HOW MUCH DOES HISTORY MATTER? AN ANALYSIS OF THE GEOGRAPHIC DISTRIBUTION OF VENTURE CAPITAL INVESTMENT IN THE U.S. BIOTECHNOLOGY INDUSTRY

Ke Chen
Department of Geosciences
East Tennessee State University
Johnson City, TN 37614
USA

Yali Liu
Department of Mathematics
East Tennessee State University
Johnson City, TN 37614
USA

Qiangbing Chen
Department of Economics and Finance
East Tennessee State University
Johnson City, TN 37614
USA

ABSTRACT

This study investigates the changing geography of venture capital investment in the U.S. biotechnology industry. From 1995 to 2007, all major regions in the U.S. experienced some growth in venture capital investment, though at various rates. Regarding the spatial distribution of investment in the absolute magnitude, our analysis shows that regional investment is positively associated with past investment. Similarly, when the share distribution of investment is considered, the current pattern is positively related to the historical pattern as well. Furthermore, we find that regional investment volume is related to recent national economic growth and stock market returns. Overall, our results suggest that areas receiving more investment in the history tend to receive even more in the future and the affluent regions become more affluent in term of relative shares.

Key Words: venture capital investment, biotechnology, spatial distribution

The Industrial Geographer, 2009, Volume 6, Issue 2, Pages 31-55.

INTRODUCTION

Venture capital is the investment made by specialized investors in high-growth, high-risk, and often high-technology firms that need capital to finance product development or growth (Black and Gilson 1998). Being a relatively new source of equity financing, venture capital plays an important role in technology innovation of new, private companies (Black and Gilson 1998; Jeng and Wells 2000; Schmidt 2003; Global Insight 2007). Many highly successful firms, such as Microsoft, Apple, Genetech, and Google received venture capital finance in their infancies. For many start-up companies, venture capital may be their only choice of financing, because tremendous risk and information asymmetry make traditional financing channels unavailable to them (Gompers et al. 1998; Gompers and Lerner 2001). Once venture capitalists are involved, they provide not only financial support, but also monitoring and advisory services, networking support, further funding opportunities, and more credibility (Cuny and Talmor 2005). Some evidence shows that venture capital-backed companies have outperformed their non-venture capital-backed counterparts in product development, revenue growth, and job creation in the long run (Brav and Gompers 1997; Gompers et al. 1998; Hellman and Puri 2000; Global Insight 2007). In 2006, public companies that were once venture-backed were estimated to account for 10.4 million jobs and $2.3 trillion in revenues in the United States, which equates to 17.6 percent of the Gross Domestic Product (Global Insight 2007). Therefore, venture capital plays an important role in both corporate innovation and the U.S. national economy.

However, not all regions have reaped the benefits of venture capital equally. Instead, it is well recognized that there are spatial clusters of venture capital investment in the U.S. and other parts of the world (Leinbach and Amrhein 1987; Thompson 1989; Florida and Smith 1993; Mason and Harrison 2002; Zook 2002; Klagge and Martin 2005). For instance, California and the New England region have concentrated a large share of venture capital investment in the United States. Likewise, London has accumulated the largest proportion of venture capital investment in the United Kingdom (Martin 1989). Furthermore, some studies suggest that the spatial distribution of venture capital is a dynamic phenomenon (Klagge and Martin 2005). Florida and Smith (1993) found that the U.S. venture capital industry increased by $30.9 billion from 1977 to 1989, among which California alone accounted for 31 percent of the growth. It is also possible that the regional disparity increases over time. In the United Kingdom, it is found that new investments tended to concentrate in the already more prosperous southeastern part of the country (Martin 1989). Similarly, Mason and Harrison (2002) indicate that regions continuously receiving a large amount of venture capital investment may reduce the investment in other areas in the long run.

One growing industry that has been attracting venture capital investment is biotechnology (Cooke 2008). Based on the biological science in genetic engineering and recombinant DNA knowledge, biotechnology has applications in a wide variety of businesses, especially pharmaceuticals (United States Department of Commerce 2003). Due to its high-cost and high-risk nature, commercial activities in biotechnology started with venture capital, and many new start-up firms would not have survived the harsh business environment without venture funding and the expertise provided by the venture capitalists (Kenney 1986). In 2007, it was estimated that around 25 percent of U.S. biotechnology companies received venture capital funding (www.bio.org). From 1995 to 2005, venture capital investment in the U.S. biotechnology industry (termed "Bio-VC investment" hereafter) increased from $830 million to $3,893 million [1]. Meanwhile, its share in the overall venture capital investment in the U.S. increased from 10 to 17 percent. In the second quarter of 2009, reports show that biotechnology led all industry sectors by a 25 percent share of all venture capital invested (Dellenbach 2009). While the Bio-VC investment has been increasing at the national level, its geographical distribution has changed significantly. For example, the once leading Boston area in Bio-VC investment in the 1980s was overtaken by San Diego in the late 1990s (Carnegie Mellon University 2002a; 2002b).

The purpose of this study is to explore the changing geographic distribution of the Bio-VC investment in the U.S. How does the past Bio-VC investment pattern influence the future? Do the leading areas in Bio-VC investment keep attracting more capital, or does the gap in capital between prosperous and underprivileged areas diminish over time? Also, is there a significant historical clustering effect when share distributions are considered? Furthermore, how are the fluctuations in Bio-VC investment related to changes in the national economy and stock markets? We try to answer these questions through statistical models in this study.

Our study attempts to add to the growing literature of financial geography. As the western countries shift from a modern to postmodern society, money, capital investment, and their related activities are playing more important roles in economies at local, national, and global levels (Gehrig 2000; Sassen 2006). Due to these changes, Martin (1999) calls for a more comprehensive understanding of financial geography. In the study of venture capital investment, some scholars have implied that historical trend has influenced the geographic clustering (Martin 1989; Florida and Smith 1993; Mason and Harrison 2002). However, few have utilized quantitative methods to explicitly explore this issue. Our study fills this gap with a time series regression analysis. We are also interested in the share distribution of the venture capital investment in different regions. Do leading areas receive larger percentages in new investment,

[1] data source: Moneytree survey https://www.pwcmoneytree.com

or do these areas receive more investment but not disproportionately so? Answers to these questions will add further insights in the study of venture capital investment clustering and business clustering in general. In addition, by including national economic changes and stock market returns in the analysis, we contribute to the literature by identifying some new macroeconomic factors that help explain the fluctuations in the venture capital investment.

VENTURE CAPITAL INVESTMENT

Venture capital is a long-term equity investment in highly risky but highly profitable companies (Black and Gilson 1998). Though venture capitalists' funding commitments are influenced by the profitability prospects of the firm, decisions of funding are mainly made on ideas instead of existing marketable products (Black and Gilson 1998; Gompers and Lerner 2001; Gompers et al. 2008). The funds invested convert to liquid stock or cash after these companies go public, merge into, or are acquired by other companies (Cumming 2002; Hand 2007). In general, investors are cautious about start-up companies' future and tend to infuse small amounts of capital into companies in their early stage of development (Sorenson and Stuart 2001). If the business outlook of a start-up company weakens, venture capitalists may cut funding or avoid further investment commitment (Sahlman 1990; Hsu and Kenney 2005). In contrast, when firms grow and move into the later stage of development, there is more assurance of future success and venture capitalists are more likely to infuse their money (Hsu and Kenney 2005). On average, the investing period of VC, calculated as the interval between the time of first round of investment and the time when venture capitalists exit the company, is about six years (Global Insight 2007).

Since the nature and history of venture capital investment have been discussed in details in previous studies (Tyebjee and Bruno 1984; Gompers and Lerner 1998; Gompers and Lerner 2001; Sorenson and Stuart 2001; Cuny and Talmor 2005), they are not repeated here. To serve the purpose of this study, we will focus on the factors that influence the overall venture capital investment, such as the profitability of the industry, the status of the public equity market, and the macro economic conditions (Gompers and Lerner 1998; Gompers and Lerner 2001; Gompers et al. 2008).

Similar to investment decisions on individual firms, the overall venture capital investment in an industry has been sensitive to the profitability of that economic sector and the satisfaction of the investors (Gompers and Lerner 2001). In the 1970s and early 1980s, high returns of some venture capital-backed companies lured more money into the venture business. By contrast, in the mid 1980s, profit returns of venture investment were not as high as expected, resulting in less capital infusion in the late 1980s and early 1990s (Gompers and Lerner 2001;

Cochrane 2005). Then in the late 1990s, the phenomenal success of venture capital-backed companies, such as eBay and Yahoo, trigged another huge wave of venture capital investment activities (Gompers and Lerner 2001). In the early 21st century, with the burst of the Dot-com bubble and many failed investments, venture capital funds declined sharply (Green 2004).

Since venture capital investment is a type of equity investment, investors' return could not be realized until the invested company is listed in a stock exchange through an Initial Public Offering (IPO), or is acquired by or merged into other companies. According to the literature, high profits from IPO are one key driving force for the involvement of venture capitalists (Black and Gilson 1998). When there were active IPO activities, more start-up companies were established, together with a greater venture capital commitment and a more vibrant entrepreneurial economy (Farrell et al. 1995). Since many new high-technology firms are listed on the National Association of Securities Dealers Automated Quotations (NASDAQ) stock exchange, some scholars have utilized NASDAQ indexes to represent the performance of IPOs (Brav and Gompers 1997; Ritter and Welch 2002; Hine and Griffiths 2004; Gompers et al. 2008). NASDAQ index is also used to estimate market-adjusted returns to venture capital investment (Brav and Gompers 1997; Ritter and Welch 2002; Hine and Griffiths 2004). By similar rationale, NASDAQ Biotechnology Index is a ready barometer for the performance of the biotechnology industry. The index includes stocks of companies classified as either biotechnology or pharmaceuticals. To be listed in the NASDAQ biotechnology index, a company must have a market capitalization of at least $200 million and an average daily trading volume of at least 100,000 shares (NASDAQ 2008). Hine and Griffiths (2004) suggest that there is a strong impact of the NASDAQ biotechnology index upon investment in the industry. Empirically, it is found that low NASDAQ index has negatively impacted IPO in the biotechnology industry (Dibner et al. 2003). Consequently, low expectation of the NASDAQ index would then become a negative factor for further venture capital investment.

Venture capital investment might also be influenced by the national economic growth (Gompers et al. 1998; Jeng and Wells 2000; Allen and Song 2002). This could be explained by the demand for and the supply of the venture capital. On the demand side, when the economy is expanding and the consumer confidence is high, entrepreneurs may find more business opportunities, and the demand for venture capital increases accordingly (Gompers et al. 1998; Jeng and Wells 2000). As biotechnology products find most of their applications in consumer product industries, which are influenced strongly by the overall performance of the macro economy (Romer 2001), it is reasonable to expect that there exists a demand effect caused by the GDP growth. On the supply side, when the economy is growing, people are more willing to take risks and invest their money. As venture funds come from a variety of sources, such as state and private pension funds, university financial endowments, foundations, insurance companies, and pooled investment vehicles, it is much easier for venture capitalists to raise funds when the economy performs well and market confidence is strong (Black and Gilson 1998). In an empirical study, Gompers et al. (1998) find that a higher GDP growth rate leads to a larger volume of venture capital investment in the U.S. from 1972 to 1994.

THE GEOGRAPHY OF VENTURE CAPITAL INVESTMENT

Previous studies have shown that a large share of venture capital investment is concentrated in a few geographic clusters (Florida and Smith 1993; Gompers et al. 1998; Gompers and Lerner 2001; Stuart and Sorenson 2003). In the biotechnology industry, investments are concentrated in regions where there is a strong life science research base, a strong entrepreneurial spirit, large pharmaceutical companies, and/or an urban environment that boosts innovative activities (Sainsbury 1999; Powell et al. 2002; Oliver 2004; Chen and Marchioni 2008). For instance, with a number of world-class universities and institutes in life science research, Silicon Valley rises as a global leader in biotechnology and attracts a large amount of venture capital investment. In comparison, biotechnology firms thrive in the New York metropolitan area through strong ties with large pharmaceutical companies and easy access to financial institutions. While in the Washington D.C. area, biotechnology firms might benefit from proximity to first-rate hospitals that conduct life science research, the Food and Drug Administration, the National Institute of Health and other federal agencies. Due to these regional characteristics, some areas have concentrated a significant amount of biotechnology firms and attracted a large sum of venture capital investment (Cortright and Mayer 2002).

Though the spatial disparity of venture capital investment is well recognized, there is no unanimous opinion regarding the historical change of the geographic pattern over time. Would the regional disparity in venture capital investment expand or diminish as time goes on? In the economic literature, Myrdal (1957) proposes that capital investment has a snow-ball effect, and that regions with an initial advantage in capital investment would very likely take the lead in the future. According to this cumulative causation theory, there is a virtuous circle in heavily invested areas and a vicious circle in under-invested areas.

Various explanations have been offered for the positive virtuous circle or snow-ball effect, including scale economy, specialized labor pooling, decreased transaction costs, and knowledge spillover (Marshall 1892; Krugman 1991; Desrochers 2001; Pinch et al. 2003; Vom Hofe and Chen 2006). Among these explanations, knowledge spillover is especially important for explaining investment clustering in biotechnology industry where technology innovation requires intensive exchanges of knowledge and ideas among researchers and entrepreneurs. This type of knowledge is now widely recognized as tacit, mostly transmitted via personal contact in limited spaces, such as face-to-face interactions (Almeida and Kogut 1999; Lawson and Lorenz 1999; Desrochers 2001; Pinch et al. 2003). When new firms are located close to established companies, it is easier for them to develop communication networks, acquire investments, utilize specialized labor, and access relevant knowledge (Desrochers 2001; Pinch et al. 2003). Given these positive externalities, the concentration of investment is very likely to generate a pattern of circular causation and a historical lock-in (Arthur 1988; Krugman 1991).

In a contrasting perspective, however, Thompson (1989) argues that there might be a spatial diffusion or the trickle-down effect in venture capital investment. When firms concentrate in a given area, it may become a challenge for individual businesses to keep their technology a secret (Fosfuri and Ronde 2004). Besides, the high mobility of labor in a dense business area may destabilize the technology base of a firm, and then decrease its competitiveness in innovation. Furthermore, higher living costs and traffic volumes would also make existing industrial clusters less attractive for future investment. As a result, new firms may want to distance themselves from competitors and choose to locate in areas with less existing venture capital investment. Another argument for spatial dispersion of venture capital investment is the life cycle theory developed by Vernon (1966). He suggests that as high-technology industry matures from the research and development stage to the mass production stage, firms tend to relocate from the center to peripheral areas to take advantage of the potential markets and lower labor costs in these places. As a consequence, capital investments disperse as well. For example, Mason and Harrison (2002) find some supportive evidence that venture capital investments were more evenly distributed in the 1990s than in the 1980s in the U.K.

Our analysis on the venture capital investment in the U.S. biotechnology industry aims to add new empirical evidence to this unresolved issue on the historical trend. While many existing studies have illustrated historical changes in numbers, we base our analysis on more rigorous and formal statistical models. In addition to the analysis of the Bio-VC spatial distribution in absolute amount, we also consider relative shares, which are equally important in examining the theories on investment clustering and dispersion.

DATA DESCRIPTION

Data on biotechnology venture capital investment used in this research are from the MoneyTree survey, a quarterly study of venture capital investment activities in the United

States.[2] The same database has been used in several other venture capital studies (Zook 2002; Green 2004; Chen and Marchioni 2008). In the MoneyTree survey, there are a variety of sources for venture capital investment, including professional venture capital firms, small business investment companies (SBICs), and venture capital investment subsidiaries of corporations, institutions, and investment banks. While the majority of venture capitalists are domestic, some are overseas investors. All invested companies in this database are private U.S. biotechnology firms, which specialize in developing technologies in drug development, disease treatment, and other relevant activities.

From the first quarter of 1995 to the fourth quarter of 2007, a total of $39,872 million was invested in the biotechnology industry, accounting for 10 percent of all venture capital investments in the United States. The annual investment increased steadily from 1995 to 1999. Then there was a sharp increase in the fourth quarter of 1999 when the Dot-com bubble began to form (see the bar graph in Figure 1). After the investment reached a peak in the third quarter of 2000, the amount invested declined in the following two years. Afterwards the investment began to recover. When the investment shares in the biotechnology industry are considered, the percentages were lowest during 1999 and 2000 (see the line graph in Figure 1). Then the percentage share increased gradually.

Two important factors may have contributed to Bio-VC's gain in market share in the past decade. First, when investors lost money after the burst of the dot-come bubble, they turned to other more profitable industries such as biotechnology, to seek investment opportunities (Metzger et al. 2003). Second, the acceleration in the approval of new biotechnology drugs by the Food and Drug Administration (FDA) makes new drug development more lucrative (Metzger et al. 2003). A promising market outlook and expected high revenue returns have attracted more investment into biotechnology, which increased its share in the total venture capital investments (Carnegie Mellon University 2002b).

Geographically, venture capital investment in the U.S. biotechnology industry is distributed very unevenly. The geographic units we use in this study conform to the definition by the MoneyTree survey, which divides the U.S. into eighteen areas: Silicon Valley, New England, San Diego, Los Angeles, New York, Southeast, Texas, Northwest, Midwest, Washington D.C., Philadelphia, Southwest, Colorado, North Central, Upstate New York state, Sacramento, South Central, and Alaska /Hawaii/Puerto Rico (see Appendix 1 for the detailed definitions of these regions). Alaska, Hawaii and Puerto Rico are excluded from this study due to too much missing data. Though it would be

[2] The investment literature in economics shows that investment varies significantly across quarters. Because quarterly data have a higher frequency than yearly data, these data are widely used in investment studies in economics (Romer, 2001).

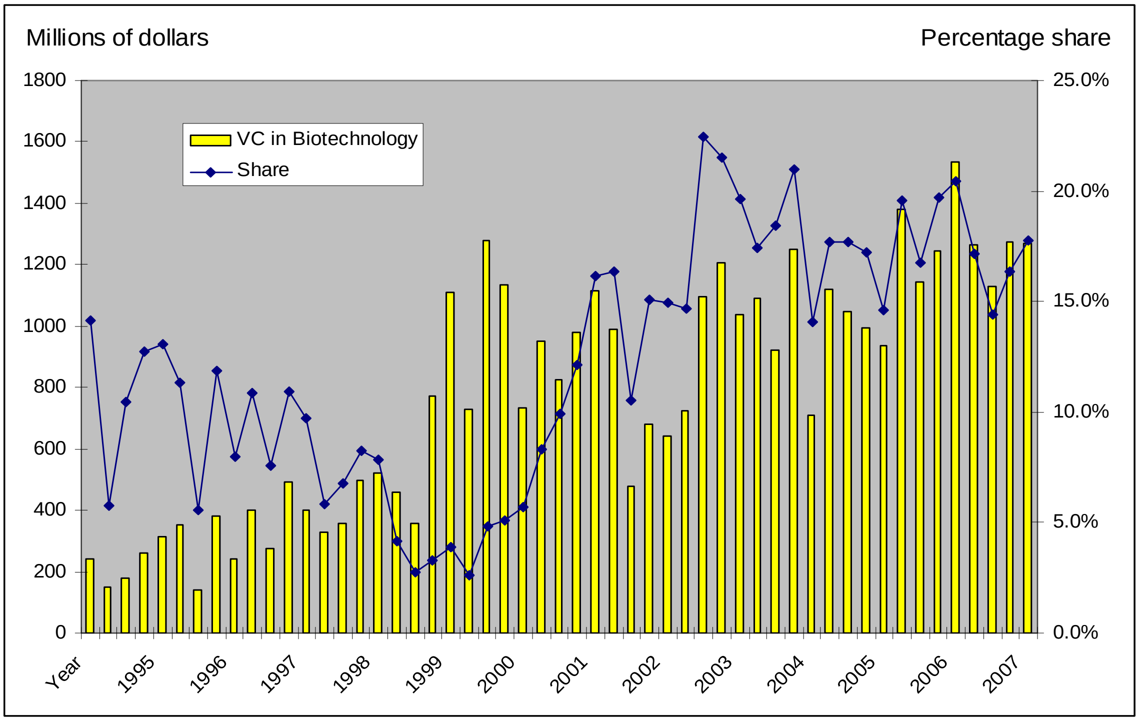


Figure 1: Venture Capital Invested in the U.S. Biotechnology Industry

desirable to use state or metropolitan area as spatial units, such data are not available on the Moneytree website. Despite the seemingly problematic scale definition, each area does have some unique regional characteristics. For instance, Silicon Valley is distinctive with high concentrations of venture capital investment businesses and high-technology firms, although its area and population size are much smaller compared to other regions. Similarly, San Diego is unique as a fast growing biotechnology center. In contrast, Midwest is aggregated as one unit, since it is the traditional manufacturing center of the U.S. and has a relatively late start in venture capital business. Also, the North Central area is characteristic of having little cutting edge research and few venture capital investing activities. Therefore, it is reasonable to use these regions as the spatial units.

Quarterly Bio-VC investments in each region are displayed in Figure 2. When ranked by total investment in the study period (see Table 1), Silicon Valley occupies first place, receiving $9,790 million in venture capital investment. This region is followed by New England ($7,195 million), the San Diego metropolitan area ($5,376 million), the New York metropolitan area ($3,340 million) and the Philadelphia metropolitan area ($2,981 million). Sacramento, South Central and Upper New York were the regions receiving the least amounts of investment.

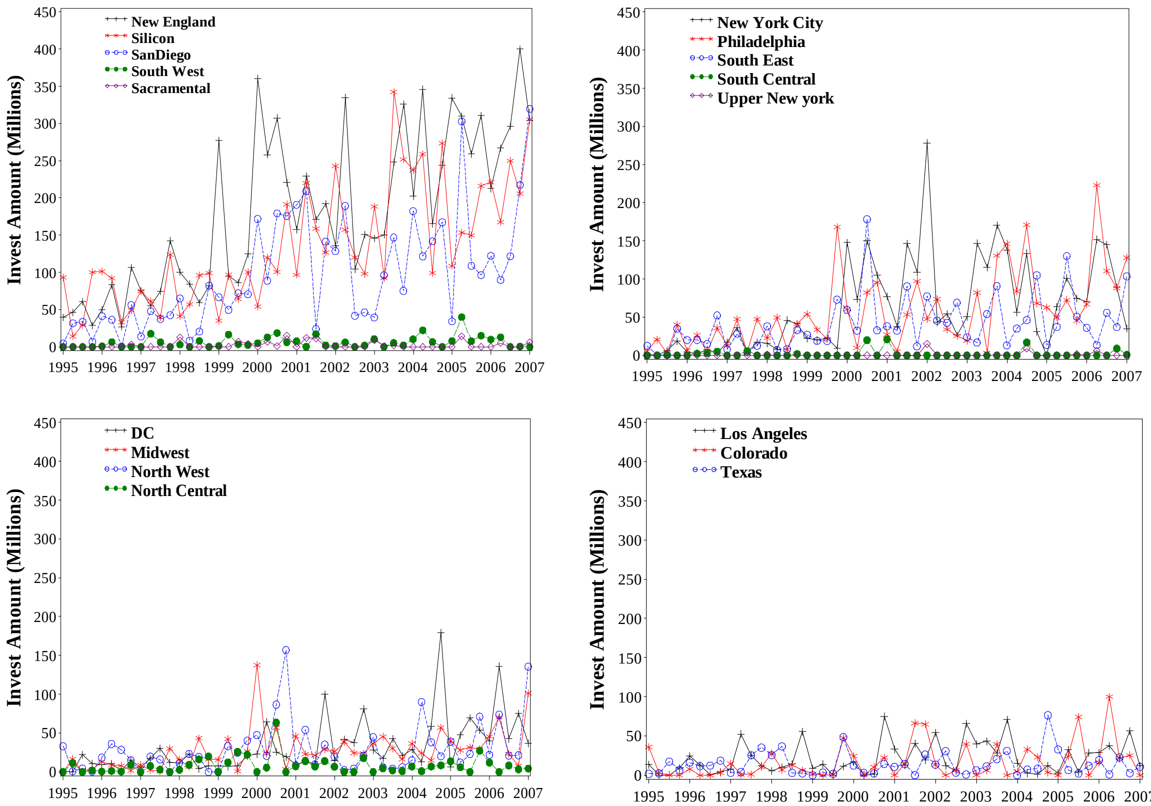


Figure 2: The regional distribution of venture capital investment in the U.S. biotechnology industry

Though all regions experienced some increases in investment volume from 1995 to 2007, their growth rates were different. This results in considerable changes in the share distribution of Bio-VC investment (Figure 3). For instance, both Silicon Valley and San Diego have increased their proportions over the years. Similarly, Midwest's share increased gradually. In contrast, the New England area has been receiving declining percentages in the Bio-VC investment. Some areas gained larger shares during the Dot-com bubble period than other years, such as New York City metro. In comparison, other regions had their lowest shares during this period, including Philadelphia, Southeast, Washington D.C., Northwest, Texas, and the North Central region.

MODELS

The objective of this research is to investigate the historical change in the spatial distribution of Bio-VC investments in the U.S. To be more specific, we are interested in understanding how the regional allocation of investment is related to historical distribution, national economic growth, and stock market

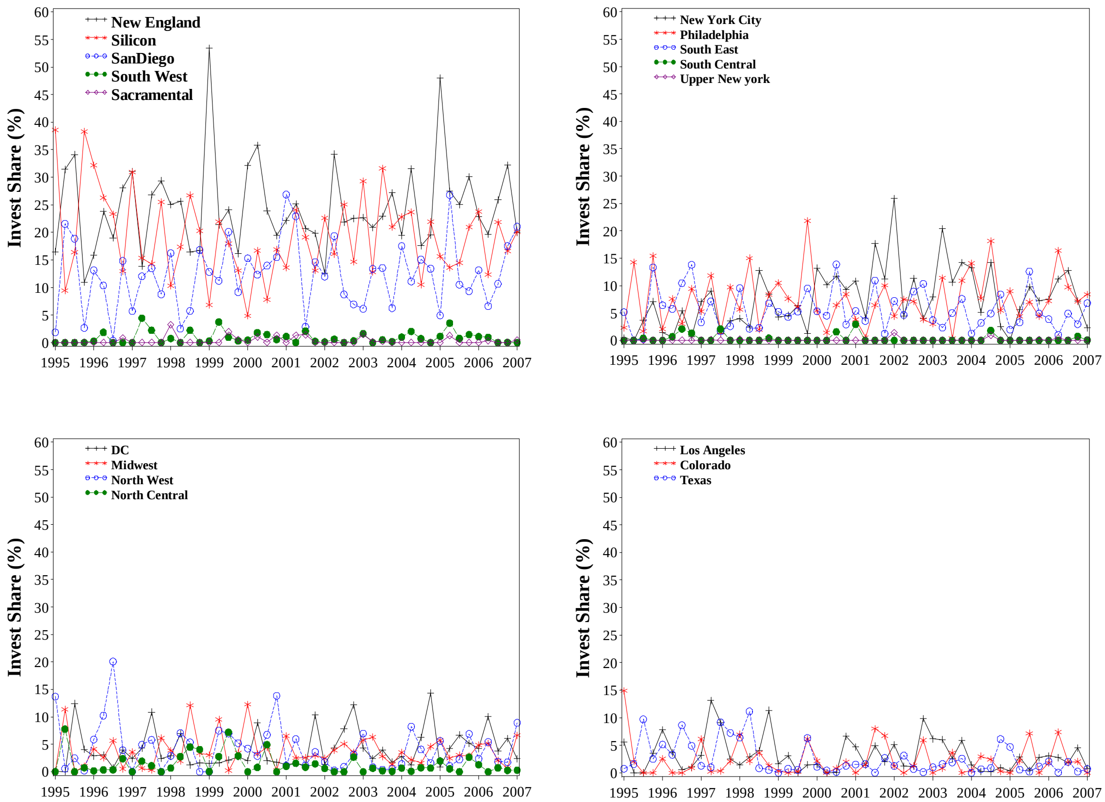


Figure 3: Regional Shares of Venture Capital Investment in the U.S. Biotechnology Industry

Table 1: Regional Distribution of Venture Capital Investments in the U.S. Biotechnology Sector

Rank	Region	Investment 1995-2007 ($ m)	Share in 1995 (%)	Share in 2001 (%)	Share in 2007 (%)	Growth 1995-2007 (%)
1	Silicon	9,790	21.19	21.94	24.55	611.0
2	New England	7,195	28.55	17.61	17.39	273.8
3	San Diego	5,376	9.29	16.55	18.35	1,112. 4
4	New York City	3,340	3.14	10.81	4.97	872.3
5	Philadelphia	2,981	8.45	5.35	5.69	313.7
6	South East	2,216	5.78	5.06	6.10	548.2
7	Washington, D.C.	1,817	3.99	3.88	5.81	792.6
8	Midwest	1,582	2.36	3.49	6.48	1,584.8
9	North West	1,549	4.69	3.13	4.91	541.8
10	Los Angeles	1,255	2.77	3.08	4.18	826.7
11	Colorado	948	4.70	4.25	2.57	236.0
12	Texas	761	3.39	1.51	1.79	223.6
13	North Central	463	1.62	1.24	1.59	502.6
14	South West	316	0.00	0.80	0.39	51,543.9
15	Sacramento	132	0.00	0.68	0.52	-
16	South Central	91	0.08	0.61	0.09	585.7
17	Upper New York	42	0.00	0.00	0.18	-

return. Two statistical models are established to explore the regional distribution of Bio-VC investment measured in both absolute amount and relative share. The spatial units are the seventeen areas defined by the Moneytree Survey. Since such a spatial division mixes cities and regions together and might cause problems, we construct two additional sets of data to test the same models. One dataset includes six city/metropolitan areas: Silicon Valley, San Diego, New York City, Philadelphia, Washington D.C., and Los Angeles. All the remaining eleven regions are pooled in the other dataset.

Model one: spatial distribution of investment in absolute magnitude

In model one, we examine how the amount of current investment is influenced by the past investment, national GDP growth rate, and NASDAQ biotechnology index. Seasonal and regional dummies are included as control variables. This is expressed mathematically in Equation 1.

Equation 1:

$$I_{it} = \alpha_i + \beta_1 CI_{i,t-1} + \beta_2 Growth_{t-1} + \beta_3 Nasdaq_{t-1} + \beta_4 Quarter_{1t} + \beta_5 Quarter_{2t} + \beta_6 Quarter_{3t} + \varepsilon_{it}$$

$i=1, 2, \ldots, 17; t=2, 3, \ldots, 51.$

The dependent variable I_{it} represents the current investment amount in the i^{th} area in quarter t. Independent variable $CI_{i,t-1}$ represents the cumulative investment from the first quarter of 1995 up to the t-1^{th} period in the i^{th} area. To deal with the heteroscadascity problem, all investment data are adjusted using square root transformation. Independent variable $Growth_{t-1}$ is the national GDP growth rate in period t-1, and $Nasdaq_{t-1}$ is the NASDAQ biotechnology index in period t-1. Quarterly GDP growth rates are calculated based on the data from the Bureau of Economic Analysis (BEA). NASDAQ biotechnology index data are from the NASDAQ official website. Variables $Quarter_{1t}$ to $Quarter_{3t}$ are dummies for the control of seasonal effects. For example, $Quarter_{1t}$ takes the value of 1 if it is quarter one in time period t and 0 otherwise. When all three dummy variables are zero, it refers to the fourth quarter. Parameters α_1, α_2, … α_{17} are included to capture regional differences. The order of the regions is the same as the rank of overall investment from 1995 to 2007 in Table 1. The error term ε_{it} is assumed to have an identical independent normal distribution. In the model, time period t starts with a value of two because there is a lag in the explanatory variables. All together, with 17 areas in 51 periods, there are 867 observations in the regression model. Detailed definitions of the variables are provided in Table 2.

If path dependence theory holds true, we would expect a positive impact from $CI_{i,t-1}$ upon I_{it} and a snow-ball effect in capital investment. In other words, areas that have received more Bio-VC investment in the past tend to receive more investment in the future. We also conjecture that economic growth rate in the recent past ($Growth_{t-1}$) has a positive effect on Bio-VC investment, as suggested in the relevant literature (Gompers and Lerner 1998; Jeng and Wells 2000). In addition, we expect a positive impact from the recent return in the stock market, measured by the NASDAQ biotechnology index in the previous quarter ($Nasdaq_{t-1}$) (Brav and Gompers 1997; Ritter and Welch 2002; Hine and Griffiths 2004). A preliminary autocorrelation analysis shows that there are high autocorrelations for up to eight lags for each of the variables $CI_{i,t-1}$, $Growth_{t-1}$, and $Nasdaq_{t-1}$. To avoid a multicollinearity problem in the Ordinary Least Squares regression, we use only one lag for each of these three variables.

Table 2: Description of Variables

Variable	Description
I_{it}	Venture capital investment (after square root) in t^{th} quarter in the i^{th} region
$I_{i,t-1}$	Venture capital investment (after square root) in $t\text{-}1^{th}$ quarter in the i^{th} region
$Share_{it}$	Venture capital investment share in t^{th} quarter in the i^{th} region
$Share_{i,t-1}$	Venture capital investment share in $t\text{-}1^{th}$ quarter in the i^{th} region
$CI_{i,t-1}$	Accumulated venture capital investment (after square root) in $t\text{-}1^{th}$ quarter in the i^{th} region
$CShare_{i,t-1}$	Accumulated venture capital investment share in $t\text{-}1^{th}$ quarter in the i^{th} region
$Growth_{t-1}$	GDP growth at $t\text{-}1^{th}$ quarter
$Nasdaq_{t-1}$	NASDAQ biotechnology index in the $t\text{-}1^{th}$ quarter
$Quarter_{1t}$	Dummy variable, 1 if the t^{th} quarter is the first quarter, 0 otherwise
$Quarter_{2t}$	Dummy variable, 1 if the t^{th} quarter is the second quarter, 0 otherwise
$Quarter_{3t}$	Dummy variable, 1 if the t^{th} quarter is the third quarter, 0 otherwise
Silicon(a_1)	Regional dummy for Silicon Valley
New England(a_2)	Regional dummy for New England
San Diego(a_3)	Regional dummy for San Diego
New York City(a_4)	Regional dummy for New York City
Philadelphia(a_5)	Regional dummy for Philadelphia
South east(a_6)	Regional dummy for South east
D.C. (a_7)	Regional dummy for Washington D. C.
Midwest(a_8)	Regional dummy for Midwest
North West(a_9)	Regional dummy for North West
Los Angeles(a_{10})	Regional dummy for Los Angeles
Colorado(a_{11})	Regional dummy for Colorado
Texas (a_{12})	Regional dummy for Texas
North Central (a_{13})	Regional dummy for North Central
South West(a_{14})	Regional dummy for South West
Sacramento (a_{15})	Regional dummy for Sacramental
South Central(a_{16})	Regional dummy for South Central
Upper New York(a_{17})	Regional dummy for Upper New York

To solve the coefficients α_1, α_2, … α_{17}, and β_1, β_2, …, β_6, we define $Y_t=(I_{1,t}, I_{2,t},\ldots, I_{17,t})^T$, $\beta=(\beta_1, \beta_2, \ldots, \beta_6)^T$, $\alpha=(\alpha_1, \alpha_2, \ldots \alpha_{17})^T$, $e_t=(\varepsilon_{1,t}, \varepsilon_{2,t},\ldots, \varepsilon_{17,t})^T$

and

$$X_t = \begin{pmatrix} CI_{1,t-1} & Growth_{t-1} & Nasdaq_{t-1} & Quarter_{1t} & Quarter_{2t} & Quarter_{3t} \\ CI_{2,t-1} & Growth_{t-1} & Nasdaq_{t-1} & Quarter_{1t} & Quarter_{2t} & Quarter_{3t} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ CI_{17,t-1} & Growth_{t-1} & Nasdaq_{t-1} & Quarter_{1t} & Quarter_{2t} & Quarter_{3t} \end{pmatrix}$$

$$Z = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 1 \end{pmatrix}_{17\times 17}$$

Then for any period $t=2,\ldots, 51,$ combining all regions, Equation 1 turns to be $Y_t = Z\alpha + X_t\beta + e_t$ $t=2, 3, \ldots, 51.$

Now, consider all time periods together to solve the parameters α and β. Let

$$Y = \begin{pmatrix} Y_2 \\ Y_3 \\ \vdots \\ Y_{48} \end{pmatrix}, \quad X = \begin{pmatrix} Z & X_2 \\ Z & X_3 \\ \vdots & \vdots \\ Z & X_{48} \end{pmatrix}, \quad e = \begin{pmatrix} e_2 \\ e_3 \\ \\ e_{48} \end{pmatrix}.$$

We have $Y = X\begin{pmatrix} \alpha \\ \beta \end{pmatrix} + e$.

By the OLS method, the estimated α and β are given by equation 2.

Model two: spatial allocation of venture capital investment in relative shares

Model two is constructed to investigate the share distribution of Bio-VC investments. It is similar to model one except that the dependent variable becomes the share of investment in period t for each region ($Share_{i,t}$), and $CI_{i,t-1}$ becomes the share of the cumulative investment $CShare_{i,t-1}$ in the previous quarter. Again, square root transformation is used for these variables to deal with the heteroscadascity problem. If there is a positive impact from $CShare_{i,t-1}$ upon $Share_{i,t}$, our analysis will provide further support for the theory of snow-ball effect. In other words, the geographic unevenness in the share distribution of venture capital tends to increase over time. In contrast, a negative impact signals a dispersion pattern and the share distribution of venture capital across regions tends to become more even over time. As in model one, economic growth, stock market return, quarterly and regional dummies are included. The model is expressed mathematically in Equation 3.

Similarly, we define:

$Y_t=(Share_{1,t}, Share_{2,t},\ldots, Share_{17,t})^T$

and

$$X_t = \begin{pmatrix} CShare_{1,t-1} & Growth_{t-1} & Nasdaq_{t-1} & Quarter_{1t} & Quarter_{2t} & Quarter_{3t} \\ CShare_{2,t-1} & Growth_{t-1} & Nasdaq_{t-1} & Quarter_{1t} & Quarter_{2t} & Quarter_{3t} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ CShare_{17,t-1} & Growth_{t-1} & Nasdaq_{t-1} & Quarter_{1t} & Quarter_{2t} & Quarter_{3t} \end{pmatrix}.$$

Equation 2:

$$\begin{pmatrix} \hat{\alpha} \\ \hat{\beta} \end{pmatrix} = (X^T X)^{-1} X^T Y$$

Equation 3:

$$Share_{it} = \alpha_i + \beta_1 CShare_{i,t-1} + \beta_2 Growth_{t-1} + \beta_3 Nasdaq_{t-1} + \beta_4 Quarter_{1t} + \beta_5 Quarter_{2t} + \beta_6 Quarter_{3t} + \varepsilon_{it}$$

i=1, 2, …, 17; t=2, 3, …, 51.

The other terms are defined in the same way as in the first model. The estimations of *α* and *β* are given in Equation 2.

RESULTS

Regression results of the first model when all seventeen areas are included are presented in Table 3. The R-square is 0.76. Both the QQ plot and residual plot illustrate a normal distribution of the error term (Figure 4), which is the assumption of the model. The second dataset (six city/metropolitans) and the third dataset (eleven state/regions) produce similar regression results regarding the significance terms. Therefore, we only report the regression results using the pooled data with all regions.

Independent variables CI_{t-1}, $Growth_{t-1}$ and $Nasdaq_{t-1}$ all have significantly positive effects (Table 3). The positive impact of CI_{t-1} indicates that areas with more historical investment tend to obtain more new investment. This result supports the theory of path dependence and circular causation. There is also a positive impact from GDP growth rate in the previous quarter. This outcome is different from Jeng and Wells (2000) but agrees with Gompers et al. (1998) and Dibner (et al. 2003). Besides the impact from long-term economic fluctuations upon venture capital investment (Gompers et al. 1998; Dibner et al. 2003), our results suggest a short term effect as well. As most biotechnology products are consumer goods that are directly related to the national economy, changes in the latter will impact the demand for the medical products and consequently the supply of the investment. A positive influence from the NASDAQ biotechnology index in the previous quarter signals that venture capital investment responds positively to the recent performance of capital market return, a result consistent with previous studies (Dibner et al. 2003; Hine and Griffiths 2004).

Regarding seasonal effects, the dummy variables for the first three quarters are all significantly negative. This means that, compared to the fourth reference quarter, there are

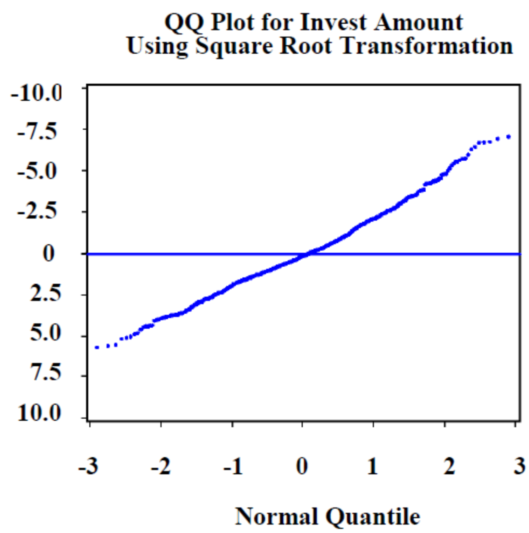
Table 3: Regression Result for Model One

Dependent variable: I_t (after square root transformation), or venture capital investment in the t^{th} quarter (N=867)

Variable	Estimate	Standard Error	t test	P Value
CI_{t-1}	0.097	0.007	13.760	**<.0001**
$Growth_{t-1}$	29.997	16.376	1.830	**0.067**
$Nasdaq_{t-1}$	0.002	0.000	4.950	**<.0001**
$Quarter_{1t}$	-0.490	0.213	-2.300	**0.022**
$Quarter_{2t}$	-0.404	0.209	-1.930	**0.054**
$Quarter_{3t}$	-0.617	0.209	-2.950	**0.003**
Silicon(a_1)	7.908	0.565	14.000	**<.0001**
New England(a_2)	6.588	0.538	12.240	**<.0001**
San Diego(a_3)	5.662	0.504	11.240	**<.0001**
New York City(a_4)	4.149	0.475	8.730	**<.0001**
Philadelphia(a_5)	4.003	0.476	8.420	**<.0001**
South east(a_6)	3.347	0.467	7.170	**<.0001**
D.C. (a_7)	3.157	0.454	6.950	**<.0001**
Midwest(a_8)	2.876	0.454	6.330	**<.0001**
North West(a_9)	2.392	0.458	5.220	**<.0001**
Los Angeles(a_{10})	2.213	0.452	4.890	**<.0001**
Colorado(a_{11})	1.494	0.447	3.350	**0.001**
Texas (a_{12})	1.602	0.447	3.580	**0.000**
North Central (a_{13})	1.033	0.441	2.340	**0.019**
South West(a_{14})	0.878	0.438	2.010	**0.045**
Sacramento (a_{15})	0.148	0.436	0.340	0.734
South Central(a_{16})	-0.084	0.436	-0.190	0.847
Upper New York(a_{17})	-0.905	0.447	-2.020	**0.043**
R square	0.766			

fewer investments from January to September. All regional dummies have significantly positive effects, except for South Central and Upper New York. Excluding Texas, the estimated coefficients for regional dummies have a descending order, which is consistent with the rank of overall investment value. Since the t-tests presented in Table 3 do not examine the difference between non-reference regions, a joint test for the null hypothesis $a_1 = a_2 = \ldots a_{16} = 0$, is further performed. Such a null hypothesis is strongly rejected (p-value<.0001), again providing sufficient evidence that regional difference is significant.

To illustrate the effects of the independent variables on the



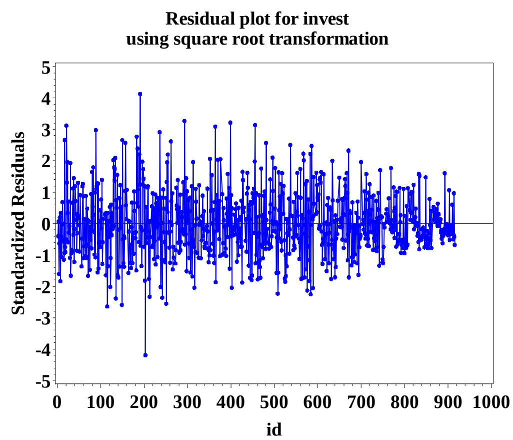


Figure 4: QQ Plot and Residual Plot for Model One (Absolute Amount after Square Root Transformation)

predicted investment, the fourth quarter of 2007 in Silicon area is taken as an example. In this quarter, the accumulated investment was $9,790 million, GDP growth rate was 1.46 percent, and NASDAQ biotechnology index was 815.72. Using our estimated model, the predicted investment in the first quarter of 2008 for Silicon Valley would be $317.8 million. If the accumulated investment increases by $100 million, the predicted investment would be $319.6 million with an increase of $1.8 million, given the same values for GDP growth rate and biotechnology index. If we only increase the GDP growth rate by one percent, the predicted investment would be $328.7 million. Also, if only the biotechnology index increases by 100, the predicted value would be $323.6 million. Now take Midwest for comparison. The accumulated investment in Midwest was $1,582 million in the fourth quarter of 2007 and its predicted investment in the first quarter of 2008 is $50.5 million. A $100 million increase in the accumulated investment would increase the predicted investment to $52.2 million in the first quarter of 2008. A one percent increase in GDP growth rate would result in $54.8 million, and an increase of biotechnology index by 100 would result in $52.8 million in the predicated value.

When the share distributions are analyzed in model two, again, all three data sets produce similar regression results. Hence we only report the results using the pooled data with all seventeen regions (Table 4). The R-square is 0.78. The QQ plot and residual plot show that the assumption of the model is satisfied (Figure 5). Variable $CShare_{t-1}$ has a significantly positive effect (P-value<.0001). This means that, in general, areas with larger shares in the cumulative investment amount in the past continue to receive larger proportions in the future. This result gives further support for the theory of path dependence. Different from model one, none of $Growth_{t-1}$, $Nasdaq_{t-1}$, and quarterly dummy variables is significant. Regarding the impact of regional dummy variables, only Colorado is significant at a level of .05, when compared to the reference Upper New York region. Similar to model one, we also test the joint null hypothesis $a_1 = a_2 = \ldots a_{16} = 0$ here. The testing result strongly rejects the null hypothesis, suggesting that regional difference is significant.

Combining results from both models, we conclude that, from 1995 to 2007, areas that attracted more Bio-VC investment in the recent past will continue to receive more and larger shares of new investment. In other words, the gap between the leading areas and others is increasing. Being consistent with some prior studies of the changing geography of venture capital investment (Martin 1989), our results provide further empirical evidence to the theory of path dependence through rigorous statistical model testing.

DISCUSSION AND CONCLUSION

This paper investigates the changing geography of venture capital investment in the biotechnology industry in the United States from the first quarter of 1995 to the fourth quarter of 2007. When the spatial distribution of Bio-VC in absolute amount is considered, we find that current investment is positively associated with historical investment. Leading areas in Bio-VC investment, such as Silicon Valley and New England, will continue to receive more capital in the future. In contrast, lagging areas in Bio-VC investment, including North Central and South Central, tend to receive fewer new investments than other areas. When the share distribution is considered, we find that a region's historical share has a significantly positive impact on its future share. Therefore, we conclude that areas with more venture capital investment in the past tend to not only attract more investments, but also gain larger shares over other

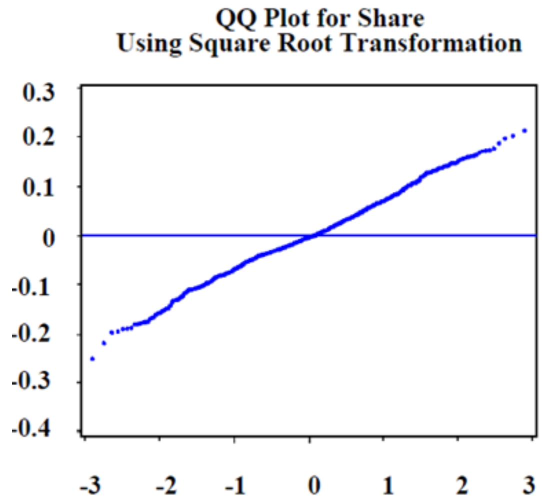
Table 4: Regression Result for Model Two

Dependent variable: $share_t$ (after square root transformation), or venture capital share in t^{th} quarter (N=867)

Variable	Estimate	Standard Error	t test	P Value
$CShare_{t-1}$	1.024	0.081	12.690	<.0001
$Growth_{t-1}$	0.096	0.547	0.180	0.861
$Nasdaq_{t-1}$	-1.59E-07	8.75E-06	-0.020	0.986
$Quarter_{1t}$	-0.006	0.007	-0.790	0.430
$Quarter_{2t}$	-0.004	0.007	-0.510	0.613
$Quarter_{3t}$	-0.003	0.007	-0.420	0.672
Silicon(a_1)	0.001	0.040	0.030	0.973
New England(a_2)	-0.024	0.038	-0.640	0.521
San Diego(a_3)	0.000	0.030	0.020	0.988
New York City(a_4)	0.010	0.023	0.450	0.654
Philadelphia(a_5)	-0.010	0.025	-0.420	0.675
South east(a_6)	-0.018	0.023	-0.760	0.446
D.C. (a_7)	0.009	0.020	0.460	0.648
Midwest(a_8)	-0.001	0.020	-0.050	0.962
North West(a_9)	-0.037	0.022	-1.710	0.088
Los Angeles(a_{10})	-0.025	0.020	-1.230	0.219
Colorado (a_{11})	-0.041	0.019	-2.160	0.031
Texas (a_{12})	-0.028	0.019	-1.460	0.144
North Central (a_{13})	-0.021	0.017	-1.240	0.214
South West(a_{14})	-0.008	0.015	-0.510	0.613
Sacramento (a_{15})	-0.014	0.015	-0.920	0.355
South Central(a_{16})	-0.022	0.015	-1.510	0.130
Upper New York(a_{17})	-0.007	0.015	-0.460	0.645
R square	0.776			

places in the future investment. Through rigorous statistical modeling, our results have added further evidence to the theory of business clustering (Martin 1989).

As the biotechnology industry is becoming more global (Cooke 2008), it is highly possible that leading regions will keep attracting both domestic and international capital, and that their positions will be strengthened in the United States and the world. By contrast, for the lagging areas to bridge the gap, it might be necessary for them to develop relevant regional attributes, such as more input in public research in life science, better



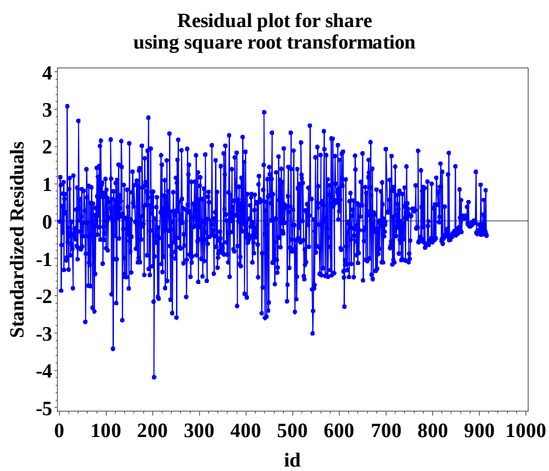


Figure 5: QQ plot and residual plot for model two (share after square root transformation)

regional infrastructure, and more innovative business environment. Finally, we find that the amount of Bio-VC investments at the regional level is positively related to recent national GDP growth rate and the return performance of biotechnology stocks. We will continue to explore these relationships as the relevant information becomes available.

REFERENCES

Allen, F., and Song, W.-l. 2002. *Venture Capital and Corporate Governance*. The Wharton Financial Institutions Center. http://finance.wharton.upenn.edu/~allenf/download/Vita/ventcap.pdf (accessed on July 15, 2008).

Almeida, P., and Kogut, B. 1999 Localization of knowledge and the mobility of engineers in regional networks. Management Science 45(7): 905-917.

Arthur, W. B. 1988 Urban systems and historical path dependence. In: Ausubel J, Herman R (eds) *Cities and their vital systems*. National Academy Press, Washington, 85-97.

Black, B. S., and Gilson, R. J. 1998 Venture capital and the structure of capital markets: banks versus stock markets. *Journal of Financial Economics* 47: 243-277.

Brav, A., and Gompers, P. A. 1997 Myth or reality? the long-run underperformance of initial public offerings: evidence from venture and nonventure capital-backed companies. *Journal of Finance* 52 (December): 1791-1822.

Carnegie Mellon University. 2002a Bio rising: venture firms rediscover Biotech. http://www.smartpolicy.org/pdf/biorising.pdf (accessed on Nov 10, 2007).

Carnegie Mellon University. 2002b Technology in Pittsburgh: trends in biotechnology investments. http://www.smartpolicy.org/pdf/tip-bio.pdf (accessed on November 10, 2007)

Chen, K., and Marchioni, M. 2008. Spatial clustering of venture capital-financed Biotechnology Firms in the U.S. *The Industrial Geographer* 5(2): 17-36.

Cochrane, J. H. 2005 The risk and return of venture capital. *Journal of Financial Economics* 75(1): 3-52.

Cooke, P. 2008 The evolution of biotechnology in bioregions and their globalisation. *International Journal of Biotechnology* 10 (5): 476-495.

Cortright, J., and Mayer, H. 2002 Signs of life: the growth of biotechnology centers in the U.S. http://www.brook.edu/dybdocroot/es/urban/publications/biotechnology.pdf (accessed on July 15, 2008)

Cumming, D. J. 2002 Contracts and exits in venture capital finance. *American Finance Association,* 2003 Meetings.

Cuny, C. J., and Talmor, E. 2005 The staging of venture capital financing: milestone vs. rounds. *The Annual Finance and Accounting Conference*, Tel Aviv, University of Houston.

Dellenbach, R. 2009. Biotechnology investments exhibit resilience. *Genetic Engineering & Biotechnology News* 29 (14).

Desrochers, P. 2001 Geographic proximity and the transmission of tacit knowledge. *The Review of Austrian Economics* 14(1): 25-46.

Dibner, M.D., Trull, M., and Howell, M. 2003 US venture capital for biotechnology. *Nature Biotechnology* 21: 613-617.

Farrell, C., Rebello, K., Hof, R. D., and Maremont, M. 1995 The boom in IPOs: it's fueling innovation and transforming the U.S. economy. *BusinessWeek*, December 18 http://www.businessweek.com/1995/51/b34551.htm (accessed on November 10, 2007).

Feldman, M. P. 2000 Where science comes to life: university bioscience, commercial spin-offs, and regional economic development. *Journal of Comparative Policy Analysis: Research and Practice* 2: 345-361.

Florida, R., and Smith, D. F. 1993 Venture capital formation, investment, and regional industrialization. *Annals of the Association of American Geographers* 83(3):434-451.

Fosfuri, A., and Ronde, T. 2004 High-tech clusters, technology spillovers, and trade secret laws *international Journal of Industrial Organization* 22, 45-65.

Gehrig, T. 2000. Cities and the geography of financial centers In *Economics of Cities: Theoretical Perspectives*, eds. J.-M. Huriot and J. F. Thisse: Cambridge University Press.

Global Insight. 2007 Venture impact: the economic importance of venture capital backed companies to the U.S. economy: National Venture Capital Association. Third edition. http://www.nvca.org/pdf/NVCA_VentureCapital07.pdf (accessed on November 10, 2007).

Gompers, P. A., and Lerner, J. 1997 Risk and reward in private equity investments: the challenge of performance assessment. *Journal of Private Equity* Winter(1): 5-12.

Gompers, P. A., and Lerner, J. 1998 Venture capital distributions: short-run and long-run reactions. *The Journal of Finance* 53(6):2161-2183.

Gompers, P. A., Lerner, J., Blair, M. M., and Hellmann, T. 1998 What drives venture capital fundraising? *Brookings Papers on Economic Activities Microeconomics* 1998: 149-204.

Gompers, P. A., and Lerner, J. 2001 The venture capital revolution. *The Journal of Economic Perspectives* 15(2): 145-168.

Gompers, P., Kovnera, A., Lernera, J., and Scharfsteina, D. 2008 Venture capital investment cycles: the impact of public markets. *Journal of Financial Economics* 87: 1-23.

Green, M. B. 2004 Venture capital investment in the United States 1995-2002. *The Industrial Geographer* 2(1): 2-30.

Hand, J. R. M. (2007). Determinants of the round-to-round returns to pre-IPO venture capital investments in U.S. biotechnology companies. *Journal of Business Venturing* 22, 1-28.

Hine, D., and Griffiths, A. 2004 The impact of market forces on the sustainability of the biotechnology industry. *International Journal of Entrepreneurship and Innovation Management* 4(2-3):138-149.

Jeng, L. A., and Wells, P. C. 2000 The determinants of venture capital funding: evidence across countries. *Journal of Corporate Finance* 6: 241-289.

Klagge, B., and Martin, R. 2005 Decentralized versus centralized financial systems: is there a case for local capital markets? *Journal of Economic Geography* 5, 387-421.

Krugman, P. 1991 Increasing returns and economic geography. *Journal of Political Economy* 99(31):483-499.

Lawson, C., and Lorenz, E. 1999 Collective learning, tacit knowledge and regional innovative capacity. *Regional Studies* 33(4):305-317.

Leinbach, T., and Amrhein, C. 1987 A geography of venture capital in the U.S. *The Professional Geographer* 39:146-158.

Marshall, A. 1890 *Principles of Economics*. Macmillan, London.

Martin, R. 1989. The Growth and Geographical Anatomy of Venture Capitalism in the United Kingdom *Regional Studies* 23 (5):389-403.

Martin, R. 1999. The new economic geography of money. In *Money and the Space Economy*, ed. R. Martin, New York: Wiley, 3-27.

Mason, C. M., and Harrison, R. T. 2002 The geography of venture capital investment in the UK. *Transactions of the Institute of British Geographers* 27(4): 427-451.

Metzger, J., Million, S., and Reyes, J. 2003 Life sciences regain prominence in venture capital arena. http://www.nvca.org/pdf/Q4_02_MT_LifeSci%20Release.pdf (accessed on November 10, 2007).

Morgan, K. 1997 The learning region: institutions, innovation and regional renewal. *Regional Studies* 31:491-503.

Myrdal, G. 1957 *Economic theory and underdeveloped regions*. Harper and Row, New York.

NASDAQ. 2008. NASDAQ Biotech Activity. http://dynamic.nasdaq.com/dynamic/nasdaqbiotech_activity.htm (accessed on August 26, 2009).

Oliver, A. L. 2004. Biotechnology entrepreneurial scientists and their collaborations. *Research Policy* 33:583-597.

Pinch, S., Henry, N., Jenkins, M., and Tallman, S. 2003 From 'industrial districts' to 'knowledge clusters': a model of knowledge dissemination and competitive advantage in industrial agglomerations. *Journal of Economic Geography* 3(4):373-388

Powell, W. W., Koput, K. W., Bowie, J. I., and Smith-Doerr, L. 2002 The spatial clustering of science and capital: accounting for biotech firms - venture capital relationships. *Regional Studies* 36 (3): 291-305.

Ritter, J. R., and Welch, I. 2002 A review of IPO activity, pricing, and allocations. *The Journal of Finance* 57(4): 1795-1828

Romer, D. 2001 Advanced Macroeconomics, McGraw-Hill Higher Education.

Sassen, S. 2006. *Cities in a World Economy* 3rd ed: Pine Forge Press.

Sainsbury, L. 1999. Biotechnology clusters: Department of Trade and Industry, United Kingdom. Last accessed on Aug 26, 2009 from http://www.berr.gov.uk/files/file28706.pdf (accessed on October 26, 2009).

Schmidt, K. M. 2003 Convertible Securities and Venture Capital Finance. *The Journal of Finance* 58(3):1139-1166.

Stuart, T., and Sorenson, O. 2003 The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms. *Research Policy* 32(2): 229-253.

Thompson, C. 1989 The geography of venture capital. *Progress in Human Geography* 13(1): 62-98.

Tyebjee, T. T., and Bruno, A. V. 1984 A model of venture capitalist investment activity. *Management Science* 30(9): 1051-1066

United States Department of Commerce. 2003. A survey of the use of biotechnology in United States Industry 2003. http://www.technology.gov/reports/Biotechnology/CD120a_0310.pdf (accessed on August 26, 2009).

Vernon, R. 1966 International investment and international trade in the product cycle. *Quarterly Journal of Economics*: 190-207.

Vom hofe, R., and Chen, K. 2006 Whither or Not Industrial Cluster: Conclusions or Confusions? *The Industrial Geographer* 4(1): 2-27.

Zook, M. A. 2002 Grounded capital: venture financing and the geography of the Internet industry, 1994–2000. *Journal of Economic Geography* 2: 151-177.