0.088</td>
</tr>
<tr>
<td>NEGPREM</td>
<td>0.523</td>
<td>1.112</td>
<td>0.472</td>
<td>0.644</td>
</tr>
</tbody>
</table>

R-squared 0.940 Mean dependent var 6.386
Adjusted R-squared 0.923 S.D. dependent var 2.059
S.E. of regression 0.572
Sum squared resid 5.893
Log likelihood -17.204 F-statistic 55.961
Durbin-Watson stat 1.952 Prob(F-statistic) 0.000

The coefficient for the NASDAQ variable is positive and statistically significant, suggesting that new investment in venture capital increases when securities market prices for high technology stock is increasing. When the NASDAQ index increases by one percent, venture capital investments are predicted to increase by 1.33 percent. Although causality is not inferred, growth in small-capitalized investments during the year is predicted to increase investor interest in private entrepreneurial firms backed by venture capital. The coefficient for capital gains tax rates (LCGTRATE) is statistically significant and negative. This elasticity takes the \textit{a priori} direction. The statistically significant coefficient for pension investment changes (ERISA) also takes the expected direction.
The variable constructed to reflect a positive NASDAQ risk premium (POSPREM) is statistically significant and negative. It can be interpreted as showing a substitution effect between venture capital investments and NASDAQ investments when the Nasdaq Index is experiencing high growth. Alternately, the variable constructed to reflect positive Treasury premiums (NEGPREM) is statistically insignificant and positive. Its positive direction might suggest that investors in venture capital are disposed towards riskier investments, and would not consider Treasury bills as substitute. Another inference posited by Bygrave and Shulman is that Treasury bill rates represent the cost of debt for entrepreneurs, and as the rate rises, venture capital firms become more attractive sources of financing.90

The Durbin-Watson statistic was tested for positive autocorrelation.91 This test failed to reject the null hypothesis of no positive autocorrelation. Given that the small number of observations allow only 19 degrees of freedom, the results of the estimation are not robust.92 Additionally, the regression does not account for non-stationary properties of the data. However, the estimation does identify statistically significant explanatory variables for investment in venture capital.

---

91 For n=24 and k=5, the D_U is 1.902 at 5 percent significance. The actual Durbin-Watson statistic of 1.952 falls between the D_U value and 2, yielding a test result of no significant serial correlation.
Regional Venture Capital Estimation Results

The results of the estimation for regional influences on total venture capital resources are presented in Table 9. A White Heteroskedasticity-Consistent estimation was performed because non-constant variance was a concern due to large differences in the magnitudes of variables between states.  

Table 9. Regional Venture Capital Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
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<td>C **</td>
<td>1732.196</td>
<td>870.684</td>
<td>1.989</td>
<td>0.049</td>
</tr>
<tr>
<td>RD **</td>
<td>8.088</td>
<td>2.654</td>
<td>3.048</td>
<td>0.003</td>
</tr>
<tr>
<td>CORPTAX1</td>
<td>-1.280</td>
<td>4.128</td>
<td>-0.310</td>
<td>0.757</td>
</tr>
<tr>
<td>AWE *</td>
<td>-3.038</td>
<td>1.579</td>
<td>-1.924</td>
<td>0.057</td>
</tr>
<tr>
<td>UNEMP *</td>
<td>-50.972</td>
<td>26.156</td>
<td>-1.949</td>
<td>0.054</td>
</tr>
<tr>
<td>AL *</td>
<td>-1487.790</td>
<td>516.732</td>
<td>-2.879</td>
<td>0.005</td>
</tr>
<tr>
<td>ARK **</td>
<td>-518.978</td>
<td>244.242</td>
<td>-2.125</td>
<td>0.036</td>
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<td>AZ **</td>
<td>-1298.434</td>
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</tr>
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<td>84.112</td>
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Table 9, continued

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** p < 0.10  *** p < 0.001
* p < 0.05  ** p < 0.05

R-squared 0.990
Adjusted R-squared 0.984
S.E. of regression 219.795
Mean dependent var 644.875
Sum squared resid 4734367.000 S.D. dependent var 1735.884
Log likelihood -1008.102 F-statistic 173.757
Durbin-Watson stat 2.003 Prob(F-statistic) 0.000

The coefficient for federal Research and Development obligations to universities in a state (RD) takes the expected positive direction and is statistically significant at 98
percent. For every million federal R&D dollars obligated to a state university, *ceteris paribus*, state venture capital funds are predicted to increase by approximately 8.1 million dollars. However, the coefficient for the proportion of corporate taxes to overall state taxes (CORPTAX1), while taking the expected direction, is statistically insignificant.

The average weekly earnings’ coefficient (AWE) takes the expected negative direction, and is statistically significant. All else equal, venture capital funds in a state are predicted to decrease by $3.04 million for every dollar increase in a state’s average weekly earnings in manufacturing. Likewise, the unemployment rate coefficient (UNEMP) is statistically significant takes an *a priori* negative direction. A one-percent increase in a state’s unemployment rate is predicted to decrease venture fund location in that state by approximately 51 million dollars, *ceteris paribus*. Finally, the coefficients on many of the state dummy variables are statistically significant and negative.
CHAPTER VII

CONCLUSION

This study has examined the venture capital industry from a national and a regional perspective. Empirical models were constructed to evaluate national investment in venture capital and the location of funds. The study has identified statistically significant, explanatory variables for new venture capital investment and the location of venture capital funds. For new investment in venture capital, these variables include the NASDAQ Index, pension fund legislation, capital gains tax rates, and risk premiums. The statistically significant variables for regional location of venture capital funds include university research and development funding, average weekly earnings, and the unemployment rate.

A positive elasticity of 1.326 was found between new investment in venture capital and the NASDAQ index. Bygrave and Schulman (1988) also found a statistically significant, positive relation between venture capital investment and the NASDAQ index. This finding indicates that rising investments in NASDAQ, or public markets that carry small-capitalized, high technology firms, may predict increased interest in small, high technology venture capital firms. However, the results do not imply causality between NASDAQ and venture capital investment. The purpose of the study was not to investigate the causal relationship between venture capital and the NASDAQ index, but
to extend upon prior research of the economic conditions that impact venture capital investment.

The relaxation of pension fiduciary rules, allowing pension funds to invest in venture capital was also found to have a positive effect on new venture capital investment. In contrast to previous research, capital gains tax rate increases were found to have a significant, negative influence on new investment in venture capital. Likewise, when the NASDAQ Index growth rate exceeded Treasury bill returns, providing a risk premium, new investment in venture capital was found to decline.

On a state or regional level, this study found that venture capital funds were attracted to states with higher levels of university research and development funding. Additionally, the study identified unemployment rates and average weekly earnings as negative influences on venture capital fund location.

The results of this study suggest that proposed policy changes on capital gains tax rates or investment regulation should incorporate an analysis of the legislation’s effect on venture capital investment. Legislative changes that reduce venture capital investment could lead to a decrease in our nation’s economic growth. Also, the study suggests that states seeking to attract high technology firms should evaluate the level of research and development conducted at universities within the state.

The objective of this study was to further identify the variables that impact new investment in venture capital, and to determine what regional or state variables influenced the location of venture capital funds. The analysis revealed significant variables that impact venture capital investment. However, the model on national investment contained only 24 annual observations, and therefore, is not statistically
robust. As this industry matures, and more data become available, future studies will be able to identify the variables that affect venture capital investment with greater confidence. The venture capital industry has contributed to economic growth in America by funding some of America’s leading entrepreneurs. And, as Benjamin Mokry said, “The entrepreneur has become something of a talisman and symbol of hope for the American economy as it moves into the twenty-first century.”

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APPENDIX A

THEORETICAL FRAMEWORK

In their study of the private equity market, including venture capital, Fenn, Liang, and Prowse suggested that limited information about private transactions had worked to depress the development of academic literature in this area.\(^5\) Bygrave and Timmons also cited the lack of conceptual models for venture capital flows when designing an empirical study.\(^6\)

However, economic and financial theories have been developed on investment and economic growth. In his evaluation of economic growth, Abramovitz noted “the process of capital formation involves three distinct, if interdependent activities:”\(^7\) saving, finance, and investment. And, investment theory can be applied to venture capital investment and the variables that influence it.

Venture Capital Firms and Financial Intermediation

When considering investment theory, venture capital firms can be viewed as financial intermediaries, providing investors (limited partners) with

informational and monitoring services on portfolio firms (entrepreneurs). As financial intermediaries, venture capital firms may serve to reduce information or search costs for investors in a market characterized by asymmetric information. Additionally, venture capital firms, as financial intermediaries, may reduce the risk of asset ownership for private investors through "transformation" of the assets by spreading ownership across a number of portfolio firms.

However, even with venture capitalists acting as financial intermediaries, an investment in a small, entrepreneurial firm entails a higher degree of risk on return than investment in less volatile assets such as Treasuries. Therefore, investors in high-risk venture capital equities, require a premium on the asset's return in order to compensate them for the additional risk. This risk premium is detailed in the financial model of investment theory developed by Bodie, Kane, and Marcus.

**Portfolio Allocation Model**

The Bodie, Kane, and Marcus model for portfolio allocation considers a risk-neutral investor. If investors are assumed to be risk neutral, a risk premium or extended return is placed upon assets with highly variable returns. For example, a diversified portfolio might hold a proportion (y) of its investment funds in risky assets,

---

and the remaining proportion \((1 - y)\) in risk-free instruments, such as three-month treasury bills. If the risk-free return is denoted by \(r_f\) and the risky rate of return denoted by \(r_p\), the authors define the return on the complete portfolio \((r_c)\) as:

\[
r_c = yr_p + (1 - y)r_f
\]

and the expected rate of return as:

\[
E(r_c) = yE(r_p) + (1 - y)r_f
\]

\[
= r_f + y[E(r_p) - r_f]
\]

The risk premium of the risky asset is, therefore, \(E(r_p) - r_f\). Additionally, if the investor's utility \((U)\) for the portfolio is defined as a positive function of the rate of return, a negative function of the variance \(\sigma^2\) in return, and a negative function of a coefficient of risk aversion \((A)\), then utility is maximized by the following function:

\[
\text{Max } U = E(r_c) - \frac{1}{2}A\sigma^2_c = r_f + y[E(r_p) - r_f] - \frac{1}{2}y^2A\sigma^2_p
\]

where the standard deviation of the portfolio is:

\[
\sigma_c = y\sigma_p
\]

and the variance of the portfolio is:

\[
\sigma^2_c = y^2\sigma^2_p
\]

Setting the first derivative of the maximization equation to zero and solving for \(y\) yields the optimal proportion of risky assets an investor would hold in a portfolio:

\[
y^* = \frac{[E(r_p) - r_f]}{A\sigma^2_p}
\]

Therefore, the optimal amount of risky assets held in a portfolio decreases in proportion to the level of risk aversion and the degree of variance in returns. Alternately,

\[101\text{ Bodie, Kane, and Marcus (1989) 130-140.}
\[102\text{ Bodie, Kane, and Marcus (1989) 167.}

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it increases in proportion to the level of the risk premium. Venture capital investment is characterized by a high degree of risk, and therefore, must offer a high-expected risk premium.

Bygrave and Timmons remarked upon unrealistic venture-capital investor expectations of returns approaching 50 percent annually.\(^{104}\) They cited a study which highlighted the relationship between high expected returns and high risk, saying, “Just 6.8% of the 383 investments made in portfolio companies between 1969 and 1985 returned ten times or more on invested capital. And more than 60% of all these investments either lost money or failed to exceed savings account rates of return.”\(^{105}\)

This section first reviewed the role of venture capital firms as financial intermediaries. It noted that venture capital firms might reduce search costs and help to balance asymmetric information between investors and portfolio firms. Risk of asset ownership is also reduced because the venture capital firm spreads the investor’s funds into equity positions across a number of portfolio firms.

Subsequently, the portfolio allocation model was reviewed. This model examined the composition of an investment portfolio composed of risk-free and risky assets.\(^{106}\) After defining a utility-maximization function, the optimal amount of risky assets held in an investment portfolio was defined as a function of the investor’s risk aversion, the variance in the asset’s return, and the level of the risk premium offered on the risky asset.

\(^{103}\) Bodie, Kane, and Marcus (1989) 172.
\(^{104}\) Bygrave and Timmons (1992) 9.
\(^{105}\) Bygrave and Timmons (1992) 9.
\(^{106}\) Bodie, Kane, and Marcus (1989) 130-140.
BIBLIOGRAPHY


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