Venture Capital Investment in the United States 1995-2002

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ABSTRACT

This paper provides an empirical examination of the investments by venture capital firms for the period before, during and after the stock market bubble of 1999 and 2000. Comparisons are made between pre-bubble, bubble and post-bubble investment patterns by state for location, stage and industry of investment. Location quotients for investments by state and industry are displayed. States with large levels of investment show well-balanced investments across industries, while states with smaller totals do not. Median polish is applied to a four-way cross tabulation table of venture capital investments defined by state location of investment, industry of investment, year of investment and stage of investment. The parameter estimates show California as a location for investment is significantly different in scale, industry and stage of investment from other states. The investment bubble of 1999 and 2000 is found to have created different patterns of investment compared to those of the pre and post bubble periods.

Key words: venture capital, United States, stock market bubble, location quotients, median polish

INTRODUCTION

Venture capital investment in the United States has displayed a roller coaster pattern. The industry has experienced high and low periods of investment activity since the 1970s (Gompers & Lerner 1999; Lerner 2002; Gompers 2002). The stock market exuberance of 1999 and 2000 was matched in equal intensity by venture capital investment when more than $161 billion was invested in the same period (Venture Economics 2003). An investment level that in 2000, was more than four times that of 1998. That wave of investment ended with the demise of the dot com bubble in mid 2000. This latest burst of activity was singular because of its size. The situation of so much money chasing investments makes the period of particular interest. What impact, if any, did this abundance of capital have on the geography of venture capital investment?

The purpose of this paper is therefore, to provide an empirical examination of the investments by venture capital firms for the period before, during and after this bubble. The basic question is whether this period of investment exuberance resulted in any change in the industry or geography of investment patterns. This study examines those patterns for the period 1995 to 2002. Comparisons are made

between pre-bubble, bubble and post-bubble investment patterns by state for location, stage and industry of investment.

VENTURE CAPITAL

Liles (1974) in his definition of venture capital provides four characteristics:

> *1) Investment in any high risk venture*
> *2) Investment in unproven ideas, products, or start-up situations. This characterizes seed capital.*
> *3) Investment in existing firms that are unable to raise funds from conventional public or commercial sources.*
> *4) Investment in large publicly traded companies and possibly acquiring controlling interest in such companies where uncertainty is significant.*

An additional characteristic is the importance of equity and high growth potential as recognized by Gompers and Lerner (1999). They define venture capital as; 'independently managed, dedicated pools of capital that focus on equity or equity-linked investments in privately held, high growth companies' (p. 11). Although venture capital is often associated with high technology investments, this is certainly not always the case. Since the recent decline of investment by the venture capital industry beginning in 2000, non-technology sectors are attracting more capital. Venture capital funds are sitting on about $80 billion of unused capital. This is coupled with no compelling new technology. Therefore, firms are facing pressure to put that money to work. (Stein 2003). What the future holds, is of course uncertain, but several projections exist. The worst case scenario is that the venture capital industry reverts back to levels last seen in the 1980s. This would require about one-half of the existing venture capital firms to exit (Meeham et al, 2000). Even if this were to happen, venture capital investment would still be an important component of financial capital, as the extant literature demonstrates.

Venture capital is important from a geographic perspective for two primary reasons. First, it is well known that the venture capital industry and its investments are spatially concentrated (Sorenson & Stuart 2001; Cooke 2001), and second, the industry is thought to have a positive impact on regional development. Although there is some debate about the extent to which venture capital investment is a primary agent, it is certain that governments and the bulk of the literature express a belief it is important.

The Bubble

The venture capital industry experienced a dramatic increase in funding levels starting in 1999 and culminating in mid 2000, mirroring the stock market bubble of the same period. The bursting of the bubble resulted in dramatic declines in investment levels, with more trouble to come (Brown and Berman, 2003). This bubble is thought to have altered the investment patterns of the industry. Works such as those by Mason and Rohner (2002) and

Gompers and Lerner (2001) that provide 'how to' and more importantly 'how should' advice for venture funding by mature corporations may indicate a shift in the industry from a cottage type one to a more formal institutionalized one. There is more and more emphasis being placed on corporate-sponsored venture capital in place of the independent firms that now dominate the industry. Other observers cite a contraction in corporate-sponsored venture capital (Abouzeki 2002). Clearly the situation is till in flux.

Lerner (2002) argues that the bubble of 1999 and 2000 was due to the imperfect nature of the venture capital market. Investors may be slow to react to more favorable conditions, and then, once investment starts, they are slow to react to deteriorating conditions. This creates an over shoot of investment. There is coupled with the problem of information lags because of the length of time between the commitment to an investment and the realization of its quality can be quite long. The conservative nature of firm valuations provided by the venture capitalists further exacerbates the market imperfections. Since few firms are taken public in 'cold' periods, reporting tends to underestimate progress in valuation, while returns posted in 'hot' periods overstate the success of venture capital in those years (Lerne, 2002). Indeed, these imperfections may lead to a shrinkage of the number of operating venture capital firms (Tunick 2003). Amit et. al, (1998) argue that although such imperfections or information asymmetries do exist, venture capital firms are still the most efficient financial intermediaries in many instances. In fact, they argue that the greater the asymmetries in an industry (examples are biotechnology and software) the more likely venture capitalists will be involved as investors. This is of course, has been a characteristic of observed venture capital investment over the last decade.

THE GEOGRAPHY OF VENTURE CAPITAL

Models

The number of geographic studies on venture capital is limited. Their number is roughly correlated with the level of investments being made by the industry. The bulk of the studies date from the mid-1980s to the early 1990s. McNaughton (1991) provides an excellent review of the geographic literature before the 1990s and it need not be repeated here. But, he points out there are two basic models of venture capital investment, the conventional and the geographical. The first or conventional model predicts diffusion of funding until investment is available in all regions. This is consistent with a neoclassical view of the spatial freedom of the availability of capital.

Thompson's (1989) geographic model postulates that investment is spatially constrained and specific, with constantly shifting opportunities and patterns of investment. Diffusion of capital is not necessarily a given. Even increases in the level of capital

available may not result in a spatial dispersion of investments because of the importance of geographical characteristics of areas (industrial traditions, corporate culture, industrial knowledge, uncertainty). In this model, not only is diffusion of the industry not a given, increased concentration is a real possibility.

Green (1991) postulates a model of venture capital diffusion based on an examination of investment preferences and venture capital firms' locations for the period 1970 to 1988. He postulates that at the urban center level, venture capital will trickle down to lower order centers over time. Increased specialization will occur over time and lower order cities will begin to host venture capital firms. Investment will still be concentrated within urban areas. It is implicit that such diffusion will take place at a national scale, although more recent history seems to indicate there is still a very strong regional bias, as discussed later in this paper.

A fourth model, by Florida and Smith (1993) postulates a diffusion of venture capital deriving from initial concentrations of financial institutions. The venture capital industry established outposts within emerging high technology industries. The success of these ventures, created pools of indigenous capital. The high risk nature of such investments allowed the emergence of local venture capitalists whose geographic proximity is crucial. Over time, they created high technology networks. The requirements of such proximity resulted in venture capitalists becoming increasing specialized and geographically differentiated. These local networks became connected to their counterparts in the financial centers. Essentially then, we have the creation of local concentrations of capital with place specific characteristics coupled with the creation of a regional or national based contact system. Of course such a model has little to say about non-high technology investment.

All of these geographic models agree that geography will remain important. All three allow for an expansion of the industry while maintaining a strong local character. The degree of diffusion and specialization if any, is what is open to question. Might the sudden infusion of much larger capital pools (as in the bubble) accelerate such an expansion or specialization and challenge the previous spatial concentration of venture capital investments? Presumably there are limited acceptable funding opportunities within a local region or metropolitan area. Increased capital pools would have to be invested either in more distant investments, less sectorally focused investments, a combination of the two, or in riskier ones.

These models provide predictions into the evolution of venture capital in the United States, but what has actually occurred since their presentation? How has the pattern of investment progressed over the last eight years? This paper deals with this question.

Previous United States based literature

The last decade or so has seen only a few efforts at geographically focused research on venture capital in the United States. This is somewhat surprising since up to mid 2000 there was a spectacular increase in the amount of venture capital being raised and disbursed.

The depth of geographically focused US-based venture capital research considerably expanded from Leinbach and Amrhein (1987) up until the early 1990s. There was a hiatus for most of the 1990s but in the last several years, there has been a resurgence of interest. These papers are not covered in McNaughton's (1991) review of the geographic literature, and are thus reviewed here. Of course, recognition of the spatial unevenness of venture capital availability goes back much further (Tribus 1970). This accumulation of research has well established the importance of geography in venture capital investments. In addition, the high degree of spatial concentration of both investments and investors is still evident. This concentration can now be almost considered axiomatic.

The importance of venture capital availability for some regions (most notably Silicon Valley and the Route 128 area around Boston) is well established (Saxenian 2000; Kenney & von Burg 2000; Bygrave & Timmons 1992). Although these entrepreneurial regions were not created by venture capital alone, it was certainly a necessary condition that was supported by outside institutions such as universities and government. They are maintained by the creation of personal contact systems between and with venture capitalists and entrepreneurs (Sorenson & Stuart 2001), although the extent and depth of these vary (Saxenian 2000). These systems are rooted in geographical proximity which helps with the transmission of tacit knowledge (Desroches 1999). This clustering or proximity can provide an innovation rich environment (Porter 1998, 2001). Other contributing factors are quality of life, local business climate and resource access. Silicon Valley is often looked to as a model of economic development that can be jump started. Its usefulness as a model is questionable because its history of development is much longer than is commonly realized (Sturgeon 2000). In fact, there is little agreement on its applicability as a model at all (Leslie 2000). What is clear, is that venture capital can play an important and perhaps a vital role in the commercialization of innovation and wealth creation (Gompers & Lerner 2001). Bygrave and Timmons (1992) identify seven urban regional clusters of and is dominated by technology oriented investing. New York and Chicago are finance oriented centers. Much of the capital raised there goes elsewhere. Boston and Minneapolis are also technology oriented and draw capital both locally and nationally. Connecticut and Texas both experience substantial outflows of capital.

Work by Gupta and Sapienza (1992) indicates that venture capital firms that specialize in early stage investment have a narrower geographic focus coupled with a narrow industry focus as well. Corporate-based venture capital firms have broader geographic orientations. The larger the firm, the greater the geographic scope and industry diversity considered in investments. This they say indicates that venture capital firms are not homogeneous in their portfolio selection.

Florida and Smith (1993) examined venture capital patterns in the US for the mid 1980s. They found that there was a well developed spatial structure with capital flowing to areas of greatest returns. They found, as did Bygrave and Timmons (1992), that there are considerable outflows of capital from major financial centers such as New York, Chicago, Los Angeles and San Francisco to areas of high technology concentration. Although capital is obtained from an array of locations, the investment of that capital is highly concentrated. They reported that California, New York and Massachusetts were the top locations for venture capital offices in 1987. For metropolitan statistical areas (MSAs), New York City was the top location for offices followed by Boston and San Francisco. Geographic proximity was found to still be important although co-investing with other venture capitalists has loosened that constraint.

They followed up with an analysis of venture capital's role in regional innovation systems (Smith & Florida 2000). As in their previous work, they found that California, New York and Massachusetts were the major locations of venture capital resources. The major targets of disbursements were California, Massachusetts and Texas. New York state is conspicuously absent. They argue that venture capitalists operate as technological gatekeepers. The venture capitalists help determine the direction of technological change through the funding of new companies and financing breakthrough technology. Sorenson and Stuart (2001) provide an interesting analysis of the role of distance and industry experience on the spatial distribution of venture capital investments. The emphasis in the paper is on the importance of personal networks. They find a very strong distance decay function for an investment target's location as one moves away from the venture capitalist. Previous experience in the target's industry also increases the likelihood of investment, as does the use of deal syndication. Stuart and Sorenson (2002) find these traits present in their industry of investigation, the biotechnology sector.

The localized nature of venture capital investment (clustering) is an important component in reducing investment risk (Norton 2001). Norton states venture capital investment is a contributing factor to the development of a new system of strategic cities in the US based on the new economy. This is the economy of

greater productivity created by information technology.

Powell et al. (2002) in their study of the relationship between venture capital and the founding of biotechnology firms come to similar conclusions. As with many other start-ups in other industries the biotechnology industry is spatially concentrated. As the venture capital companies become older and larger they invest in more distant regions. Powell concludes that deliberate replication of existing hotbeds of biotech start-ups would be difficult.

The latest work featuring the United States is by Zook (2002) with his study of the impact of venture capital on the development of the Internet. He argues that the location of venture capital financing was central to the determination of the location of new Internet start-up firms. He, as have others, stresses the importance of the personal networks and knowledge of the venture capitals as important attributes. Geographical proximity between investor and investee facilities the success of the venture.

Even though there has been a recent resurgence of interest, it has generally been focused on investment in specific industries such as biotechnology. There has not been a general overview of the location, stage or industry of investment. This description of US venture capital investment, which is over due, is provided in this paper.

DATA

The data is drawn from the *Money-tree Survey* conducted by Price-waterhouseCoopers, Thomson Venture Economics and the National Venture Capital Association. The survey reports the quarter, year, industry, stage, financing sequence and location of venture capital investments for the period 1995 forward. Zook (2002), Norton (2001) and Mason and Harrison (1999) have also used this survey. The survey divides industry into 17 classes (see appendix), seven investment stages, all 50 states plus Washington, D.C., and up to 30 sequential investments. Because of the laboriousness of the collection process only four of the seven stages were used (startup, early, later and expansion) but these for account for 97 percent of the investments by value. The data was compiled from almost 3500 spreadsheets downloaded from the web site. Access to the underlying database was denied by PricewaterhouseCoopers. This paper restricts itself to the period 1995 to 2002.

The quarterly survey includes investments by professional venture capital firms, Small Business Investment Companies (SBICs), the venture arms of corporations, institutions, and investment banks. Members of the National Venture Capital Association, a co-sponsor of the survey, are the main participants. If other participants are involved, such as angel investors or corporations, the entire amount of the investment is reported. It is likely that the survey may under report angel investors. Survey submissions are made by internet and are done by registered

members of the survey site. Individual investors are not identified. To be included, investment targets must be located in the United States even if they have substantial international activities (PriceWaterhouseCoopers 2003). Although there are no estimates provided as to the comprehensiveness of the survey, it appears comprehensive. More details are available at the *Moneytree Survey* internet web site.

INVESTMENT FROM 1995 TO 2002

The eight year period of the survey saw the total reported venture capital investment of just more than $271 billion. The level of investment by year shows considerable variation. Table 1 shows an increase from $7.64 billion in 1995 to a maximum of $99.72 billion in 2000 during the dot com bubble. In the last two years, it has declined back to $21.32 billion, a level similar to that in 1998, ($21.40 billion) just before the bubble. This compares with $94 billion for 2000 and $19.4 billion for 2002 as reported by Alster (2003). The mean investment per deal shows a similar pattern with a maximum value of $12.2 million in 2000. The number of cells in the industry by state investment matrix for a year (17 by 51) showing at least one investment gives a crude measure of the broadness of investment. The percentage of cells with at least one investment increases steadily to the year 2000, then falls back again. Some diffusion of investment was occurring both geographically as well as by industry class up until the collapse of the bubble in 2000. Subsequent years saw a retrenchment. At its maximum in 2000, just over 14.5% of the cells had nonzero investments, so 85.5% did not. Therefore, the norm is not to receive capital. Investment is concentrated not only by state but by industry sector as well. The industry investment pattern is illustrated in Table 2. Detailed descriptions of the industry classes may be found in the appendix.

The top four industry classes of: software (17.4%), telecommunications (15.4%), networking (10.0%) and media (9.1%) comprise more than 50% of total investment. If these four are grouped within the broad category of information technology, the total percentage is even greater than Freeman's (2002) estimates of one-half of all investments going to that group. Telecommunications and media have the highest average investments at $12.1 and $11.3 million respectively. The smallest average investments among the major industry classes are software and medical both at $6.1 million. Figure 1 illustrates the temporal pattern of investment for the top four industry groups as well as total investment. The figure illustrates the increase in investment as one approaches the bubble period of 1999 and 2000. Analysis of correlations between years for industry investment patterns indicates there are some temporal differences in investment during the 1995 to 2002 period, as evidenced by the varying slopes of the trend lines.

Figures 2 through 4 provide a pictorial display of the location quotients of

investment for these four major industry groups by state for the period 1995 to 2002 inclusive. The reader should note the maps are color coded to match their respective trends lines in Figure 1.

LOCATION QUOTIENTS

Mason and Harrison (1999) provide a table of location quotients for US venture capital disbursements for the years 1996 and the first three quarters 1997. The table is for a mix of states, regions and metropolitan areas. This mix of spatial scale makes their interpretation problematic.

A similar approach is taken here, but in this instance it is for all 50 states and the District of Columbia covering the entire period of 1995 to 2002. A modified location quotient is calculated for each of four major industries of investment; software, telecommunication, networking and media. Instead of using employment in the quotient, investment in dollars was used (equation 1). Although normally employment is used in

$$LQ = \frac{\text{state investment in } i^{th} \text{ industry} \,/\, \text{total state investment}}{\text{national investment in } i^{th} \text{ industry} \,/\, \text{total national investment}} \quad (1)$$

Table 1: Total Venture Capital Investments 1995-2002

Year	Number of deals	Investment (billions $)	Mean investment per deal (millions $)	% cells occupied
1995	1884	7.64	4.06	9.9
1996	2634	11.57	4.39	10.8
1997	3231	15.08	4.67	11.5
1998	4046	21.40	5.29	13.4
1999	5668	53.95	9.52	13.0
2000	8165	99.72	12.21	14.6
2001	4629	40.65	8.78	12.6
2002	3046	21.32	7.00	11.6
Total	33303	271.36	8.15	12.2

Table 2: Investments by Industry Class 1995-2002

Industry	Percent	Total Investment in billions	Average Investment in millions	Number of deals
Software	17.43	47.29	6.13	7713
Telecommunications	15.36	41.68	12.10	3444
Networking	10.02	27.20	9.39	2897
Media	9.11	24.72	11.29	2189
Its	7.16	19.42	9.12	2129
Biotech	6.53	17.71	8.59	2063
Business	5.10	13.85	7.26	1908
Medical	4.16	11.28	6.36	1773
Financial	3.90	10.59	6.13	1728
Industrial	3.70	10.03	7.00	1433
Consumer	3.70	10.03	8.30	1209
Retailing	3.47	9.41	8.24	1142
Semiconductors	3.38	9.17	8.45	1086
Computers	2.98	8.08	7.90	1023
Health	2.71	7.34	7.97	921
Electronics	1.10	2.98	5.59	533
Other	0.21	0.56	5.03	112
Total		271.36	8.15	33303

the calculation of location quotients, in principle any measure that can provide state and national totals could be used. Because the data provides a near population sample, the use of investment for total state and national investment should not be problematic. Location quotient values greater than one for a given industry signify venture capital investment greater than expected. The quotient is a relative measure for a given amount of investment in state in a particular industry, so it is unaffected by differentials in absolute investment volumes between states.

Figure 2 shows the distribution of location quotients for the total software investments by value for the period 1995 to 2002. The largest quotients are not where one might expect them, such as California. The largest quotient is for West Virginia at 3.1, and the second is for North Dakota at 2.5. These states along with Utah and Montana all have low amounts of total investment with the majority in software. With the exception of Utah these states received the majority of their funding during the bubble period. This is indicates a very recent diffusion of capital.

Telecommunications investments are shown in Figure 3. Again we find the states with the highest quotients are some of those with very moderate levels if investment.

An exception is Colorado (quotient=1.9) with a total of $10.9 billion (see Table 3). Hawaii has the highest quotient with 6.2 followed by Mississippi with 5.9. Unlike the case with software, the investments were evenly spread across the years. Of the top four states by investment (California, Massachusetts, New York and Texas) only Texas has a quotient above one with a value of 1.3.

Figure 4 shows the pattern of quotients for network investments. As mentioned previously, California has a greater than expected level of investment in network development firms. It is however just above one at 1.06. The highest location quotient is for New Hampshire at 2.8, followed by Maryland at 2.5. Both states experienced investment spread over most of the years. Twenty-one states had no investment at all.

The last industry class is media, shown in Figure 5. This map has the greatest variation in quotient values. Alaska tops the list with a quotient of 11.0, but that is based on only two reported investments. The next highest is Montana at 3.5. Of the top four states only New York has a value more than one with a value of 1.98. Only eight states had no investment. The conclusion to be drawn from these figures is states with large investment totals tend to have moderate location quotients. This is dramatically revealed when the variance is calculated for the location quotients for all the states across the 17 industry classes. California has the lowest variance with a very low value of 0.07. This indicates California has a very balanced set of location quotients. Rounding out the top four we have Massachusetts (ranked second lowest) with 0.14, New York (ranked 13th) with 0.56 and Texas (ranked 19th) 0.97. The strength of the relationship between balance of investment and investment totals declines as the size of a state's total investment declines (r=-0.61 for top five states, r=-0.51 for top 10 states, r=-0.29 for all states).

If a similar approach is taken to measure the balance across states within an industry by measuring the variance of the location quotients, we find software has the lowest variance. The only industries to exhibit very large variances were consumer and health. Large variances indicate substantial state differences in attracting investment.

States with substantial investments experience incremental changes. Some states with little previous venture capital investments show more severe changes. Clearly there is not an even spatial spread of investment outward from the dominant states, but a more spatially sporadic one. The cause of this is difficult to determine since the data provides no information on the investing or investee firms. The pattern would seem inconsistent with Green's (1991) or Florida and Smith's (1993) models.

However, Thompson's model allows for such a pattern given its emphasis on areal characteristics. It may also be

indicative of personal networks providing the impetus for entry of investment.
Figure 6 shows investment by stage by year. The stages of financing are defined by the Moneytree Survey as:

Seed/Start-Up Stage - *The initial stage of development. The firm has a concept or product under development. The age of the firm is probably less than 18 months.*

Early Stage - *Firm's product in testing or pilot production. Firm is usually less than three years old and may or maybe not be generating revenues.*

Expansion Stage - *The firm's product is in production and available. Significant revenue growth is evident although the firm may not yet be profitable. The firm is usually more than three years old.*

Later Stage - *The firm's product or service is widely available. Firm may be showing a profit. (PricewaterhouseCoopers, 2003)*

The percentage of venture capital investment that has been targeted toward startup/seed has steadily declined since the beginning of the survey in 1995, reaching a low of 1.7% in 2002.

As startup deals decline, expansion investments take up the loss, leaving early and later investment stages relatively constant.

This is consistent with the trend noticed by Freeman (2002) of more money going to companies that are shipping products but are not yet profitable. Even in 1992, Bygrave and Timmons (1992) conclude that most venture capital is not in the high value adding classic venture capital stereotype.

They assert that it should be more properly called 'merchant capital', because of the preference for investing in established ventures (Bygrave and Timmon 1992) Venture capital is moving away from its oft touted role of funding new firms with substantial risk and moving to lower risk later stages of firm development investment. Increasingly capital is being invested at the expansion and later stages of investment. This undermines the importance of venture capital as a contributing factor for regionally based innovation. A table of venture capital investments by state for the study period is Table 3.

When looking at total investment there is little surprise at the states listed at the top. California, Massachusetts, New York, Texas and Colorado are often cited as recipients. Together they account for more than 62% of all investment. However, raw totals don't distinguish between the different sizes of the states' economies. To more effectively measure the potential impact of investment on a state's economy, the size of that economy should be considered. If total investment is standardized by reference to the size of the states' economies, a somewhat different picture emerges. The ratio of each state's total investment to that of its gross state product (BEA 2003) can provide such a picture. Table 3 provides the rank of each state when considering this ratio. When this is done, Massachusetts not California leads the list.

Figure 1: Top Four Industry Class Investments, 1995 to 2002

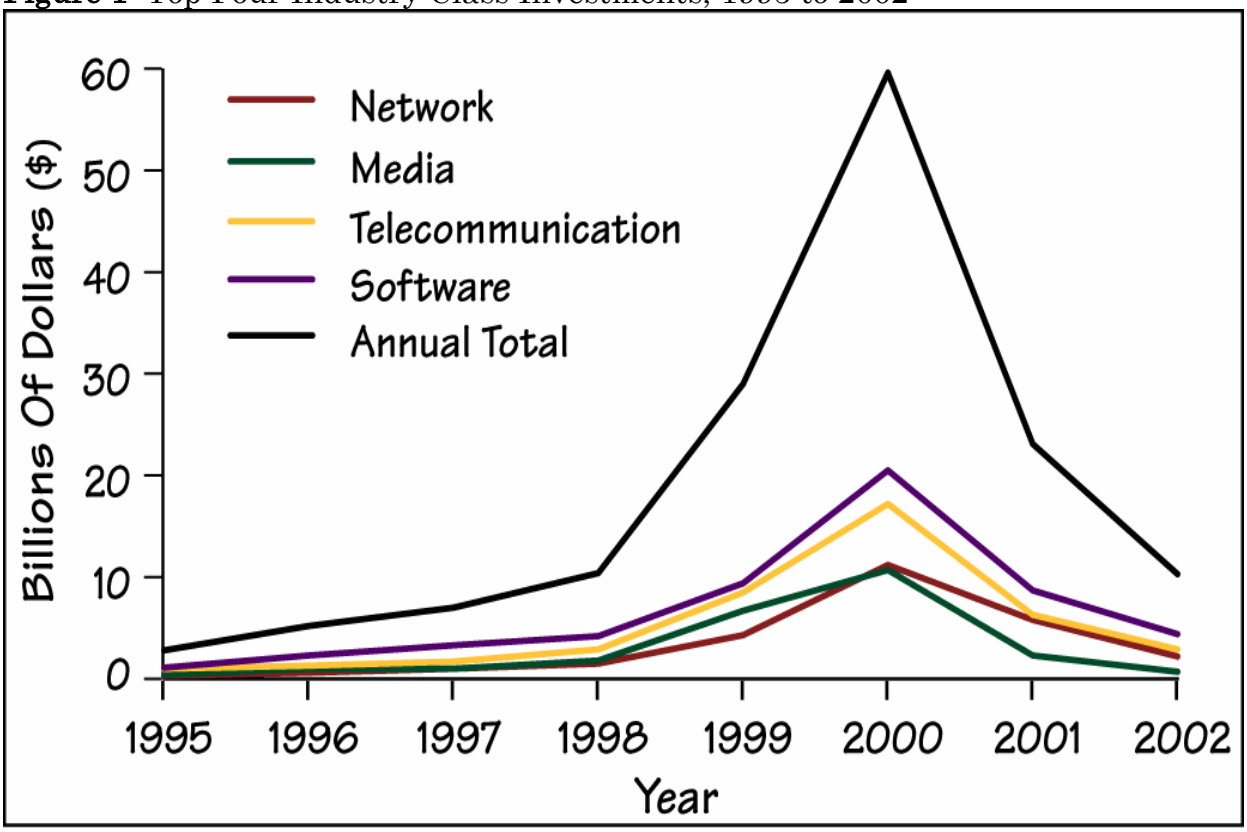


Figure 2: Software Location Quotients for 1995 to 2002

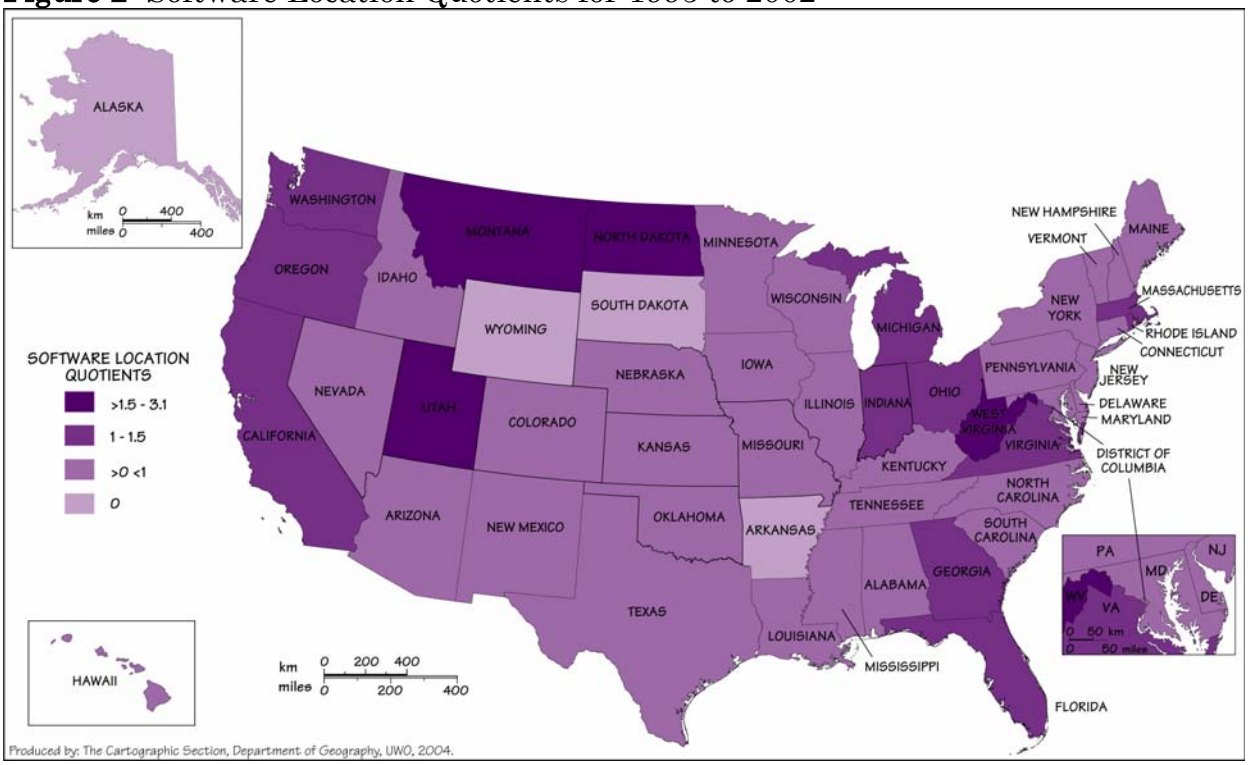


Figure 3: Telecommunications Location Quotients for 1995 to 2002

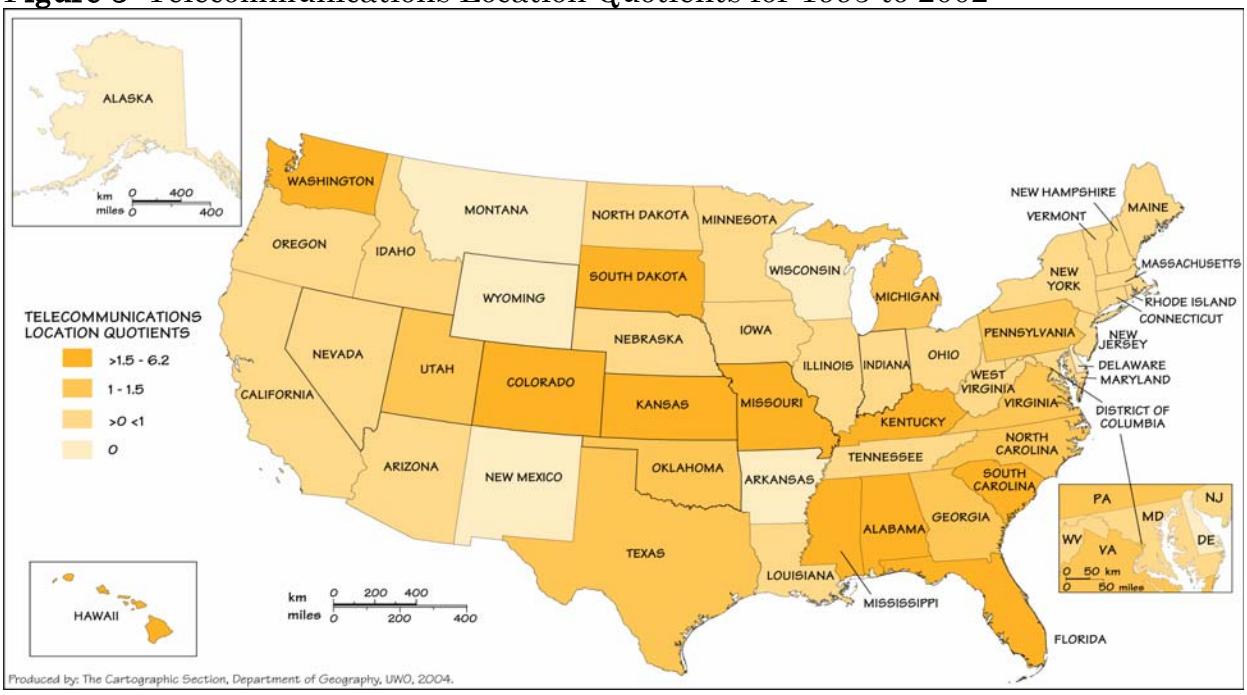


Figure 4: Network Location Quotients for 1995 to 2002

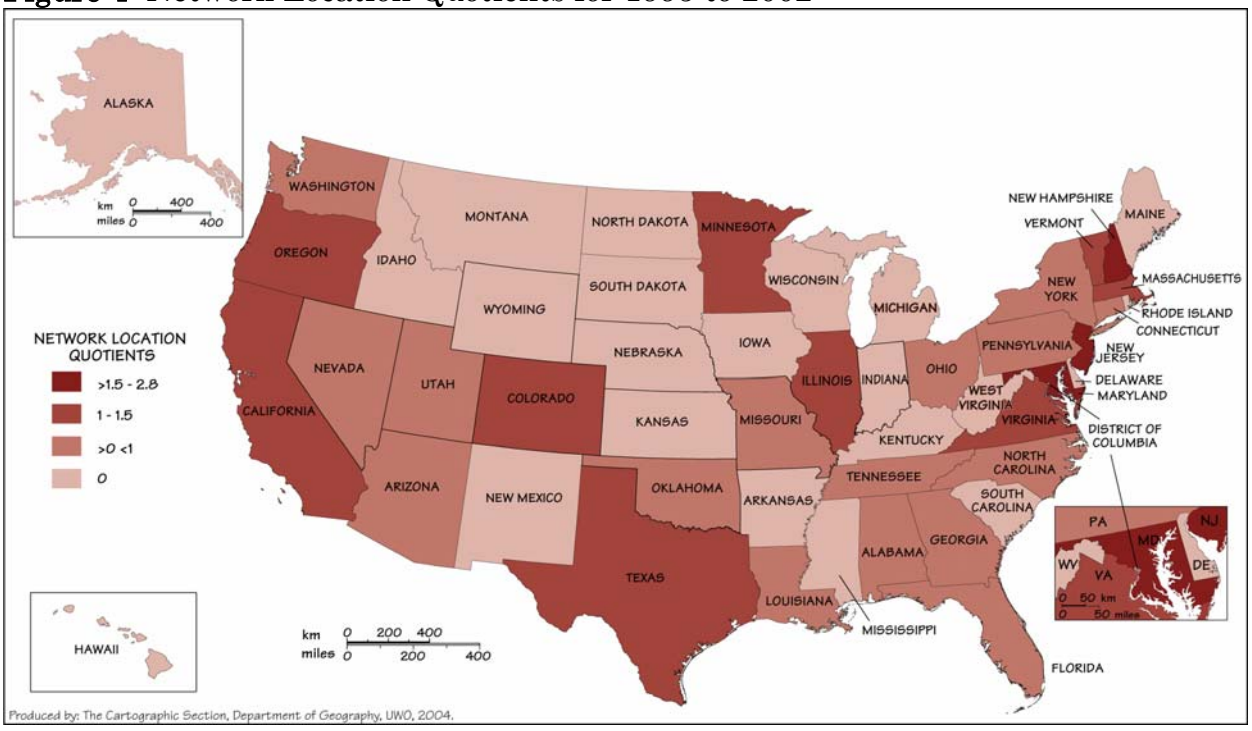


Figure 5: Media Location Quotients for 1995 to 2002

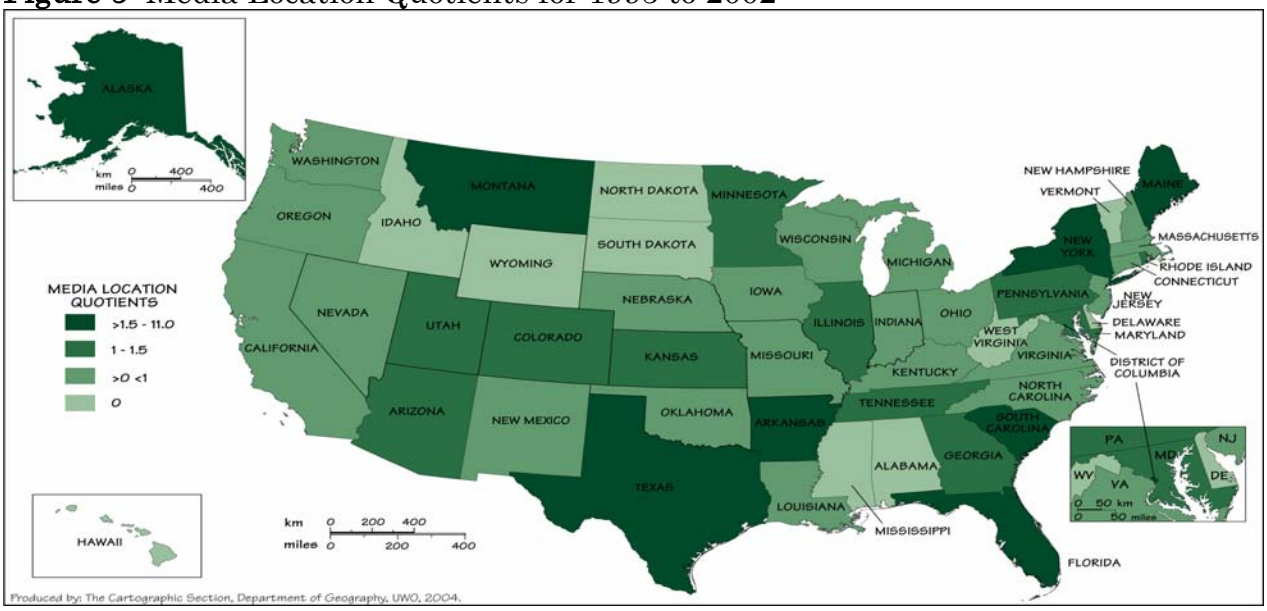
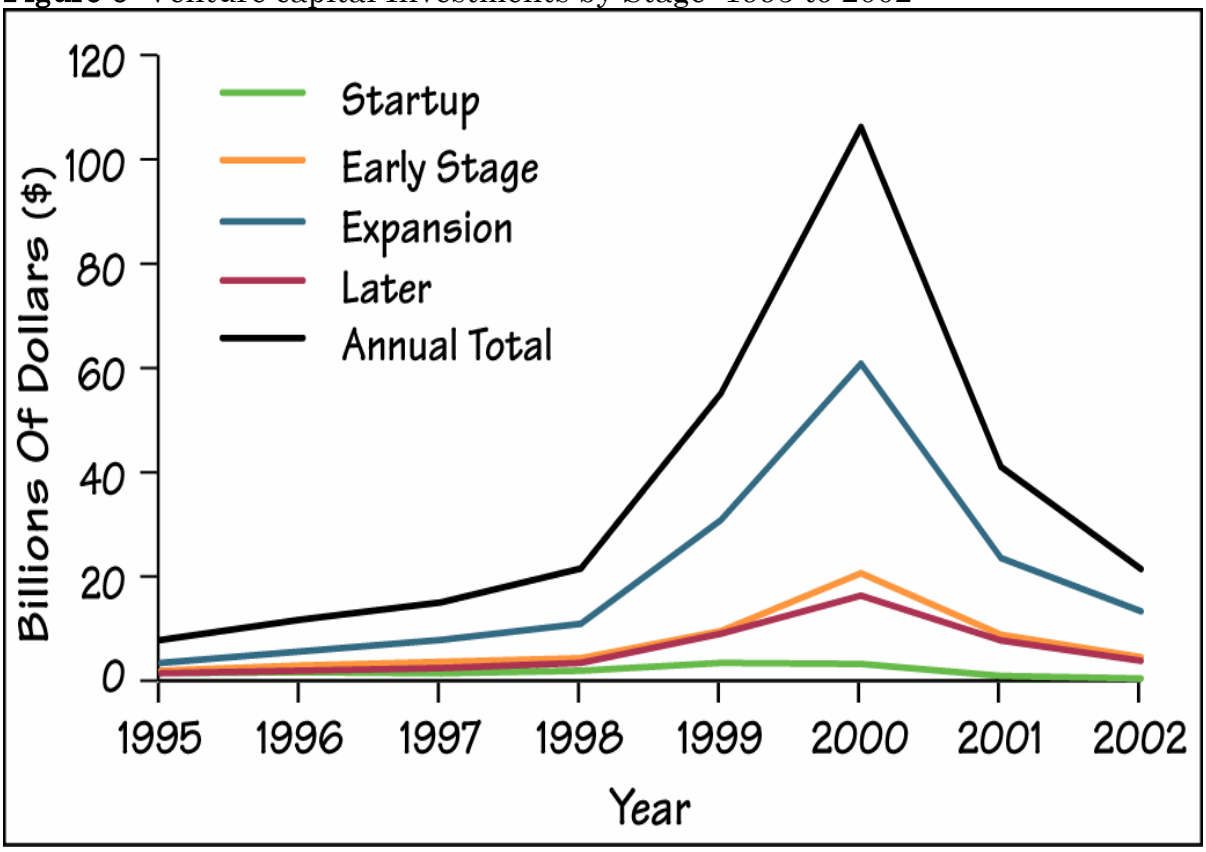


Figure 6: Venture capital Investments by Stage: 1995 to 2002



New York State and Texas rank lower on the investment/gsp ratio than their rank on total investment. Another obvious difference is the District of Columbia, ranked tenth on the ratio but twenty-fourth in total value. Of

course, venture capital is often more geographically concentrated than the state level (see Figure 7). Even the ratios understate the potential impact of investment. One should not overstate the differences since the Spearman correlation coefficient between the two sets of ranks is 0.89. When examining states' shares of total investment by a pre-bubble, bubble and post-bubble division, some interesting trends come to light (Tables 4a, 4b and 4c). In the period running up to the 1999-2000 bubble, (Table 4a) New York and California's percentage increases were in excess of 2% of the nation's total. Other gainers such as Washington, D.C. and Maryland experienced much lower gains. Losses of share were confined primarily to those states already having marginal venture capital participation such as Michigan and Missouri. Of the larger shares holders, Florida and Washington state showed declines. It is important to note that although the losers showed a percentage loss in terms of national share, in only five states (Idaho, Iowa, Nebraska, New Mexico, and North Dakota) did the actual amount of investment dollars drop.

The post bubble period had Massachusetts and Texas as major gainers. California lost about a quarter of a percent of investment in this shakeout period, while New York state gave back much of its gains experienced in the pre-bubble to bubble period (Table 4b). In contrast, in the pre-bubble to bubble period almost all states experienced an absolute decline in the amount of dollars invested. The only exceptions were: Delaware, South Dakota, New Mexico, and West Virginia, all states with very modest levels of investment. The dramatic shrinkage in investment after the bubble is illustrated by an absolute loss of just over $8.3 billion for the biggest percentage gainer Massachusetts from 1999-2000 to 2001-2002.

When examining the total gain or loss of venture capital investment shares though the pre-bubble to post-bubble period, (Table 4c) the biggest gainers were Massachusetts, Texas and California, all previously recognized concentrations of capital. In Massachusetts case, this may be the harbinger of a reversal of the declining fortunes it has experienced since the 1980s (Saxenrian, 2000). Essentially it's a case of the rich getting richer and the poor getting poorer. It appears that venture capital investment is becoming more concentrated in recent years. Twenty-seven of the states experienced absolute losses of investment pre-bubble to post-bubble and twenty-four experienced some absolute gain. The three largest absolute gainers were Texas ($1.6 billion), Massachusetts ($1.9 billion) and California ($3.9 billion), about 59% of the total increase of $12.6 billion (total declines were $3.9 billion, total increases $16.5 billion). These top three states' share was 54% of the nation's total for the pre-bubble period, 55% during the bubble and 61% post-bubble. This retraction of investment does not fit well with models postulating diffusion of investment either down the urban

hierarchy or spatially.

The venture capital literature makes it quite clear that investment is more spatially concentrated than observed at the state level. Figure 7 shows the investment into the major urban targets for the three investment periods by venture capital received of the nation's total for that time period. The area of greatest investment is the San Jose area (Silicon Valley), followed the San Francisco/Berkeley area, both of which are consistent with common perception. It is interesting to note that San Jose actually saw a slight decline in its share during the bubble while San Francisco saw a dramatic increase. Boston and New York were the other major target areas. It is difficult to discern whether or not the smaller cities as a whole saw increases in their shares during the bubble period. Some like Denver did while others such as San Diego saw a decline unfortunately, analysis at the urban level cannot be taken further because there is no information on industry or stage of investment.

The factors of location, stage of investment, industry class and year of investment all operate together to create the observed flows of venture capital investment. While Tables 1 through 3 show that venture capital investment varies for each survey variables, more insight can be gained if they can be examined together. A suitable technique to do this is median polish analysis.

MEDIAN POLISH ANALYSIS

The venture capital investment data lends itself naturally to a cross tabulation form. The value of investment is cross tabulated by year of investment, state of investment, stage of investment and industry of investment, producing a four-way table.

This table is populated by a large number of zero valued cells (see Table 1) which precludes analysis by methods such as log-linear or analysis of variance. A technique that can provide estimates of the effects of each of these variables that is not unduly influenced by zeros is median polish. Median polish is less computationally complex than other contingency table methods. The four dimensional model in this analysis is notationally defined as:

$$Y_{ijkm} = t + r_i + c_j + l_k + h_m + z_{ijkm} \quad (2)$$

where

Y_{ijkm} *is data array element in row i, column j, layer k and hyper-layer m*

t *is a typical value*

r_i *is row effect of row i*

c_j *is column effect of column j*

l_k *is layer effect of layer k*

h_m *is hyper-layer effect of hyper-layer m*

z_{ijkm} *is the residual effect of element ijkm*

The computational procedure begins by finding the median of each column in the data matrix and subtracting it from all elements in the column. This 'sweeps' a contribution of the column

in the model's fit. This produces a row of column medians and a new table from which the initial effect of the column has been removed from the new table. This process is repeated for all the rows, including the newly created one of the partial column effects. The procedure is applied to the layer that now also includes the column and row effects. The procedure is applied once again to the hyper-layer that includes the column, row and layer effects (Green, 1991). The model used here does not include interaction terms.

Although theoretically possible, the complexity of the computational task and the relative obscurity of the technique has so far prevented readily available software from being produced. Therefore, only a main effects model is pursued. The model's estimated parameters must be interpreted as a series of additive terms that recreates the original data value found in each cell of the four-way data table. The common effect is the median of all the data values found in the cross tabulation table.

It can be viewed as simply a scale effect, analogous to the grand mean in an analysis of variance. Each of the other parameters are the estimated impact of membership in one of the four classificatory variables. For example, a value of 5.90 for the state of Massachusetts (Table 5) indicates that the median of the investments made in that state are $5.90 million larger than the median of investments made in other states when the effects of the variables of industry, stage and year of in-vestment are removed.

This controlling of the other three variables allows for direct comparisons of median investment levels between states. The temptation is to compare these parameters via ratios such as 11.56 for biotechnology for California to 1.87 for the biotechnology for the nation as a whole (Table 5). It is correct to say that California has about six times more investment dollars than the national median when the effects of the other three variables are removed, but not to say that California is six times more likely to receive investment. The distinction is subtle but important. The parameters are part of a linear equation, not a multiplicative one, where statements about likelihood would be more appropriate. The use of the word *times* implies a multiplicative relationship that is not appropriate for this model.

The sweeping of the data matrix continues iteratively until the estimates converge or the magnitude of the residuals reach a specified level. Typically the estimates converge, as was the case here. A more complete description of the procedure may be found in Cook (1985) and Mosteller and Tukey (1977). The computational package used was Dataplot (Filliben & Heckert 2003).

Table 3: Investment by State 1995-2002

State	Investment in billions of dollars in a state (rank)	Percentage of dollar investment	Number of investments in a	Average dollar amount per deal (millions)	Rank Ratio Investment/gsp
California	108.38 (1)	39.94	12412	8.73	2
Massachusetts	28.08 (2)	10.35	3510	8.00	1
New York	16.76 (3)	6.18	2031	8.25	13
Texas	16.01(4)	5.90	1839	8.71	12
Colorado	10.19 (5)	3.76	1075	9.48	3
Washington	8.27 (6)	3.05	1039	7.96	4
Virginia	8.06 (7)	2.97	1006	8.01	6
New Jersey	8.00 (8)	2.95	982	8.15	11
Florida	7.16 (9)	2.64	921	7.77	18
Pennsylvania	6.99 (10)	2.58	824	8.48	19
Georgia	6.02 (11)	2.22	752	8.01	14
Illinois	5.73 (12)	2.11	752	7.62	22
Maryland	5.10 (13)	1.88	748	6.82	7
North Carolina	4.85 (14)	1.79	648	7.49	16
Connecticut	4.27 (15)	1.57	626	6.82	8
Minnesota	3.53 (16)	1.30	602	5.87	15
Ohio	2.59 (17)	0.95	410	6.31	27
Missouri	2.45 (18)	0.90	313	7.83	20
Arizona	2.13 (19)	0.79	304	7.02	21
Oregon	2.07 (20)	0.76	268	7.72	17
Utah	1.70 (21)	0.63	268	6.35	9
Tennessee	1.69 (22)	0.62	228	7.42	24
New Hampshire	1.68 (23)	0.62	221	7.60	5
District of Columbia	1.44 (24)	0.53	202	7.14	10
Michigan	1.17 (25)	0.43	132	8.86	37
Alabama	0.71 (26)	0.26	116	6.15	29
Wisconsin	0.63 (27)	0.23	109	5.74	34
Louisiana	0.61 (28)	0.23	108	5.69	33
South Carolina	0.59 (29)	0.22	94	6.32	30
Indiana	0.47 (30)	0.17	83	5.63	42
Kentucky	0.46 (31)	0.17	80	5.74	36
Kansas	0.44 (32)	0.16	78	5.63	31
Nevada	0.43 (33)	0.16	68	6.34	23
Delaware	0.40 (34)	0.15	68	5.85	32
Mississippi	0.33 (35)	0.12	55	6.05	25
Maine	0.32 (36)	0.12	49	6.58	28
Hawaii	0.28 (37)	0.10	44	6.34	26
Rhode Island	0.27 (38)	0.10	38	7.19	40
Oklahoma	0.24 (39)	0.09	28	8.53	39
New Mexico	0.16 (40)	0.06	27	5.75	45
Nebraska	0.14 (41)	0.05	24	5.68	44
Iowa	0.11 (42)	0.04	22	5.09	46
Idaho	0.09 (43)	0.03	22	4.03	43
Montana	0.08 (44)	0.03	18	4.70	35
Arkansas	0.07 (45)	0.02	17	3.87	38
Vermont	0.06 (46)	0.02	13	4.93	49
South Dakota	0.06 (47)	0.02	13	4.74	41
West Virginia	0.03 (48)	0.01	8	3.19	47
North Dakota	0.02 (49)	0.01	6	3.66	48
Alaska	0.00 (50)	0.00	1	3.50	50
Wyoming	0.00 (51)	0.00	1	3.50	51
Total	271.36	100.00	33303	8.40	

Table 4a: Gainers and Losers by State from 1995-1998 to 1999-2000

State	% of 95-98 investment (period 1)	% of 99-00 investment (period 2)	change from period 1 to period 2
Biggest Gainers			
New York	4.57	6.85	2.28
California	41.28	43.35	2.07
District of Columbia	0.17	0.61	0.45
Maryland	1.32	1.68	0.36
Texas	5.00	5.25	0.25
Oregon	0.57	0.81	0.25
Colorado	3.54	3.78	0.24
Utah	0.50	0.66	0.16
Mississippi	0.04	0.17	0.12
Hawaii	0.04	0.13	0.08
Biggest Losers			
Missouri	1.45	0.65	-0.80
Minnesota	1.64	1.04	-0.61
Washington	3.37	2.84	-0.53
Florida	3.02	2.55	-0.47
Michigan	0.75	0.34	-0.41
Virginia	3.37	2.96	-0.41
Tennessee	0.94	0.58	-0.37
Ohio	1.21	0.86	-0.35
Arizona	0.97	0.63	-0.34
Alabama	0.49	0.20	-0.29

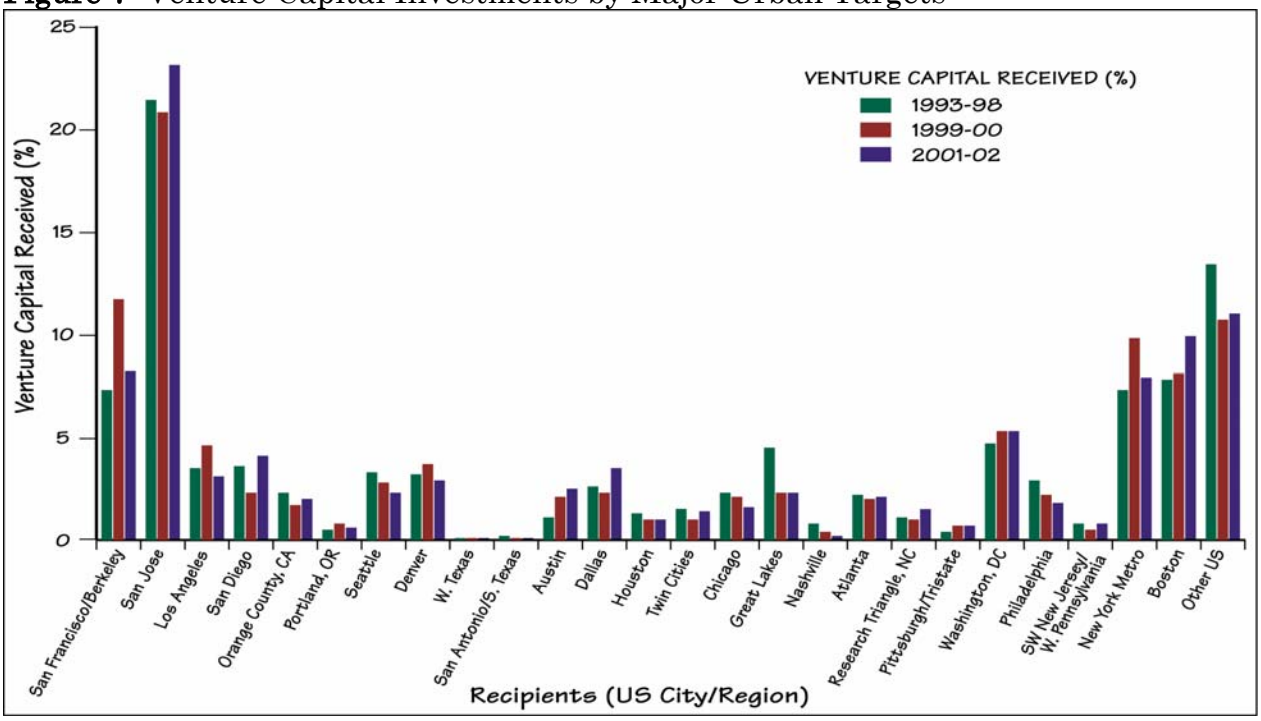
Table 4b: Gainers and Losers by State from 1999-2000 to 2001-2002

State	% of 1999-2000 investment (period 2)	% of 2001-2002 investment (period 3)	change from period 2 to 3
Biggest Gainers			
Massachusetts	9.38	11.48	2.11
Texas	5.25	6.92	1.67
Maryland	1.68	2.46	0.78
New Jersey	2.65	3.20	0.54
Minnesota	1.04	1.39	0.36
Georgia	2.01	2.30	0.29
Delaware	0.09	0.37	0.28
Missouri	0.65	0.92	0.28
North Carolina	1.58	1.85	0.27
New Hampshire	0.55	0.81	0.27
Biggest Losers			
New York	6.85	4.61	-2.24
Virginia	2.96	2.12	-0.84
Colorado	3.78	3.05	-0.72
Florida	2.55	1.92	-0.62
Pennsylvania	2.51	2.09	-0.42
Illinois	2.04	1.70	-0.34
California	43.35	43.09	-0.26
Tennessee	0.58	0.32	-0.26
Connecticut	1.50	1.28	-0.22
Washington	2.84	2.63	-0.21

Table 4c: Gainers and Losers by State from 1995-1998 to 2001-2002

State	% of 95-98 investment (period 1)	%of 01-02 investment (period 3)	change from period 1 to period 3
Biggest Gainers			
Massachusetts	9.32	11.48	2.16
Texas	5.00	6.92	1.92
California	41.28	43.09	1.81
Maryland	1.32	2.46	1.15
District of Columbia	0.17	0.55	0.39
Delaware	0.02	0.37	0.35
New Hampshire	0.47	0.81	0.34
New Jersey	2.88	3.20	0.31
Rhode Island	0.04	0.19	0.15
Georgia	2.18	2.30	0.12
Biggest Losers			
Virginia	3.37	2.12	-1.25
Florida	3.02	1.92	-1.10
Washington	3.37	2.63	-0.74
Tennessee	0.94	0.32	-0.63
Pennsylvania	2.68	2.09	-0.59
Illinois	2.24	1.70	-0.54
Missouri	1.45	0.92	-0.52
Colorado	3.54	3.05	-0.49
Michigan	0.75	0.28	-0.46
Ohio	1.21	0.75	-0.46

Figure 7: Venture Capital Investments by Major Urban Targets



The row, column, layer and hyper-layer effects are a measure of the relative importance of the row, column, layer or hyper-layer once the effects of the other terms have been removed. As in the equation above, the value of an individual cell is the sum of the effects of the terms. The primary advantage of this model is that it is relatively insensitive to extreme values of non-normally distributed data and the ability to handle zero valued cells.

Estimated effects

To keep the analysis simple, the entire survey's data was not analyzed. In particular, the stage of investment was restricted to the four of the seven most common types, early, later, expansion and start-up. All the states, industry classes and years are included.

An examination of the residuals of an initial 4-way median polish with all states included showed that all the largest residuals were associated with the state of California. This coupled with California being by value, the largest target region for venture capital investment, indicated that separate models for California versus the other states were required. Table 5 shows the parameter estimates for two models; one with California alone, and one with the other 49 states and the District of Columbia together.

Looking first at the industry estimates, one is struck by the larger absolute values for California and its larger range. The California values are on average larger by a factor of 12. The larger size of investments in California when compared to most other states coupled with the far greater number of investments is responsible. The values are in general agreement in trend since the correlation coefficient between the California estimates and those of the other states is 0.83.

The two models differ when looking at the stage of investment. California investments are more likely to be in the later stage (+$0.46 million) when compared to other states (-$3.18 million). The same is true for early stage investments with the California model showing +$0.16 million and the other states model showing -$0.32. What may surprise some are the low estimates for startup in both models, -$17.00 million for California and -$27.83 million for the other states. Venture capital investment for the period 1995 to 2002 was not targeting startup firms, although the investments that were made, were larger in California.

The year effect parameters exactly mirror the overall temporal pattern of investment for both models. The estimates are very close agreement for both with a correlation co-efficient of .94. The California estimates are on average a little larger than those of the other states.

The two models have different regional variables. The non-California model has the states as its regional

component. The California model has the state divided into four sub-regions as defined by the *Moneytree Survey*, Los Angeles/Orange County, Sacramento/Northern California, Silicon Valley and San Diego. This is the only instance where the *Survey* provides comprehensive data on a sub-regional level that does not overlap state boundaries.

Looking at the state estimates first, the values of most interest are at the top and bottom of the table. Massachusetts has the greatest positive effect estimate at 5.90, followed by Texas (3.36), New York (3.13), Washington state (2.52), New Jersey (2.49) and Florida (2.44). This ordering is roughly consistent with the list of top states in terms of total investment with the notable exceptions of Colorado and Virginia that appear a little further down the list. The states least likely to receive investment are no surprise with New Mexico (-2.20), Wyoming (-2.28), South Dakota (-3.75), Alaska (-4.49) and North Dakota with -4.81.

The California regional parameters show that Sacramento/Northern California is the least favored region of the state with a value of -$32.69 million, while Silicon Valley not surprisingly is largest with $48.30 million. The negative value (-9.42) for San Diego is maybe somewhat surprising, although it is offset by the dominant industries of the area; medical devices and equipment (14.71), bio-technology (11.56) tele-communications (29.63) and software (40.24), which together account for over 58% of all investment. This is a good example, of a case, where the ability of the model to separate investments into the underlying effects is useful. San Diego as a target area is relatively unattractive when the effects of its major industry groupings are removed. Table 6 shows the industry shares for the four California sub-regions.

The patterns of residuals for the two models are also similar. The bubble period is associated with the largest residuals in absolute value. The year 2000, in particular, was associated with the largest residuals. The persistence of residuals for the year 2000 is likely due to interaction effects with the other variables not captured by the model.

CONCLUSIONS

What is readily apparent from the preceding analysis is that the bubble investment period was different from pre and post periods on a number of dimensions. The bubble period experienced larger absolute flows of capital, more and larger deals. The spatial impact was uneven. At the urban level the largest targets stayed the largest targets although there was some shifting of percentage shares of total investment. The bubble period showed investments over a wider range of states and industries than either the pre or post periods, but the expansion was overly large. The expansion of the capital pool seemed

to have created some diffusion of venture capital but the diffusion was short-lived, a sort of negative diffusion. The share of the top three states increased post bubble indicating a contraction of the geographically expanded investment patterns. Presumably investors are sticking closer to home in a 'cold' market.

The implications for the geographic models presented early in this paper is uncertain. The sudden increase of the venture capital market was unprecedented. The explosive growth of the venture capital industry in the bubble period seems to have upset previous trends. The evolving gradual expansion of the industry both in terms of geography and investable capital seems to have been disrupted. Investments were temporarily made in more remote locations than previously.

The movement away from start-up ventures was not affected, although the increasing availability of angel capital may be responsible.
Subsequent contraction of investment has shown that the expansion of investment bordered on the irrational. The data is insufficient to allow a clear evaluation of existing models. Will the venture capital industry revert to pre-bubble patterns and then proceed as theoretically hypothesized or has there been a fundamental change in the industry? It is clearly too early to tell. However, of existing models, Thompson's (1989) best accommodates the recent past. Of course, there has yet only been a short readjustment period. Use of the location quotients showed that states that are historically large attractors of venture capital were balanced in their participation in the range of industry classes. More marginal states tended to be heavily weighted in specific industries. The more marginal the state the more unpredictable their variability becomes.

The analysis should be repeated in the future to see what long term effects if any, the recent contraction of the venture capital industry has had. Once this readjustment has occurred and the legacy of the bubble has passed, the industry may resume its gradual diffusion as witnessed pre bubble.

A significant set in the analysis could be achieved if it were possible to conduct the median polish analysis with the presence of interaction terms. The inclusion of just two-way interactions would likely improve the model and make it possible to determine how significant the interactions are. Such an analysis must await the availability of suitable software. Finally, the inclusion of data on transfers of capital from venture capital firm locations to target locations for the study period would also be welcomed. This should be coupled with data on the venture capital firms themselves to provide a more complete picture of the geography of the venture capital investment process than could be

presented here.

Appendix

The following is an abbreviated version of the industry definition used in the *MoneyTree Survey*. A complete description is available at the Survey's website: http://www.pwcmoneytree.com/moneytree/nav.jsp?page=definitions.

Biotechnology - Technology promoting drug development, pharmaceuticals, biosensors and disease treatment. Includes biotechnology products and services.

Business Products and Services - Products and services marketed to another business. Includes advertising, consulting, engineering services, distribution, and wholesaling.

Computers and Peripherals - Manufacture and distribution of all types of computer equipment. Also included are digital imaging, scanning hardware, video cards and plotters.

Consumer Products and Services - Products or services targeted at consumers.

Electronics/Instrumentation - Electronic components include scientific instruments, electronic testing products, and business and consumer electronic devices.

Financial Services - The provision of financial services to businesses or individuals including banking, real estate, brokerage services, and financial planning.

Healthcare Services - Health insurers, hospitals, clinics, nursing facilities, managed care organizations, Physician Practice Management Companies, child care and emergency care. **Industrial/Energy**- Producers and suppliers of energy, chemicals, and materials, industrial automation companies, oil and gas exploration companies, environmental, agricultural, transportation, manufacturing, construction and utility related products and services.

IT Services - Computer and internet-related services to businesses and consumers.

Media and Entertainment - Products or providers of services designed to inform or entertain consumers.

Medical Devices and Equipment - Medical diagnostic equipment (X-ray, CAT scan, MRI), medical therapeutic devices (drug delivery, surgical instruments, pacemakers, artificial organs), and other health related products.

Networking and Equipment - Data communication and fiber optics products and services. **Retailing/Distribution** - Firms making consumer goods and services available for consumer purchase. E-Commerce companies are included.

Semiconductors - Design, develop or manufacture semiconductor chips/microprocessors.

Software - Producers of bundled and/or unbundled software applications for business or consumer use.

Telecommunications - Companies focused on the transmission of voice and data.

Other - Not classified elsewhere

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Table 5: Median Polish Estimates for California and the Rest of the Nation

	California	Nation
Industry		effect
Biotechnology	11.56	1.87
Business Products and	-14.06	-0.41
Computers and Peripherals	-2.42	-1.03
Consumer Products and	-5.69	-0.92
Electronics/Instrumentation	-28.91	-1.57
Financial Services	-12.38	0.00
Health Services	-13.74	0.42
Industrial/Energy	-14.31	-1.38
IT Services	-0.18	0.98
Media and Entertainment	4.50	0.56
Medical Devices and	14.71	-0.37
Networking and Equipment	12.22	2.61
Other	-60.25	-2.67
Retailing/Distribution	-15.18	-0.96
Semiconductors	6.50	0.06
Software	40.24	2.08
Telecommunications	29.63	2.64
Year		
1995	-18.08	-17.60
1996	-9.18	-9.42
1997	-7.61	-2.68
1998	0.17	2.68
1999	23.21	29.93
2000	54.93	34.52
2001	9.27	15.31
2002	-3.73	-3.45
Stage of Investment		
Early Stage	0.16	-0.32
Expansion	24.32	27.55
Later Stage	0.46	-3.18
Seed/Startup	-17.00	-27.83

common effect for National model =0.45, all terms statistically significant at p=.05.
common effect for California model = 22.26, stage and region terms statistically significant at p=.05.

Table 5 (continued)

nonCalifornia State Effects		nonCalifornia State Effects	
STATE Effect		STATE Effect	
California	na	Delaware	-0.41
Massachusetts	5.90	Arkansas	-0.45
Texas	3.36	Louisiana	-0.47
New York	3.13	Utah	-0.54
Washington	2.52	Rhode Island	-0.58
New Jersey	2.49	Kentucky	-0.69
Florida	2.44	Indiana	-0.72
Colorado	1.76	Oklahoma	-0.87
South Carolina	1.49	Vermont	-0.88
Illinois	1.40	Mississippi	-0.91
Virginia	1.34	Alabama	-0.96
Arizona	1.21	Wisconsin	-0.97
Minnesota	1.18	District of Columbia	-0.99
Georgia	1.08	Kansas	-1.19
Connecticut	1.05	Nebraska	-1.33
Oregon	0.87	Michigan	-1.66
Pennsylvania	0.84	Iowa	-1.87
New Hampshire	0.80	Maine	-1.88
Maryland	0.76	West Virginia	-2.04
Tennessee	0.74	Hawaii	-2.13
Idaho	0.33	New Mexico	-2.2
North Carolina	0.32	Wyoming	-2.28
Missouri	-0.02	South Dakota	-3.75
Nevada	-0.04	Alaska	-4.49
Ohio	-0.07	North Dakota	-4.81
Montana	-0.36		

California subregion parameters	
region effect	
Los Angeles	8.01
Sacramento/Northern California	-32.69
San Diego	-9.42
Silicon Valley	48.30