Temporal Changes in the Spatial Distribution of Venture Capital Investment to Biotechnology Companies within the United States.

Rocky Graziano Bilotta
East Tennessee State University

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Temporal Changes in the Spatial Distribution of Venture Capital Investment to Biotechnology Companies Within the United States

A thesis presented to the faculty of the Department of Technology and Geomatics East Tennessee State University In partial fulfillment of the requirements for the degree Master of Science in Technology

by Rocky Graziano Bilotta May 2008

Dr. Marian Clark, Chair Dr. Ke Chen Dr. Ting-Heng Chu

Keywords: Biotechnology, Venture Capital, Investments, GIS
ABSTRACT
Temporal Changes in the Spatial Distribution of Venture Capital Investment to Biotechnology Companies Within the United States

by
Rocky Graziano Bilotta

The objective of this research is to investigate temporal changes in the spatial distribution of venture capital investments to biotechnology companies within the United States. Data included venture capital to biotech investments from 1995 to 2005. Venture capital and biotech data from the Money Tree Report, were gathered, analyzed, and mapped to show if a spatial relationship exists. The research examined venture capital investments at both the individual and the aggregated levels. At the individual level, the research examined whether the amount of investments a biotech company receives are influenced by physical distance to its closest investor, number of venture capitalists, time, region, sequence, company size, stage of development, etc. The research also included an aggregated study examining the changing patterns of investments in metropolitan areas. This research further enhances knowledge on the spatial distribution of investments.
DEDICATION

The time and effort put into this thesis is dedicated to the faculty and staff at ETSU, especially: Dr. Ke Chen, Dr. Andy Clark, Dr. Marian Clark, Dr. Ting-Heng Chu, Dr. Keith Johnson, Dr. Michael Marchioni, Dr. Paul Sims, Dr. Mick Whitelaw, and Dr. Chunhua Zhang. You all have contributed greatly to my education and experience here at ETSU.

To the Geography and Geology professors at the University at North Carolina at Pembroke: Dr. Dennis Edgell, Dr. Martin Farley, Dr. Lee Phillips, and Dr. Thomas Ross. Thank you for getting me interested in the field and for your continued help and guidance.

To my old friends and the new ones I have made during my educational career, thanks for making the journey fun. To my family, thank you for providing me the time and support needed to complete this thesis. And, to my wife, I do not know where I would be without you.
ACKNOWLEDGEMENTS

I would like to extend my deepest thanks and appreciation to the members of my graduate committee: Dr. Marian Clark, Chairperson; Dr. Ke Chen; and, Dr. Ting-Heng Chu, for their continued guidance, direction, and support during the writing and completion of this thesis. Also, a special thanks to Graduate and Professional Student Association (GPSA), Dr. Linda Garceau, and Dr. Keith Johnson for providing me the funding needed to present this research at the 2008 Association of American Geographers (AAG) Conference held in Boston, Massachusetts.

In addition, I would like to thank my family and friends for allowing me the time and support necessary to complete my education and this thesis.
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CHAPTER 1
INTRODUCTION

Much work has been completed on the significance of the venture capital industry and the biotechnology industry. Far less has been accomplished in reference to the relationship of the locations of venture capitalist and biotechnology, considering biotech’s dependency on venture capital funds.

In the biotechnology industry, there are thousands of companies employing more than 150,000 people in the United States, making them the world leader in biotechnology (Sainsbury, 1999). Biotechnology firms, and the venture capital firms that fund them, are highly clustered in certain key U.S. regions. According to Powell, Koput, Bowie, and Smith-Doerr (2002), more than half of the biotech firms in the United States received locally-based venture funding from 1988 - 1999. Most corporations that received non-local funding have a tendency to be older, larger, and have research projects further along the commercialization process. The case is similar for venture capital firms. As these firms grow older and larger, they invest more in non-local firms (Powell et al., 2002).

Venture capital investment in the United States has resembled a roller coaster pattern beginning in the 1970s, reaching its peak during the Internet bubble in 1999 and 2000. Majority of the venture capital investments during the bubble period funded companies in the Internet and telecommunications industries and had little influence on the biotechnology industry. After the bubble period subsided, the Internet and telecommunication industries suffered a rapid decline in investments, while funding for biomedical ventures has continued to increase (Powell, White, Koput, & Owen-Smith, 2003).
There are several factors that come into play when a venture capital company is deciding on investing into a particular biotechnology company. In the past, research has shown that significant considerations for venture capitalist are: location of the industry, age of the industry, size of the industry, success of the industry, etc. (Powell et al., 2002). Other factors also include the age, size, and experience of the venture capital company. According to these factors, a venture capital company may choose to invest in either a local or a non-local biotech company. Overtime, there has been an increase emergence of new biotech companies in newer regions (e.g. Research Triangle, NC) and an increase emergence of new venture capital companies.

Currently, there are relatively few publications that explain or refer to the spatial relationship between venture capitalists and biotechnology companies. Thus, the purpose of this paper is to provide insight on the unique relationship between the locations of venture capitalists and the locations of their funded biotechnology companies. More importantly, this research will attempt to explain what variables influence the amount of capital a biotechnology company receives from its venture capitalist.

The research methodology for this study consists of three parts. The initial step includes the means of gathering and collecting the data. Data included only records of venture capital firms investing in biotechnology companies from 1995 to 2005 within the United States. All data were collected by accessing Pricewaterhouse Coopers’ the Money Tree Report website. The Money Tree Report was chosen because of its data, its use of updated information from reliable sources, and ease of accessibility. The second step consisted of the use of Geographic Information Systems (GIS) to display the locations of venture capital firms and biotechnology companies. Maps were also created using GIS to provide visual aids of the geographic locations of venture capitalists and biotechnology companies, their geographic regions, and the percent of
reallocate from 1995 to 2005 by region. The final step included the use of Statistical Analysis Software (SAS) to compute statistics from the data. Statistics included basic statistical tables and a regression model. SAS was also used to calculate the distance between biotechnology companies and their associated venture capital investors.

This paper proceeds as follows. Chapter 2 contains the literature review of venture capital, biotechnology, and the relationship between them. Chapter 3 presents the hypotheses, data, and methodology. Chapter 4 provides statistics, including a regression model, analysis, and results. Chapter 5 presents a conclusion of the work.
While investigating biotechnology and venture capital firms for this study, it was found that very little work has been completed directly relating to this subject. Regardless, a variety of periodicals were used to examine this topic. This chapter includes a brief history of venture capital, the significance of venture capital investments, the prosperity of the biotechnology industry, biotechnology dependency on venture capital investments, and the spatial influence on venture capital investments. Each area is essential in the understanding of the investment relationship between venture capital firms and the biotechnology industry.

**Brief History of Venture Capital**

Venture capital can be defined as a unique form of capital that involves the exchange of funds for an ownership stake in a firm (Florida & Smith, 1993). According to Kortum and Lerner (1998), venture capital can be defined as equity or equity-linked investments in young, privately held companies, where the investor is a financial intermediary who is typically active as a director, advisor, or even as manager of a firm. Venture capital funds are typically private equity capital invested by institutional investors used to fund new or growing businesses. Funds are usually invested in high-growth, high-risk, but potentially highly-profitable companies in exchange for preferred shares in the invested companies (Black & Gilson, 1998). This preferred stock converts into liquid common stock or cash at one of two major exit points: an Initial Public Offering (IPO) or an acquisition by another entity (Hand, 2007). Exits through IPOs are reached when a firm becomes public traded. Companies that reach IPO bring their investors high profits through the selling of shares. Exits through acquisition means the company was purchased by
another firm. In the case of biotechnology, these firms are typically acquired by larger biotechnology companies or pharmaceutical companies (Cumming, 2002).

The first modern venture capital firm established in the United States was the American Research and Development (ARD) in 1946. It was formed MIT President Karl Compton, Harvard Business School Professor Georges F. Doriot, and other local business leaders (Kortum & Lerner, 1998). The ARD was structured as a publicly traded closed-end firm, whose shares trade from investor to investor on an exchange like an individual stock. Selling shares to investors allows ARD and other venture capital firms to raise capital up front. For 26 years ARD invested in high-risk, emerging companies that were based on technological development. Their most profitable investment came in 1957 when ARD invested $70,000 in Digital Equipment Company, which grew in value to $355 million. As a result of their success, the ARD stimulated competitors in the biotechnology industry the following decade (Gompers, Lerner, Blair, & Hellmann, 1998).

Most United States venture capital firms remained publicly traded and marketed to individuals due to a shortage of investments from institutional investors in the 1950s-1970s. Many firms raised money through closed-end funds or small business investment companies (SBICs). SBICs are federally guaranteed risk-capital pools that proliferated during the 1960s as a result of the United States’ fear of lagging behind in technological competitiveness, especially after the Soviet Union launch of Sputnik in 1957. Regardless of the strong market for SBICs during this time, some firms became interested in making a greater profit by taking greater risks than government guarantees created. This resulted in the collapse of the sector (Gompers & Lerner, 2001). Also, during this time period the United States began to see the emergence of venture capital limited partnerships, which primarily invest the financial capital of third-party
investors in projects that are extremely risky for the standard capital markets or bank loans. Investors included wealthy individuals, pension funds, financial institutions, insurance companies, and other sources that were interested in investing in high-risk businesses but lack the ability to do so independently (Powell et al., 2002). Investors in return become limited partners with restricted liability in the venture capitalist firms. The first limited partnership was formed in 1958 with the partnership of Draper, Gaither, and Anderson and imitators followed. Although venture capital limited partnerships were on the rise in the United States, they still accounted for a marginal section of the venture pool during the 1960s and 1970s (Gompers, et al. 1998).

Two significant contributions to the venture capital industry that assisted in its continued growth overtime include funding and organization. The 1970s and early 1980s brought about a dramatic increase in funding opportunities. This increase was the result of the passing of the 1979 amendment, also known as “prudent man” rule, which governed the use pension funds. Prior to 1979, the Employee Retirement Income Security Act (ERISA) restricted pension funds from investing large amounts of money into high-risk asset classes. After the ruling of the 1979 amendment, pension funds significantly increased the amount of venture capital funds. In 1978, $424 million was invested in new venture capital funds and pension funds only accounted for 15%. In 1986, more than $4 billion in capital was invested and pension funds accounted for more than half of all contributions (Kortum & Lerner, 1998).

Also, there has been a significant change in the dominant organizational form in the past 20 years. From the start of ARD in 1946 until the early 1980s, publicly traded closed-end funded firms dominated the organizational form. The collapse of the SBIC sector and the dramatic increase in venture capital funds, opened the door for the limited partnership to become the new
dominant organizational form. Limited partnerships have several advantages, one of which is taxes. Capital gain taxes are not paid by the limited partnership, instead they are paid only by the taxable investors. This makes limited partnerships very attractive to tax-exempted institutional investors, who remained uninvolved until the early 1980s (Gompers & Lerner, 2001).

Venture capital investment in the United States resembled a roller coaster pattern beginning in the 1970s and reached its peak from 1999 to 2000, mirroring the stock market bubble of the Internet industry during the same period (Green, 2004). During this time period, venture capital funds increased from $3.34 billion in 1990 to $103.85 billion in 2000 and the number of firms increased from 1,317 in 1990 to 5,458 in 2000 (Peng, 2001). Funding during these years was predominantly concentrated in the Internet and telecommunication industries, which accounted for 39% and 17% of all venture disbursements in 1999 (Lerner, 2002). Short lived, the bursting of the Internet bubble resulted in dramatic declines in investment levels and is thought to have altered the investment patterns of the industry. Today, there is continued emphasis being placed on corporate-sponsored venture capital in place of the independent firms that now dominate the industry. Also, during the bubble many venture capitalists invested in ideas with little assurance, while many of them watched as their capital in the boom ultimately failed. After the bubble collapsed, no longer will venture capitalist throw money at grandiose promises about potential discoveries or new technology platforms (Weintraub, 2004).

Significance of Venture Capital Investments

Venture capitalists funds in the United States are predominately invested in early-staged ventures and high-technology industries. Venture capital plays a dominant role in several important and growing sectors where the United States is viewed as a world leader, including biotechnology (i.e. Genentech), personal computers and workstations (i.e. Apple and Compaq),
personal computer software (i.e. Harvard Graphics), and semiconductors (i.e. Intel) (Black & Gilson, 1998).

Venture capital investment is often called smart money because it provides more than just money to portfolio companies (Cuny & Talmor, 2005). In addition to capital, the venture capital investments provide the portfolio companies with management assistance, intensive monitoring of performance, and reputational capital. With management assistance, the venture capital firms have experience in developing startup companies, providing market knowledge, locating and recruiting workers, and assisting a company through prototype development to production, marketing, and distribution. With intensive monitoring of performance, they maintain control rights, voting rights, as well as greater board representation that investors use if they feel the entrepreneur is driving the company in the wrong direction. With reputational capital, venture capital financing enhances the portfolio company’s credibility with third parties by providing talented managers, suppliers, and customers (Gilson & Black, 1999). Venture capitalist knowledge and experience greatly increases the chances for a portfolio company to become successful.

Although many venture capital firms are large enough to effectively diversify their funds to several portfolios, funding is an extremely competitive business with free entry (Cochrane, 2001). In other words, because venture capital funding is so competitive, biotechnology companies can freely send proposals to several investors in search for funding. According to Kortum and Lerner (1998), only one percent of those firms that submit business plans to venture organizations have been funded. In other words, the rejection rate for these proposals is extremely high (99%) (Powell et al., 2002). If funding occurs, funds are typically distributed in two ways: milestone financing or round financing. Milestone financing includes both an
immediate funding and a commitment for additional investment later. Future funds have a predetermined price and are only distributed to a portfolio company if it meets pre-specified technological or operational goals. Round financing has no pre-commitment to invest beyond the current funding needs. Future investments are priced based on the status of the portfolio company at the time funding is desired. Both milestone and round financing have their advantages and disadvantages and each particular firm has to determine the best method for their company (Cuny & Talmor, 2005). Tian (2008) finds biotech firms located closer to their investors receive fewer rounds of investments in comparison to those firms located farther away. Firms located closer to their investors receive a greater overall amount of capital, have greater chance of IPO exits, and manage to outperform their distant competitors. In other words, the greater amount of rounds, or sequences, a biotech company receives is not necessary related to the amount of capital it receives.

With funding comes a specific contract with portfolio companies. These contracts are heterogeneous; in other words, they vary from one company to another and depend on other factors such as the success of those companies. These contracts include control rights, veto rights, provisions for different contingencies, liquidations rights, among other things (Cumming, 2002). Most of these rights are transferable. If a company performs poorly, the venture capitalist obtains full control; however, if a company performs well, the venture capitalist retains its cash flow rights but relinquishes most of its control and liquidation rights (Kaplan & Stromberg, 2000). Because monitoring is costly and cannot be performed continuously, the venture capitalist will periodically check the project’s status and preserve the option to abandon. If the portfolio company does poorly and continues to do so, the venture capitalist may choose to cut off any new financing (Gompers, 1995).
Prosperity of the Biotechnology Industry

According to the Pricewaterhouse Coopers (2007), biotechnology can be defined as developers of technology promoting drug development, disease treatment, and a deeper understanding of living organisms, industrial biotechnology, biosensors, biotechnology equipment, and pharmaceuticals. In other words, biotechnology is a developing science in which scientific and product development processes are collaborative (Oliver, 2004). Biotech firms are highly dependent on ideas, discoveries, and patents they generate through large research and development (R&D) expenditures, that are some of the most intensive of all businesses (Hand, 2007).

Commercial bioscience began in 1974, when Cohen-Boyer patented their work that provided the means to manipulate genetic material to produce commercial products. These genetic commercial products are more naturally accepted by the human body and its environment (Feldman, 2000). This work sparked biotechnology as a commercial industry. During the early years, from the 1970s to the late 1980s, biotech industries were very small start-ups that relied on external support. Lacking the skills and resources needed to bring new innovations to the market, they became involved in complex relationships with research-oriented universities (most notably: MIT, Harvard, Stanford, among others) and large pharmaceutical companies. Hundreds of small science based firms were founded adjacent to universities by the late 1980s. By the end of the decade, several of those firms (Biogen, Genentech, Immunex, etc.) became large and formidable organizations (Owen-Smith & Powell, 2004).

As biotechnology firms continued to locate themselves in this pattern, this resulted in the beginning formations of biotechnology clusters in key U.S. regions (Sainsbury, 1999). The most notable clusters include the San Francisco Bay Area and the Boston Metropolitan Area, which
stand as the largest and most commercially successful biotechnology regions in the world. Other notable clusters include San Diego (CA), Raleigh (NC), Seattle (WA), and Denver (CO). The success of these clusters is dependent on a unique combination of dense social networks and geographic co-location (Porter, 2005). In other words, within these clusters, there are extensive relationships between biotech firms and public research organizations, including universities, government laboratories, and research hospitals (Porter, Whittington, & Powell, 2005). These spatial concentrations grant several advantages, including transportation costs, access to skilled labor markets, communication markets, sophisticated customers, and access to technology. The advantages of location then are very much based on access and information. These advantages coupled with the success of biotech clusters draw new entrants to these key U.S. regions (Powell et al., 2002).

**Biotechnology Companies Dependence on Venture Capital Investments**

Biotechnology is considered a high-technology, high-risk, potentially high-rewarding industry. This makes receiving financing through traditional sources such as banks, government funds, private investors, and large pharmaceutical companies extremely difficult. Thus, biotech companies look to venture capital firms for funding (Ang, 2006). A number of studies have shown that the presence of local venture capital has an important positive impact on the formation of new firms (Stuart & Sorenson, 2003; Zucker, Darby, & Brewer, 1998).

The prototypical young biotech firm is in an intense R&D race against competitors to discover and patent a new drug. Consequently, these firms have large capital needs over a continuous period of time. Failure to receive funds can result in the termination of a project, thus giving competitors the advantage to make initial discoveries and receive patents (Hand, 2007).
Some new biotechnology companies can require millions to 10s-of-millions of dollars to get started (Lee & Dibner, 2005). Thus, some biotechnology companies depend entirely on venture capital for their existence (Weeks, 2005). These venture capitalists funds can range in size from about $20 million to billions of dollars (Lee & Dibner). Eventually, the capital needs of a firm become so large that they can only be satisfied via IPO or a buyout from a large pharmaceutical company (Hand). If a biotech firm succeeds by reaching IPO or being acquired, the venture capitalist can reap profits of 5 to 10 times its initial investments or possibly more. However, venture capitalists can lose their capital investments if the portfolio company fails in reaching IPO or fails in being acquired (Lee & Dibner).

Because venture capital funds are limited and competitive, biotech companies will submit proposals to several venture capital firms to increase their possibilities. Biotech firms may receive funding from multiple venture capitalists, whether for the same project or for discrete projects. The same is true for venture capitalist who are likely to invest in other biotech firms, including some that may be competitors in a particular area (Powell et al., 2002).

Again, venture capital funds are often called smart money because it plays a dual role. In addition to providing capital, venture capitalists provide coaching, guidance, connections with suppliers, customers, and so on (Cuny & Talmor, 2005). Thus, venture-backed biotech firms grow more rapidly and are more flexible than do their competitors that do not receive venture capital funding or only receive public funds (Hand, 2007).

Spatial Influence on Venture Capital Investments

Regardless of the complication of networks, geography plays an essential role in the biotechnology industry (Owen-Smith & Powell, 2004). As Porter, Whittington, and Powell
(2005) have pointed out, biotechnology firms are located in a small number of U.S. regions because of the extensive relations between firms and public research organizations.

From the 1970s to the late 1980s, biotech industries were very small start-ups located near research-oriented universities because they lacked the skills and resources needed to bring new innovations to the market (Owen-Smith & Powell, 2004). This resulted in the formations of heavily concentrated biotechnology clusters throughout the United States. For example, by the beginning of the 21st century, the Kendall Square neighborhood in Cambridge, Massachusetts became the largest single, geographically concentrated cluster of biotech firms in the world (Porter, Whittington, & Powell, 2005). The formation of clusters sparked a shift in the geographic location of venture capital companies from financial centers to these high-technology regions. This shift was initially made to reduce the high-risks of investing in high-technology companies (Florida & Smith, 1993). By locating within these regions, venture capitalists can monitor their investments and the portfolio company’s progress more effectively, while significantly reducing transaction, transportation, and other costs associated with distance (Tian, 2008). According to Lerner (1995), venture capital firms with offices within five miles of the portfolio company are twice as likely to serve as board members as those located over a 100 miles away.

The spatial pattern of venture capital investing became more complicated in 1999, as they began to disburse their funds more widely. A study completed by Kenney and Patton (2005) found that only around 25% of venture capitalists invest in local firms. Another study completed by Powell et al. (2002) found that majority of the biotechnology companies in their sample receive local venture capital funding. Venture capitalists located within high-technology centers tend to invest locally (Florida & Smith, 1993). Venture capitalists outside the biotech clusters
(i.e. New York and Chicago) are significantly more likely to export their capital to non-local companies that are located within these high-technology clusters (Kenney & Patton, 2005).

Today, it is not unusual for venture capitalist to ask academic scientists if they have any ideas that are ready for product development in the United States. If so, there would be no surprise if a newly created firm would be located close to the university. This way, scientists can resume their faculty association and serve on the board of these newly created firms (Schweitzer, Connell, & Schoenberg, 2004). If scientists were located outside of the biotech clusters (i.e. New York, Los Angeles, Houston, etc.) they would be more likely to serve on the company’s board from a distance (Powell et al., 2002).

By investigating the recent literature on biotechnology and venture capital firms, this research used a variety of periodicals to examine the topic. The subjects were diverse and covered a brief history of venture capital, the significance of venture capital investments, the prosperity of the biotechnology industry, biotechnology dependency on venture capital investments, and the spatial influence on venture capital investments. Background information of investment relationship between venture capital firms and biotechnological industries are vital for contributing to further research.
CHAPTER 3
HYPOTHESES, DATA, AND METHODOLGY

The study area for this research includes all data records of venture capital firms investing in biotechnology companies from 1995 to 2005 within the United States. Once the study area was defined, the records of investments from venture capital to biotechnology were accumulated into one large database. Another database was compiled containing the names and addresses of the venture capital firms that invest in these biotech companies. Upon completion of the databases, GIS was used to locate and map both the venture capital firms and the biotechnology companies. SAS statistical software was then used to calculate the distance between venture capitalists and biotechnology companies and provide statistically information about the data.

Hypotheses

This study’s initial focus is on whether or not variables influence the amount of capital a biotech company receives from its venture investors.

Several papers have focused on the importance of distance and its influence on investments, most notably Tian (2008), Powell et al. (2002), Coval and Moskowitz (2001), and Lerner (1995). These authors found that the closer a biotech company is to its investors, the greater amount of capital it would receive. This idea is based on the thought that venture capital investors would feel safer investing large amounts of capital into biotech companies they can monitor closely and efficiently. The first hypothesis is:
**Hypothesis #1 Research:** The closer the spatial relationship between venture capital investors and biotechnology companies, the more capital biotechnology companies receive from those venture capital investors.

**Hypothesis #1 Null:** The distance between venture capital investors and biotechnology companies has no effect on the amount of capital invested in those companies.

Physical distance between investor and investee greatly influences a venture capital firm’s decision when investing. Venture capitalists have to take into consideration their monitoring costs, which include visiting the firm, attending board meetings, being engaged in daily operations, talking with suppliers and employees, and assessing the local market condition. Because distance increases cost, distance is likely to limit a venture capitalists decision when investing. (Coval & Moskowitz, 2001). Studies completed by Tain (2008) and Lerner (1995) show that firms located in closer proximity to their venture capital investors receive more money, outperform, and have a greater possibility of an IPO exit than firms located farther away. In addition, Powell et al. (2002) reported that venture capital supported companies were three times more likely to generate patents than their competitors who receive no venture capital support. Thus, testing this hypothesis will provide insight on the importance of distance in accordance to the amount of capital a biotechnology companies receives from its venture capital investors.

A previous study completed by Sorenson and Stuart (2001) has shown that a biotech’s stage of development can influence the amount of capital it receives from venture capitalists. Biotech companies in earlier stages of development search for capital to fund new projects, while
companies in later stages of development require more capital to cover the costs of production, marketing, and distributing its product. The second hypothesis is related to this issue.

**Hypothesis #2 Research:** Biotech companies in later stages of development receive more capital from their venture capital investors.

**Hypothesis #2 Null:** Stage of development has no effect on the amount of capital a biotech company receives.

Stage of development can influence the amount of capital a biotech company receives. Biotech companies in their first stage of development, known as the Start-Up/Seed Stage, have little to no experience. Due to the lack of experience and track records, earlier stage biotech companies can expect to receive smaller quantities of capital as opposed to a biotech companies in their later stages (Sorenson & Stuart, 2001). According to Sorenson and Stuart, biotech companies in their later stages of development have extensive experience and have become known, thus increasing the possibility of them attracting new/more venture capitalists firms.

A study completed by Tian (2008) explains that the amount of capital a biotech company receives can be influenced by its financial sequence. In respect to this idea, it was hypothesized that a biotech company would receive a greater amount of capital if it received several financial sequences. This thought was based on the idea that the more financial sequences would result in more capital for a biotech company. The third hypothesis is related to this issue.

**Hypothesis #3 Research:** Biotech companies with a greater number of financial sequences receive more capital from their venture capital investors.
**Hypothesis #3 Null:** The number of financial sequences biotech companies receive does not affect the amount of capital they obtain.

Financial sequence can greatly influence the amount of capital a biotech company receives because it has to do with the total number of times a venture capitalists invests capital into a particular biotech company. Biotech companies that are located farther away from their investors have a tendency to receive more rounds of financing than a biotech company located closer to its investor (Tian, 2008). According to Tian (2008), although biotech firms located closer to its investors receive fewer rounds of investment, they still receive a greater overall amount of capital and manage to outperform their distant competitors. This may be the case because venture capital firms are not enthusiastic about investing large amounts of capital into companies they are not capable of monitoring efficiently.

**Data**

Data were gathered through the Pricewaterhouse Coopers’ Money Tree Report website. The Money Tree Report stands as the only industry-endorsed research of its kind, providing a quarterly report of venture capital investment activity in the United States. The website offers quarterly data beginning from the first quarter of 1995 until today. For the purposes of this study the focus will be on venture capital investment data that begins with the first quarter of 1995 and extends to the fourth quarter of 2005, totaling 11 years or 44 quarters of data.

After logging into the website, the Money Tree Report provides an aggregated bar graph of all quarterly data and the options to limit the search by region, state, industry, stage, and financing sequence. By clicking on any of the quarters, the website exhibits a list of investee companies by quarter in alphabetic order. The Money Tree Report offers the options of selecting
any of the companies and provides detailed information of the particular company selected. The type of information the Money Tree Report offers includes the biotech companies name, address, region, contact information, capital received, financing sequence, stage of development, type of industry, description of industry, and all the investors in that company for the quarter. Also, the Money Tree website goes one step further by providing venture capital firm details for each company on a quarterly basis. Venture capital firm details include: name, address, region, contact information, website, email, and other investments, if any, for that same quarter. The predominate interest in this research is on the amount of capital a biotech company receives and its association with the financial sequences, stage of development, number of investors, region, and the locations of both the biotech company and its investors. The Money Tree Report website has more than a sufficient amount of data, allowing the possibility to explore several different questions and options. The only task will be grouping all 44 quarters of data into one large dataset.

Combined, the 44 quarters of data totaled 3,219 records of investments of venture capitalists in biotechnology firms. Due to the number of companies with undisclosed information, which included unknown locations of biotechnology and investor firms, some records were eliminated from the database. The same was true for a minority of biotechnology companies that were listed but actually received no capital. Because the goal of this research was to look at the proximity and amount of investment flowing from venture capital firms to biotechnology companies, it was necessary to delete these records. After cleaning the data and deleting the inadequate records, this left a total of 2,890 records of investments of venture capitalists in biotechnology companies.
A basic statistical table was created on the 2,890 biotech records to see the overall results (see Table 1, page 41). This table displays the mean, standard deviation, median, minimum, and maximum for all the records in accordance to the amount of investment ($), number of investors, financial sequence, stage of development, minimum distance (in miles), and international investors. To better understand the variables and their effect on investment capital, one has to understand the parameters that the Money Tree Report uses when disclosing information. For instance, the Money Tree Report employs 18 geographical areas to represent the regions of the United States. These regions include:

1) Alaska, Hawaii, and Puerto Rico  
2) Colorado  
3) DC and Metroplex  
4) LA and Orange County  
5) Midwest  
6) New England  
7) New York Metro  
8) North Central  
9) Northwest  
10) Philadelphia Metro  
11) Sacramento and Northern California  
12) San Diego  
13) Silicon Valley  
14) South Central  
15) Southeast  
16) Southwest  
17) Texas  
18) Upstate New York

The website defines a financial sequence as “cash for equity investments as the cash is actually received by the company (also called a tranche)” (Money Tree Report, 2007, para 3). According to the gathered data, financial sequence spans from 1 to 18, with majority of the records having a financial sequence between 1 and 3. Finally, the Money Tree website breaks stage of development into four groups. The four stage of development groups include:

1) Start-Up and Seed Stage – company is probably not fully operational, products and services are under development, and have been in existence for less than 18 months;
2) Early Stage – company is probably in testing or pilot production, products and services could possibly be commercially available, and have been in existence for less than 3 years;
3) Expansion Stage – products and services are in production and commercially available, significant revenue growth, and have been in existence for more than 3 years; and,
4) Later Stage – products and services are widely available, company is generating on-going revenue, and may include spin-outs of operating divisions of existing and established private companies.

Methodology

The research only includes biotechnology companies (biotech) located within the United States. Data, including the locations of venture capitalist and biotech companies, were gathered, analyzed, and mapped to show the correlation and spatial relationship between venture capitalists and biotech companies. The study focuses both on the spatial relationship between venture capitalists and biotech companies at the individual level and at the regional level.

Biotech and venture capital data were gathered through Pricewaterhouse Coopers’ Money Tree Report. The data were collected by means of copying and pasting. Every biotech company for every quarter spanning from 1995 to 2005 was copied and then pasted into an Excel database. Biotech information included the name, address, region, contact information, website, email, amount of investment, financing sequence, stage of development, type of industry, description of industry, and all the investors of that company. The 11 years of gathered data totaled 3,219 entries of investment. A significant number of records were deleted because they contained undisclosed information. In other words, the undisclosed records were deleted because they exclude the biotech companies name, address, financial sequence, stage of development, and quite often, who are the investor(s). Because the objective of this study is to look at the spatial relationship between biotech companies and venture capital firms, it was necessary to delete these records.
Also, a small number of biotech records were deleted from the database because their received investment was zero. Thus, they pose no significance in this study and the objective of this study. Insufficient data resulted in the deletion of 329 biotech records, leaving a total of 2,890 companies that contain the necessary information.

After the biotech companies were complied, it was necessary to gather information on the venture capitalists. Venture capitalist information was gathered through Pricewaterhouse Coopers’ Money Tree Report. The data included the venture capital companies name, address, region, contact information, website, email, and all the invested companies. Venture capital information was gathered by copying the data and pasting it into an Excel database. There were 854 venture capital companies collected from the Money Tree Report. During the copy and paste process, all undisclosed venture capital companies were excluded from the database because they lacked vital information. With the completion of both the biotech and venture capital databases, the next step was to map their locations. This was completed by opening both database files in ArcGIS, GIS software developed by Environmental Systems Research Institute, Inc. (ESRI).

**Geographic Information Systems (GIS)**

In order to find out if the spatial relationship between biotech companies and venture capital firms was significant or not, the term “local” has to be defined. The locations of biotech and venture capital companies were mapped in accordance to their zip codes. An investment was local if the investment(s) from the venture capital firms are within 60.4 miles, or within an hour’s drive, of the invested biotech company’s zip code. Thus, any venture capitalist investing in a biotech company that was 60.5 miles or further was considered non-local.
Both the biotech and venture capital database files were added to ArcMap 9.2, a program of ESRI’s ArcGIS software package. There are several ways to display the locations of the biotech and venture capitalist companies. Because biotech and venture capital companies were mapped based on their zip codes, it was crucial to find a way to display them accurately. Considering the size of the files and their distribution across the United States, it was far more efficient and accurate to display the coordinates of the companies as opposed to geocoding the addresses of the files. The coordinates were necessary to display these files by zip code area. This was completed by downloading the entire United States zip code shapefile from the Census Bureau website. The U.S. zip code shapefile was added to ArcMap 9.2 and displays as a point layer containing 41,588 different zip codes across the country. The U.S. zip code file also included the longitudes and latitudes associated with each zip code. The longitudes and latitudes for each biotech company was obtained by “joining” the biotech dataset table with the U.S. zip code attribute table. To perform a “join” in ArcMap, two tables have to have some type of commonality. In this case, the tables were “joined” together using the zip code field. The results of the “join” table displayed each biotech company’s zip code with its corresponding coordinates. In order to map the locations of the venture capital firms, the same type of joining feature was performed between the venture capital database and the U.S. zip code attribute table.

With the use of ArcMap 9.2, several maps were created from the data. The first map (Figure 1) displays the locations of biotech companies across the United States from 1995 - 2005. The second (Figure 2) and third (see Figure 3, Appendix A) maps focus on the locations of venture capital firms across the world and the United States, respectively. Two other maps were
Figure 1: Displays the locations of biotechnology companies that receive some degree of venture capital investment between 1995 and 2005.
Figure 2: Displays the locations of Venture Capital Firms that invested some amount of capital into the Biotechnology Industry.
created showing a zoomed in picture of the San Francisco Bay Area and Boston Metropolitan 
Area maps (see Figures 4 and 5, Appendix B and C) display two side-by-side maps showing the 
locations of the biotechnology companies and venture capital firms in these areas. Maps (see 
Figures 6 and 7, Appendix D and E) on the locations of biotech companies in from two periods 
(Q1/1995-Q2/2000 and Q3/2000-Q4/2005) were created, as well as a map (see Figure 8, 
Appendix F) to show the percent biotech growth between these periods. Other maps (see Figures 
9-11, Appendixes G, H, and I) include the locations of biotech companies that receive at least 
$10 million, $25 million, and $50 million from their venture capital investors in one funding 
period.

Once the companies and the venture capitalists were mapped, the distances between 
biotech companies and their closest investor needed to be calculated. This distance will help 
explain the investment flow between venture capital investors and their biotech companies.

Statistical Analysis Software (SAS)

All statistics completed during this research was performed using SAS’s Statistical 
Software 8.2. The objective of using SAS is to calculate a minimum distance, create basic 
statistical tables, and perform a regression based on the study’s dependent and independent 
variables.

Both the biotech and venture capital databases used in ArcMap 9.2 were imported into 
the SAS program. The tables were examined to make sure they contained all of the information. 
Because the tables already contained the coordinate information, it was simple to calculate a 
‘minimum distance’ – the distance between a biotech company and its closest investor. This was 
completed by using the Great Circle Route formula:
\[ \Delta \hat{\sigma} = \arccos \left( \sin \phi_s \sin \phi_f + \cos \phi_s \cos \phi_f \cos \Delta \lambda \right). \]

Where, \( \phi_s, \lambda_s \); \( \phi_f, \lambda_f \) represents the geographical latitude and longitude of two points, \( \Delta \lambda \) represents the longitude difference, and \( \Delta \hat{\sigma} \) the (spherical) angular difference/distance. This calculation will help to understand if distance has an effect on the amount of money venture capital firms invest.

It was noticed that the biotech database needed some additional cleaning. A small number of the biotech records were between stages of development or financial sequences. As a result, these records listed both stages or sequences. To prevent confusion and to keep consistency, this needed to be resolved. For stage of development, there were initial four stages in this study (Start-up and Seed, Early, Expansion, and Later), which became six groups for the purposes of this study. The six groups include Start-Up and Seed, Early, Early and Expansion, Expansion, Expansion and Later, and Later. For financial sequence, if a biotech record listed more than one sequence, the first listed sequence was used to represent the company’s financial status. With this information corrected, it was time to run statistics tables and a regression model properly and accurately.

The SAS program was used to create five tables based on the biotech database. The first table (Table 1) shows some basic statistically information on all 2,890 biotech records. The second table (Table 2) displays the overall number of investment contracts by region. The second table also shows the difference and percent change between the first 22 quarters (Quarter 1 of 1995 – Quarter 2 of 2000) and the last 22 quarters (Quarter 3 of 2000 – Quarter 4 of 2005). The third table (Table 3) displays the local vs. non-local count and average capital investments broken down by the stages of development, financial sequences, and domestic vs. international
investments. The fourth table (Table 4), similar to the second table, presents the total amount of capital invested by region. Also, Table 4 shows the difference and percent change in invested capital from the first 22 quarters to the last 22 quarters. The final table (Table 5) represents the regression, where capital signifies the dependent variable and other biotech characteristics are tested as independent variables to test their significance.

**Regression Model**

Biotechnology companies receive varied amounts of capital from their venture capital investors. Thus, a regression model was used to find the influence variables have on the amount of capital a biotech company receives. The regression formula:

\[
Y = a_0 + b_1 X_1 + b_2 X_1 + b_3 X_1 + b_4 X_1 + b_5 X_1 + b_6 X_1 + b_7 X_1 + b_8 X_1 + e
\]

where, the amount of capital a biotechnology company receives is the dependent variable \(Y\). Independent variables include Financial Sequence \((X_1)\), Stage of Development \((X_2)\), Minimum Distance \((X_3)\), Local Investors \((X_4)\), International Investors \((X_5)\), Boom \((X_6)\), New England \((X_7)\), and California \((X_8)\). It is believed that each of these variables has some effect on the amount of capital a venture capital firm will invest into a biotechnology company.

Before the regression model was executed, a log transformation was performed on the dependent variable. This was performed based on the dependent variables being heavily skewed and the log transformation was used to reduce the skewness and better fit the data into a normal distribution. The regression model is as follows:
\[ \log (\text{Capital}) = a_0 + b_1 \text{Financial Sequence} + b_2 \text{Stage of Development} \]

\[ + b_3 \text{Minimum Distance} + b_4 \text{Local Investors} \]

\[ + b_5 \text{International Investors} + b_6 \text{Boom} + b_7 \text{New England} \]

\[ + b_8 \text{California} + e \]

where Financial Sequence will show if the number of financial rounds a company receives affects the total amount of capital it receives. In this research, biotech companies’ financial sequence ranges between 1 and 18. This variable will explain how financial sequences affect the amount of capital a biotech company receives. The Stage of Development variable will show whether there is a change in the amount of capital a biotech company receives based on its stage of development. The Minimum Distance variable will explain whether distances between a biotech company and its closest venture capital investor influence the amount of capital a company receives. The Local Investors variable was used to describe how local investors influence the total amount of capital a biotech company receives from its investors. In other words, this variable will explain whether biotech companies that receive local funding obtain a greater amount of capital than those companies that receive no local funding.

The other variables in this research are dummy variables that were used to locate any existing or missing information that might influence the results. International Investors describe how foreign investments affect the total amount of investments a biotech company receives. Biotech companies that receive foreign investments were issued a value of one, and companies that received no foreign support were issued a value of zero. The Boom dummy variable represents the spike in venture capitalists investments during 1999 to 2000. Biotech companies were issued a value of one if they received venture capital investments during this time period and the others were issued a value of zero if they received an investment outside this period.
Dummy variables, New England and California, represent the two largest biotechnology clusters in the world. With this in mind, both regions were issued as variables during the regression model. The New England variable, biotech companies located within the region received a value of one, while biotech companies outside of the New England region received a value of zero. This worked similarly for the California regions; biotech companies inside the California regions received a value of one and those located outside the region received a value of zero.
CHAPTER 4

RESULTS

Basic statistical tables and a regression analysis were used to test the outcomes of the hypotheses. Table 1 presents summary statistics of the overall biotech database file. This file includes 2,890 records of investment from venture capitalists to biotech companies. As the results below indicate, a biotech company receives an average of $9,816,885 million from its venture capital investors per contract. Of the 11-year span (1995 – 2005), Biosynthesis, Inc. from Lewisville, TX received the smallest quarterly investment of $3,000 (1996 – Quarter 1) and Reliant Pharmaceuticals LLC located in Liberty Corner, NY received the largest quarterly investment of $161,000,200 (2002 – Quarter 1). The average biotech company receives investments from 3 to 4 venture capital investors. Considering all biotech companies with undisclosed investors were deleted, this means all biotech companies in this database have at least one investor. The maximum number of investors a single biotech company received was 19 by Renovis, Inc. (2003 – Quarter 3) and Memory Pharmaceuticals Corporation (2002 – Quarter 1).

The typically biotech company maintained an average financial sequence of 3 investment rounds per investor. According to the Table 1 more than 2/3 of the records were listed having a financial sequence from 1 to 3. Only a handful of companies listed a financial sequence of 10 or greater. Also, during these 11 years, the typically biotech company was in its expansion stage of development. A majority of the biotech companies in this study are in an early to expansion stage of development. Biotech companies are an average of 44.65 miles away from their closest investor, with Sequenom, Inc. in San Diego, CA having the furthest minimum distance of
Table 1


N = 2890

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital (in Millions of Dollars)</td>
<td>9.816</td>
<td>13.477</td>
<td>5.100</td>
<td>0.003</td>
<td>161.0002</td>
</tr>
<tr>
<td>Number of Investors</td>
<td>3.643</td>
<td>2.611</td>
<td>3.000</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Financial Sequence</td>
<td>2.970</td>
<td>2.217</td>
<td>2.000</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Stage of Development</td>
<td>3.259</td>
<td>1.631</td>
<td>3.400</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Minimum Distance (in miles)</td>
<td>44.653</td>
<td>49.922</td>
<td>21.170</td>
<td>0</td>
<td>215.072029</td>
</tr>
<tr>
<td>Local Investors</td>
<td>0.834</td>
<td>0.371</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>International Investors (dummy)</td>
<td>0.0813</td>
<td>0.273</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>New England (dummy)</td>
<td>0.178</td>
<td>0.383</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>California (dummy)</td>
<td>0.345</td>
<td>0.476</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note.* This table presents summary statistics for the biotech database table. The table includes 2,890 biotech investment records listed from 1995 – 2005. These records included several biotech variables including capital, number of investors, financial sequence, stage of development, minimum distance, local investors, international investors, New England, and California. The table shows the calculated mean, standard deviation, median, minimum, and maximum for each variable.
215 miles from its closest investor and several biotech companies receiving venture capital funding from the same zip code.

Table 2 provides insight about biotech firms aggregated by U.S. regions. The Money Tree Report divides biotech companies into 18 geographic regions. The table lists the overall number of contracts from 1995 to 2005. The table also shows the number of investments located in each region for the first 22 quarters - Quarter 1 of 1995 to Quarter 2 of 2000 (Q1/1995-Q2/2000), and the last 22 quarters - Quarter 3 of 2000 to Quarter 4 of 2005 (Q3/2000-Q4/2005), and the percent difference in change over these two periods. As the literature noted, the largest biotech regions exist in New England and California. The four largest biotech regions (Silicon Valley, LA and Orange County, San Diego, and New England) in this research are located within the California and New England areas. Combined, the four regions made up greater than 50% of the total amount of investment contracts in the sample (1,506 out of 2,890 contracts). In accordance to the amount of investment contracts, the smallest biotech regions include Alaska, Hawaii, and Puerto Rico region, Sacramento and Northern California region, Upstate New York region, and South Central region (Oklahoma, Kansas, and parts of Texas). Together, those four regions only represent 40 out of 2,890 contracts. All 18 regions, with the exception of Colorado and Texas, experienced some type of positive growth from Q1 of 1995 - 2 of 2000 to Q3 of 2000 - 4 of 2005.

There are several regions in Table 2 that experience a significant increase in the amount of received investment contracts. For instance, the DC and Metroplex region experienced a 136.7% increase in their biotech activity rising from only 49 contracts in the Q1 of 1995 - Q2 of 2000 period, up to 116 contracts during the Q3 of 2000 – 4 of 2005 period. The Upstate New
Table 2

Aggregation of Biotech Firms in Regions

N = 2890

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Contracts</th>
<th>Absolute Change 1995 to 2005</th>
<th>Percent Change (Between Groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Q1 of 1995 - Q2 of 2000</td>
<td>Q3 of 2000 - Q4 of 2005</td>
</tr>
<tr>
<td>AK, HI, and PR</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Colorado</td>
<td>48</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>DC and Metropole</td>
<td>165</td>
<td>49</td>
<td>116</td>
</tr>
<tr>
<td>LA and Orange County</td>
<td>91</td>
<td>45</td>
<td>46</td>
</tr>
<tr>
<td>Midwest</td>
<td>183</td>
<td>67</td>
<td>116</td>
</tr>
<tr>
<td>New England</td>
<td>517</td>
<td>208</td>
<td>309</td>
</tr>
<tr>
<td>North Central</td>
<td>57</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>Northwest</td>
<td>120</td>
<td>46</td>
<td>74</td>
</tr>
<tr>
<td>NY Metro</td>
<td>168</td>
<td>69</td>
<td>99</td>
</tr>
<tr>
<td>Philadelphia Metro</td>
<td>242</td>
<td>116</td>
<td>126</td>
</tr>
<tr>
<td>Sacramento and N,Cal</td>
<td>10</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>San Diego</td>
<td>337</td>
<td>127</td>
<td>210</td>
</tr>
<tr>
<td>Silicon Valley</td>
<td>561</td>
<td>230</td>
<td>331</td>
</tr>
<tr>
<td>South Central</td>
<td>13</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Southeast</td>
<td>219</td>
<td>88</td>
<td>131</td>
</tr>
<tr>
<td>Southwest</td>
<td>56</td>
<td>17</td>
<td>39</td>
</tr>
<tr>
<td>Texas</td>
<td>86</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>Upstate NY</td>
<td>11</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>2890</td>
<td>1165</td>
<td>1725</td>
</tr>
</tbody>
</table>

Note. This table displays the count of investments contracts by regions defined by PricewaterhouseCoopers’ Money Tree Report. The number of contracts column shows the total amount of contract in those regions from 1995 - 2005. The absolute change 1995 to 2005 column explains the total count of investment contracts for the first 22 quarters (Quarter 1 of 1995 – Quarter 2 of 2000) in comparison to the last 22 quarters (Quarter 3 of 2000 – Quarter 4 of 2005) of this study and the difference between these two periods. The percent change (between groups) column explains the percentage growth of biotech investment contracts between these two periods.
York region experienced a 350% gain in biotech investment activity. From the period Q1 of 1995 - Q2 of 2000, Upstate New York only received two investment contracts, but that number grew to nine contracts during the Q3 of 2000 - Q4 of 2005 period. A couple of regions in the research received no (zero) increase in biotech activity from Q1 of 1995 - Q2 of 2000 to Q3 of 2000 - Q4 of 2005. These regions include Colorado and Texas, which received the same amount of funding contracts in both periods. Overall, there were 1,165 investment contracts during the first period. This number rose to 1,725 investment contract by the second period of this research, resulting in the total difference of 560 contracts, or a 48.1% increase in biotech activity across the United States.

Table 3 displays the differences between local and non-local investments. Local and non-local investment counts and capital means are compared by stage of development, financial sequence, and funding location. Stage of development has been divided into six groups. The six stages of development include Start-Up and Seed, Early, Early and Expansion, Expansion, Expansion and Later, and Later. The Early and Expansion and Expansion and Later stages were added to the initial four stages used by the Money Tree Report because a handful of biotech companies listed two stages. Within these six stages, biotech companies received a greater amount of capital from their local investors in all stages except in the Start-Up and Seed stage. In the Start-Up and Seed stage, biotech companies received an average of $400,000 more from their non-local investors. The table also shows that biotech companies receive a greater amount of capital as they advance in their stages of development. In other words, companies in the Later stage of development receive the greatest average amount of capital.

According to the biotech database, biotech companies have a financial sequence of 1 to 18. Considering the majority of the biotech companies in this study have a financial sequence of
Table 3

*Single Statistics related to the Amount of Dollar Value*

N = 2890

<table>
<thead>
<tr>
<th>Stage of Development</th>
<th>Non-local Investors</th>
<th>Local Investors</th>
<th>Overall</th>
<th>Local Mean Capital (Smillion)</th>
<th>Non-local Mean Capital (Smillion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up and Seed (1)</td>
<td>68</td>
<td>352</td>
<td>420</td>
<td>2.360</td>
<td>2.798</td>
</tr>
<tr>
<td>Early (2)</td>
<td>156</td>
<td>749</td>
<td>905</td>
<td>6.918</td>
<td>5.370</td>
</tr>
<tr>
<td>Early and Expansion</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>18.804</td>
<td>0</td>
</tr>
<tr>
<td>Expansion (3)</td>
<td>185</td>
<td>904</td>
<td>1089</td>
<td>13.439</td>
<td>8.165</td>
</tr>
<tr>
<td>Expansion and Later</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>39.897</td>
<td>0</td>
</tr>
<tr>
<td>Later (4)</td>
<td>68</td>
<td>397</td>
<td>465</td>
<td>16.655</td>
<td>10.978</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Financial Sequence</th>
<th>Non-local Investors</th>
<th>Local Investors</th>
<th>Overall</th>
<th>Local Mean Capital (Smillion)</th>
<th>Non-local Mean Capital (Smillion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>159</td>
<td>718</td>
<td>877</td>
<td>6.089</td>
<td>5.220</td>
</tr>
<tr>
<td>2</td>
<td>113</td>
<td>536</td>
<td>649</td>
<td>9.201</td>
<td>7.747</td>
</tr>
<tr>
<td>3</td>
<td>72</td>
<td>426</td>
<td>498</td>
<td>13.599</td>
<td>7.366</td>
</tr>
<tr>
<td>4 to 6</td>
<td>85</td>
<td>574</td>
<td>659</td>
<td>14.566</td>
<td>8.942</td>
</tr>
<tr>
<td>7 to 9</td>
<td>33</td>
<td>127</td>
<td>160</td>
<td>8.657</td>
<td>6.202</td>
</tr>
<tr>
<td>10 or more</td>
<td>15</td>
<td>32</td>
<td>47</td>
<td>7.468</td>
<td>3.933</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Funding</th>
<th>Non-local Investors</th>
<th>Local Investors</th>
<th>Overall</th>
<th>Local Mean Capital (Smillion)</th>
<th>Non-local Mean Capital (Smillion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>55</td>
<td>180</td>
<td>235</td>
<td>7.778</td>
<td>6.770</td>
</tr>
<tr>
<td>Domestic</td>
<td>422</td>
<td>2233</td>
<td>2655</td>
<td>15.363</td>
<td>9.996</td>
</tr>
</tbody>
</table>

*Note.* This table presents summary statistics comparing the count of contracts and mean capital for the Local Investors and Non-local Investors variables. The table displays both a count of contracts and means capital for several of the research variables (stage of development, financial sequence, and origin of funding). These variables are broken down (six stages of development, six levels of financial sequence, and two funding sources) to view the distribution of contracts and capital. According to the results of the table, Local Investors provide biotechnology companies with a greater average amount of investment contracts and mean capital than Non-local Investors in every category, with the exception of the first Stage of Development (Start-Up/Seed stage).
1 to 3, it makes sense to combine some of the financial sequences together. In Table 3, there are six groups of financial sequences. The six financial sequences include 1, 2, 3, 4-6, 7-9, and 10 or more. According to the table, biotech companies with a financial sequence between 4 and 6 have the largest average mean of capital (local mean of $14,556,200 and non-local mean of $8,941,900). Financial sequence has a pyramid effect on capital investments. In other words, the average mean capital rises as the financial sequence rises, until it finally peaks at the 4-6 sequence group. As the financial sequence rises above the 4-6 group, the average mean capital decreases.

Table 4 provides information about biotech firms aggregated by U.S. regions. Similar to Table 2, Table 4 displays biotech information in the 18 geographic regions used by The Money Tree Report. The table lists the overall capital from 1995 to 2005. The table also displays the capital investments located in each region for the two periods in this research, Q1 of 1995 - Q2 of 2000 and Q3 of 2000 - Q4 of 2005, and the difference in change between them. The overall results of the biotech database show that $28,370,799,150 (over $28 billion) was invested from 1995 to 2005. Also, there was a 151.8% overall increase in capital growth from the first period ($8,065,013,000) to the second period ($20,305,786,200). For the 11-year period, the Silicon Valley region received $7,149,583,488 and the New England region received $5,229,732,888 in investment capital. Combined, these two regions received over $12 billion in capital, nearly 50% of the total capital invested during this study. In 1995, the Alaska, Hawaii, and Puerto Rico region, Sacramento and North California region, and Upstate New York region received zero ($0) capital investments. These regions, combined with South Central, represent the four least amounts of capital invested regions in the United States. These regions received a
Table 4

Aggregation of Money in Regions

N = 2890

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Capital (Millions of Dollars)</th>
<th>Change 1995 to 2005 (absolute)</th>
<th>Percent Change (Between Groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Q1 of 1995 - Q2 of 2000</td>
<td>Q3 of 2000 - Q4 of 2005</td>
</tr>
<tr>
<td>AK, HI, and PR</td>
<td>11.700</td>
<td>1.800</td>
<td>9.900</td>
</tr>
<tr>
<td>Colorado</td>
<td>631.243</td>
<td>198.921</td>
<td>432.322</td>
</tr>
<tr>
<td>DC and Metroplex</td>
<td>1175.593</td>
<td>290.894</td>
<td>884.699</td>
</tr>
<tr>
<td>LA and Orange County</td>
<td>645.193</td>
<td>262.893</td>
<td>382.300</td>
</tr>
<tr>
<td>Midwest</td>
<td>1072.278</td>
<td>400.414</td>
<td>671.864</td>
</tr>
<tr>
<td>New England</td>
<td>5229.733</td>
<td>1390.117</td>
<td>3839.616</td>
</tr>
<tr>
<td>North Central</td>
<td>318.146</td>
<td>109.311</td>
<td>208.835</td>
</tr>
<tr>
<td>Northwest</td>
<td>1167.243</td>
<td>387.537</td>
<td>779.707</td>
</tr>
<tr>
<td>NY Metro</td>
<td>2584.365</td>
<td>484.467</td>
<td>2099.898</td>
</tr>
<tr>
<td>Philadelphia Metro</td>
<td>2112.731</td>
<td>696.421</td>
<td>1416.310</td>
</tr>
<tr>
<td>Sacramento and N.Cal</td>
<td>90.900</td>
<td>27.200</td>
<td>63.700</td>
</tr>
<tr>
<td>San Diego</td>
<td>3670.814</td>
<td>914.966</td>
<td>2755.848</td>
</tr>
<tr>
<td>Silicon Valley</td>
<td>7146.583</td>
<td>2151.644</td>
<td>4994.940</td>
</tr>
<tr>
<td>South Central</td>
<td>69.620</td>
<td>10.840</td>
<td>58.780</td>
</tr>
<tr>
<td>Southeast</td>
<td>1619.684</td>
<td>437.658</td>
<td>1182.026</td>
</tr>
<tr>
<td>Southwest</td>
<td>256.263</td>
<td>72.136</td>
<td>184.127</td>
</tr>
<tr>
<td>Texas</td>
<td>541.397</td>
<td>226.584</td>
<td>314.813</td>
</tr>
<tr>
<td>Upstate NY</td>
<td>27.310</td>
<td>1.210</td>
<td>26.100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28370.799</strong></td>
<td><strong>8065.013</strong></td>
<td><strong>20305.786</strong></td>
</tr>
</tbody>
</table>

Note. This table displays the total amount of capital venture capitalists invests by region. The Total Capital column displays the total amount of money in those regions from 1995 - 2005. The absolute change 1995 to 2005 column explains the total amount of capital invested for the first 22 quarters (Quarter 1 of 1995 – Quarter 2 of 2000) in comparison to the last 22 quarters (Quarter 3 of 2000 – Quarter 4 of 2005) of this study and the difference between these two periods. The percent change (between groups) column shows the percentage growth of investment capital between these two periods.
total of $199,530,603 over the 11-year period, less than 1% of the total overall capital investments.

Several regions experience a significant change from the first time period (first quarter of 1995 to the second quarter of 2000) to the second time period (third quarter of 2000 to the fourth quarter of 2005). All regions during these periods in the United States saw a positive growth in their capital investments. Most notably, the Upstate New York region experienced an increase of 2,057% in its venture capital investments, from only receiving $1,210,000 during the first period and over $26 million during the second period. The Alaska, Hawaii, and Puerto Rico region received $1,800,000 during the Q1 of 1995 – Q2 of 2000 period and nearly $10 million in the Q3 of 2000 – Q4 of 2005, thus experiencing an increase of 450% in their capital investments. The Texas region experienced the smallest percentage growth in its venture capitalist investments. During the first period, the Texas region received $226,584,300 from venture capitalist. This number grew to $314,813,100 during the second resulting in an increase of only 38.9%. This result corresponds to Table 2, which showed the Texas region received a zero percent (0%) growth in its venture capital investment contracts.

A regression analysis was performed to see the effect independent variables have on the amount of capital a biotech company receives. Due to the heavy skewness of the dependent variable, a log transformation was performed to better fit the dependent variable into a normal distribution. According to the regression table (Table 5), the effects on the amount of capital a biotech company receives are statistically significant at the 5 % level for all independent variables, with the exception for the Local Investor variable.
Table 5

Regression Model

N = 2890

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>f-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>8</td>
<td>1595.44574</td>
<td>199.43072</td>
<td>98.23</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error</td>
<td>2881</td>
<td>5848.96284</td>
<td>2.03018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>2889</td>
<td>7444.40858</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Root MSE 1.42485  
Dependent Mean 1.40034  
Coefficient Variable 101.75007  
R-Square 0.2143  
Adjusted R-Sq 0.2121

Parameter Estimates

| Independent Variable          | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|------------------------------|----|--------------------|----------------|---------|------|-----|
| Financial Sequence           | 1  | -0.10199           | 0.01396        | -7.31   | <.0001 |
| Stage of Development         | 1  | 0.79007            | 0.03362        | 23.5    | <.0001 |
| Minimum Distance             | 1  | -0.0039            | 0.0011         | -3.55   | 0.0004 |
| Local Investors              | 1  | -0.1005            | 0.11877        | -0.85   | 0.3976* |
| International Investors (dummy) | 1  | 0.44781            | 0.09797        | 4.57    | <.0001 |
| Boom (dummy)                 | 1  | 0.32803            | 0.06874        | 4.77    | <.0001 |
| New England (dummy)          | 1  | 0.29233            | 0.07436        | 3.93    | <.0001 |
| California (dummy)           | 1  | 0.42236            | 0.05967        | 7.08    | <.0001 |
| y - Intercept (dummy)        | 1  | -0.36574           | 0.1495         | -2.45   | 0.0145 |

Note. These tables present descriptive statistics of the regression model. The Analysis of Variance table explains the significance independent variables have on the dependent variable. According to the f-value of 98.23 and the p-value of <.0001 explains that the independent variables do significantly influence the amount of capital a biotech company receives from its investors. The Parameter Estimates table displays the independent variables (Financial Sequence, Stage of Development, Minimum Distance, Local Investors, International Investors, Boom, New England, and California) relationship and influence on the dependent variable (Capital). * Indicates that the Local Investor independent variable does not have a significant effect on the dependent variable because its p-value is greater than .05.
For instance, the Financial Sequence variable has a negative relationship with the dependent variable. This means as the financial sequence of biotech companies’ increase, the less total capital these biotech companies receive. This makes sense considering the results of Tian (2008) who found that local companies receive fewer rounds of capital but more overall capital than those firms receiving more rounds of finance. Also, the majority of the biotech companies in this study have a financial sequence of three or less and this influences the Financial Sequence variable.

The Stage of Development variable has a positive relationship with the dependent variable. In other words, as a biotech company moves to higher stages, the greater total amount of capital it receives from its investors. This makes sense because venture capitalists are more likely to invest greater capital if a biotech company is within its production phase or already profitable. Venture capitalists are also attracted to biotech companies in their later stages because they have a greater chance in reaching public (IPO). When a biotech company becomes public, venture capitalists can expect a significantly large payout in comparison to their invested capital.

Minimum distance has a negative relationship with the dependent variable. As the distance between venture capital firm and biotechnology company increases, the less total capital those biotechnology companies receive from their investors. Geographic proximity is extremely significant when it comes to the amount of capital a venture capitalist company will invest. Thus, venture capitalists are more willing to invest greater amounts of capital if the biotech company is close enough to effectively monitor. Aside from monitoring, being in close proximity also allows the investor to inspect, assist, speak with suppliers and workers, and regulate decisions based on the success and direction of the biotech company, while significantly reducing the costs of transportation, lodging, etc.
The Local Investors variable has a negative association with the amount of capital a biotechnology company receives. In other words, the closer the distance between a biotech company and its venture capital investors, the smaller the quantity of capital the biotech companies receive. The Local Investor variable was ignored considering its p-value (Local Investor p-value = .3976) is greater than .05. Given the data used in this analysis the effect of the Local Investor variable on the amount of capital a firm receives is not statistically significant.

The other variables (International Investors, Boom, New England Region, and California Region) were used as dummy variables during this regression model. These dummy variables were used to detect the absence or presence of some categorical effect that may influence the outcome. International Investors dummy variable characterizes those biotech companies that receive some type of funding from foreign investors. International Investors has a positive relationship with the dependent variable, meaning biotech companies that receive foreign investments receive a greater amount of capital on average. The Boom dummy variable represents investments made during the internet bubble from 1999 to 2000. The Boom variable has a positive association with the dependent variable, meaning biotech companies received a greater amount of venture capital investments during this period.

The New England region dummy corresponds to the venture capital contracts completed within the New England area. New England region has a positive association with the dependent variable, meaning those biotech companies located within the New England region receive more capital on average than those companies outside of the New England region. The same is true for the California dummy variable. California has a positive relationship with the dependent variable, so those biotech companies located within the California region receive more capital on average than those located outside the region. On average, biotech companies located within the
California region receive more capital than those located within the New England region. As a result, the dummy variables have responded as expected.

The significance of the regression table results help provide a better understanding on how variables influence the amount of capital a biotech company receives from its venture capital investors. The first research hypothesis states, the closer the spatial distance between venture capital investors and biotechnology companies, the more capital biotechnology companies receive from those venture capital investors. The result of the regression table supports this hypothesis. The Minimum Distance variable supported this hypothesis because it had a negative relationship with the amount of capital a biotech company receives. In other words, the farther a biotech company is from its investor, the less amount of capital those companies receive. The second research hypothesis states, biotech companies in later stages of development receive more capital from their venture capital investors. The findings show that the Stage of Development variable supports this hypothesis because of its positive relationship with the amount of capital a biotech company receives. In other words, companies in a higher stage of development receive more capital from its investors. The third research hypothesis states, biotech companies with a greater number of financial sequences receive more capital from their venture capital investors. The regression table shows that the Financial Sequence has a negative relationship with the amount of capital a biotech company receives. This means, the more financial sequences a biotech company receives, the less amount of capital they receive. This result opposes the researchers initial thought and results in the rejection of the third research hypothesis.

In accordance with the regression model results, those biotech companies that receive the greatest amount of capital from their investors can be expected to have: 1) a great number of
investors; 2) are in their later stages of development; 3) receive few financial sequences; and, 4) are located in close proximity to their investors.
CHAPTER 5

CONCLUSION

Due to the high-risk nature of the biotechnology industry, biotech companies have relied on venture capital firms to fund their potentially high-profitable projects. The greater amount of capital a biotechnology company receives can significantly increase its chances of success. Thus, the purpose of this research was to provide insight on the spatial relationship between the locations of biotechnology companies and the venture capitalist firms that provide them funding. This was done by using venture capitalists to biotech investment data gathered through the Money Tree Report website. Investment records from 1995 to 2005 were compiled into a large database containing a total of 2,890 entries. Geographic Information Systems (GIS) software was used to display the locations of these biotechnology companies and their venture capital investors. GIS was also used to create several maps as visual aids. Statistical Analysis Software (SAS) was used to calculate the distance between a biotechnology company and its closest investor using the Great Circle Routes formula and performs some statistic tables include a regression model. The regression model provided significant results and findings for this research.

The results show that a biotech company’s variables (financial sequence, stage of development, distance form investor, etc.) influence the average amount of capital a biotech company receives from its investors. The results suggest that biotechnology companies receive more capital from their venture capital investors if they are located in close proximity. This finding fails to reject the first research hypothesis of this research and relates to the findings of Tian (2008), Powell, et al. (2002), Coval and Moskowitz (2001), and Lerner (1995), who have all mentioned the importance of proximity in accordance to investments and overall success of
the company. The results also show that biotech companies in higher stages of development receive more capital on average from its investors. This finding fail to reject the second research hypothesis of this research and corresponds to the findings Sorenson and Stuart (2001), that biotech companies in their later stages of development receive more capital based on their production, success, and popularity. The results also suggest that the more financial sequences a biotech company receives, the less amount of capital it receives from its investors. Although this finding rejects the third research hypothesis of this research, it is associated with the findings of Tian (2008), that local firms receive fewer financial sequences, more capital, and outperform biotech companies located further away.

The results of the regression table indicate that other variables have a significant influence on the amount of capital a biotech company receives from its investors. These other variables are not mentioned or related to the hypotheses of this research and include the biotech company’s location in either the San Francisco Bay Area or Boston Metropolitan Area clusters, receiving an investment during the Boom period (1999-2000), or receiving capital from foreign investors. Each of these variables has a positive relationship on the amount of capital a biotech company receives. In other words, these variables increase the average amount of capital a biotech company receives from its venture capital investors.

This researcher sought to explain the unique relationship between venture capital firm and the biotechnology companies that provide investments. Although few publications are directly related to this research, the findings of this research correlates with the findings similar publications.
REFERENCES


Figure 3: displays the both domestic and foreign venture capitalists that invested capital into United States biotechnology industry from 1995-2005.
Figure 4: Displays the locations of biotechnology and venture capital firms within the San Francisco Bay Area. Maps are placed side-by-side to show their relationship and prevent overlapping.
APPENDIX C

Distribution of Biotechnology and Venture Capital Firm
Within the Boston Metropolitan Area (1995-2005)

Figure 5: Displays the locations of biotechnology and venture capital firms within the San Francisco Bay Area. Maps are placed side-by-side to show their relationship and prevent overlapping.
Figure 6: Displays the locations of all the biotechnology companies that receive venture capital funding from the first quarter of 1995 to the second quarter of 2000.
Figure 7: Displays the locations of all the biotechnology companies that receive venture capital funding from the third quarter of 2000 to the fourth quarter of 2005.
APPENDIX F

Figure 8: Displays the percentage growth of biotechnology companies by state from the Q1/1995-Q2/2000 (first twenty-two quarters) to Q3/2000- Q/2004 (second twenty-two quarters)
Figure 9: Displays the locations of biotechnology companies that receive a minimum of $10 million in investments from venture capitalists
APPENDIX H

Figure 10: Displays the locations of biotechnology companies that receive a minimum of $25 million in investments from venture capitalists
APPENDIX I

Figure 11: Displays the locations of biotechnology companies that receive a minimum of $50 million in investments from venture capitalists
VITA

ROCKY GRAZIANO BILOTTA

Personal Data: Date of Birth: September 29, 1982
Place of Birth: Norwood, Massachusetts

Education: Rutherfordton-Spindale Central High School, Rutherfordton, North Carolina 2001
B.A. History, Geography and Geology minors, University of North Carolina at Pembroke, Pembroke, North Carolina 2005
M.S. Technology, Geoscience concentration, East Tennessee State University, Johnson City, Tennessee 2008

Professional Experience: Intern, Johnson City Transit; Johnson City, Tennessee, 2008
Graduate Assistant, East Tennessee State University; Johnson City, Tennessee, 2006 – 2008
Teacher and Coach, Rutherford County Schools; Rutherfordton, North Carolina, 2005 – 2006


Professional Memberships: Association of American Geographers (AAG)
Graduate and Professional Students Association (GPSA)