VENTURE CAPITAL AND CLEANTECH SYMBIOSIS

Sean Tierney
Department of Geography
University of North Texas
Denton, TX 76203
sean.tierney@unt.edu

ABSTRACT

The term "cleantech" defines companies dedicated to renewable energy generation, curbing greenhouse gas emissions and other pollutants, promoting energy efficiency and natural resource conservation. In terms of the overall venture capital (VC) activity, cleantech gets more financing from VC firms than any other sector (except software), with dollar commitments and total deal volume rising each year through 2008. Cleantech firms are concentrating close to VC firms in California and Massachusetts, but other clusters of activity are noticeable. Solar remains the most funded technology, but both biofuels and storage are making significant inroads and garnering sizable later stage funding commitments.

Keywords: Cleantech, Energy, Venture, Capital, Cluster, Innovation

The Industrial Geographer, 2011, Volume 8, Issue 2, Pages 63-85.

INTRODUCTION

Cleantech is the umbrella term describing companies creating the tools, manufacturing processes, and energy sources designed to transition the world away from fossil fuels and waste. Cleantech is more than wind and solar power; it also encapsulates materials, buildings, water, recycling, electricity transmission, and energy software. While many large global corporations are formidable cleantech players, a growing collection of private companies have emerged to capitalize on improving environmental performance. Financing is critical for this fledging sector and the venture capital industry has stepped in to nurture these varying technologies.

This study aims to identify the pattern, pace and technological targets of venture capital (VC) activity in cleantech since the beginning of the decade. Through 2008, cleantech's national footprint continued to expand as measured by the geography of VC investments. As an economic sector in 2008, cleantech received the second largest amount of financing from venture capital firms (NVCA 2009). A broad financial market collapse has constricted capital flows, but for the last three years cleantech VC activity was rapidly accelerating. Conforming to Gompers and Lerner (2004), a symbiosis between venture capital and cleantech exists, with significant concentrations in California and the Northeast. A variety of technologies have been funded, but solar related investments are outpacing all other cleantech categories by a wide margin.

WHAT IS CLEANTECH?

PricewaterhouseCoopers (2008) describes Cleantech as: "not one tidy group, but rather an array of distinct sub-sectors: solar, wind, and geothermal energy generation, biofuels, energy storage (power supplies such as batteries and uninterruptible power supplies), nuclear, new pollution-abatement, recycling, clean coal, and water technologies (Figure 1). The common thread is that all of these sub-sectors represent technologies, services, or products aimed at reducing greenhouse gas emissions and other pollutants and promoting energy efficiency and the conservation of natural resources."

Firms in the cleantech industry are dedicated to finding technological solutions to energy, ecological, and industrial processes while growing the economy and improving environmental productivity. Energy related companies make up the largest cleantech segment, and energy is broken down into supply side and demand side technologies. Energy generation (supply side) gets more of the attention with sexy components like wind turbines, batteries, electric cars, and solar panels. These technologies are tasked with changing the way we make and use energy, but because of their capital costs and technological immaturity they have medium- to long-term investment time horizons.

Offering near-term benefits on the demand side are technologies and services like smart grid applications, commercial lighting, and programmable

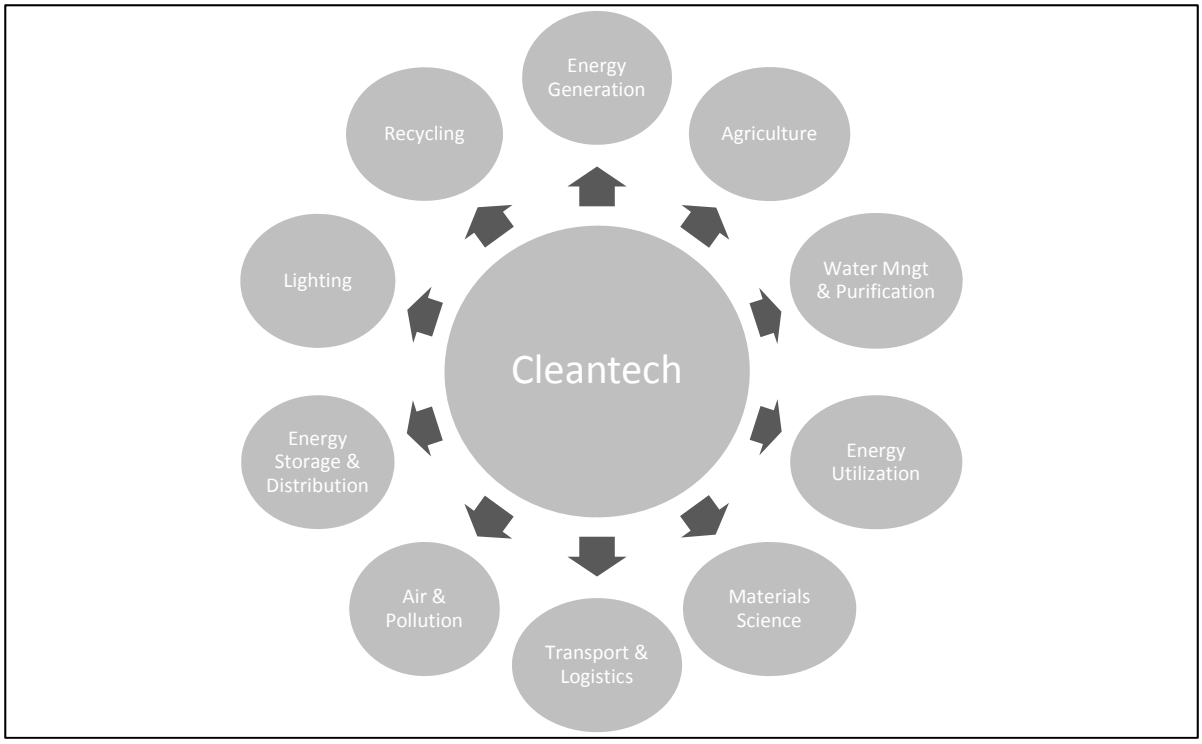


Figure 1. Cleantech Taxonomy

thermostats. Many of these products have already achieved commercial viability, and are part of the lower hanging fruit that have a proven financial and carbon savings. Other areas within the cleantech taxonomy, including intelligent network devices, materials, recycling, water and air purification, and transportation have achieved some measure of market penetration, but they are not yet scalable.

VENTURE CAPITAL IN A MARKET ECONOMY

Venture Capital Fundamentals

Virtually all small businesses access their capital requirements through traditional channels like banks or credit unions (de Bettignies and Brander 2007; Davis 2003). But a small subset of start-ups, particularly conceptual businesses are too risky for securitized loans, seeks financing from a Venture Capital Firm. Venture Capital (VC) is aggregated sums of money from institutions (pensions, insurance companies, university endowments, etc.)

that are invested in small privately held firms. Unlike traditional securitized bank finance, where entrepreneurs retain all the profits and risks of the business, VC-backed finance dilutes the owner's control in exchange for capital. The bank makes its money through interest payments, while the Venture Capital Firm (VCF) makes money once its companies are acquired or go public (Hand 2007). Lungren (1984) summarizes the difference as bank finance being 'collateralized' whereas venture capital is 'idea based'.

Most VC investments are concentrated in high growth segments of the economy and these investment decisions are rooted in specialized industry knowledge (Bottazzi et al 2008); deep industry experience that enables a thorough understanding of the opportunities and threats (Saxenian 1996). Upon investing, the VCF know-how provides technical and managerial guidance which is crucial in nurturing the high-tech industries of tomorrow (Zucker et al. 1982). As active investors, VCFs help companies navigate the competitive landscape more efficiently than companies with passive investors (Inderst and Mueller 2009). There is also the 'rolodex' benefit; the VCF personal industry network of contacts that might provide additional value as the company grows. In short, VC is 'private money, professionally managed, always growth oriented, and providing managerial assistance' (Cornelius 2005)

VCFs make incremental investments, establishing milestones for its portfolio companies, targets that must be achieved in order to receive the next round of funding (Gorman and Sahlman 1989). VCFs are unlikely to commit large sums of money to small firms with limited track records. This works well for both the entrepreneur, who wants to retain as much ownership as possible, and the VCF who wants to gauge the viability of the company; because the VCF is making investments in lots of firms, these smaller upfront commitments enable them to make more 'bets' and limit their downside exposure should the firm fail early on. By casting this wide net, the VCF has exposure to many different technologies, anticipating that one or perhaps a handful of the companies will become a product, industry or technological leader. The first round of financing is referred to as a Series A round, and should the company continue making progress, the VCF might make a second round, or a Series B round, and so on. Later rounds typically involve larger capital commitments, and are usually done in syndication, as the company fulfills its promise and future success is more assured (Sorenson and Stuart 2001).

Geography and Venture Capital

The role of geography in innovation and VC investing has attracted considerable attention over the years (Rosenberg 1972; Dorflinger and Rivkin 1987; Thompson 1989). In an era of global financial flows (Martin 1999), there remains a strong local investment focus by VCF (Lerner 1995; Sorenson and Stuart 2001). VCFs favor local companies because of the pre-investment due diligence, the so-called non-monetary aspects of VC. Information on market conditions, entrepreneurs and competitors, are more easily and cost-effectively performed on nearby investment opportunities (Zook 2002). By adhering to a regional investment focus, VCF can more effectively govern, monitor, and supervise their portfolio companies, particularly in the early phases (Kenney

1986; Lerner 1995). VCFs also favor local companies because they contribute technological, operational, and managerial experience, alleviating them of the daily distractions which are not among the entrepreneur's core expertise, but are vital to the long-term health of the company (Casamatta 2003). These post-investment roles are more effective when a VCF is close, a distance between entrepreneur and VC that averages 60 miles, or the 'one-hour rule' (Gompers and Lerner 2004). While there remains a tendency for close spatial proximity, VCF have recently begun casting longer geographic shadows (Fritsch and Schilder 2008).

The presence of venture capital has a catalyzing effect on innovation and local economic growth (Mason and Harrison 2003). These VC 'rich' regions have advantages, like attracting entrepreneurs, which propel new firm formation in a way that 'poor' regions with inferior VC infrastructure are handicapped (Wray 2011, Martin et al. 2005). In this sense, a vibrant VC environment is a leading indicator in regional development (Zook 2004). On the other hand, entrepreneurs with good ideas that are unwilling to move their companies to be near VC are still able to attract funding, defying some of the conventional VC literature (Griffith et al. 2007).

By and large however, firms and VCFs tend to cluster. The resulting circular and cumulative causation is obvious; Von Burg and Kenny (2000) refer to these feedback strengths as embeddedness, and these regional knowledge clusters are an important source of growth and innovation in advanced economies (Florida and Smith 1993). Public research collaboration offers another important part of these clusters, as facilities, scientists, and ideas are all found in spades on the campuses of large research universities and are often leveraged for additional technological guidance (Chen et al. 2010). The benefits are even more widespread, as agglomeration economies, industry expertise and regional innovation centers are additional resources available within these knowledge hubs (Powell et al. 2002; Florida and Kenney 1988; Gompers and Lerner 2001; Saxenian 1996).

Managing Volatility and Risk

Few VC funded start-ups actually mature, making the VC arena fraught with risk (Kaplan and Stromberg 2004). While calculating the 'success and failure' of a VCF's portfolio is highly subjective and closely guarded, it is accepted within VC circles that only a small fraction of the investments ever go public. According to the NVCA (2009), 40% of companies fail, 40% are able to generate a small return for the VC, and 20% or less produce high returns. In a review by Global Insight (2007), less than half of the 11,686 venture backed companies from 1991-2000 went public or was acquired (Table 1). While an acquisition is a desired outcome, it may actually be a financial 'loser', for it is impossible to determine if the valuations were favorable or if the company's sale was simply an exit that allowed the VCF to cut its losses and move on.

One of the most important developments in VC financing has been the growth of syndication networks, where multiple VCFs invest in start-up companies (Lerner 1994). Syndicated investments offer two distinct advantages for VCFs.

Table 1. Outcome of VC Investments Between 1991 and 2000

Went/going public	14%
Acquired	33%
Known to have failed	18%
Still Private or unknown (assumed to have quietly failed)	35%

Source: *Global Insight 2007*

First, it brings additional expertise to the initial screening stage, which is particularly important when partnering with innovators or scientists in far-reaching oftentimes esoteric corners of their fields. Second, syndication allows VCFs to spread the risk of an investment. Although this does limit the funds overall returns, if the VC improve the odds of an elusive or lucrative exit, it should proceed with syndication (Brander et al. 2002; Manigart et al. 2006).

There are four primary reasons a venture funded company fails: technology risk, people risk, market risk, and financial risk (Gorman and Sahlman 1989). Of the four, financial risk is really the most perilous because it leads to one of the golden rules in VC – being early is indistinguishable from being wrong (Gertner 2008). If the market is not prepared to accept a technology, will the VCF escalate its commitment and sustain the business until the market matures? An escalation of commitment is the justification for future investments based on cumulative past investments; some might say it is throwing good money after bad.

For techno-economic paradigm shifts, it may take years for the market to shake out the scalable and effective technologies, thus proceeding with an investment may be the only way to determine the viability of a technology. Cleantech VC is particularly challenging since it takes longer for market acceptance than in traditionally safer VC sectors like software or multimedia. Telecommunications (particularly fiber optic networks) and genetic engineering are other examples of investments that require longer time horizons, making them more capital intensive. With cleantech, some technologies will take years or decades to achieve market acceptance, and capital commitments are needed for the duration.

Financing is the most obvious risk, but unlike other broad sectors that are attracting VC, investing in cleantech is extraordinarily vulnerable to policy risk. Energy has always been subject to uncertain regulatory drivers. At the national level, congressional lawmaking has been unable to create long-term price signals or consistent policy support for cleantech; with the exception of the PURPA in 1978 and the Energy Policy Act in 1992, most legislation targets specific technologies or is designed for short durations (Gielecki et al. 2001). Additional rule-making, enforcement, or market-steering powers have devolved to the Environmental Protection Agency and the Department of Energy, further complicating the investment landscape.

In the absence of national guidelines, states have crafted their own set of standards which further segments the investment landscape (Menz 2005; Byrne et al. 2007). As it relates to renewable energy in particular, the US has had a chaotic and often piecemeal approach, marked by sporadic R&D funding and unreliable tax breaks. When compared with a country like Germany, which has enjoyed more consistent support for renewable energy, policy making fragmentation in the United States has denied the markets adequate visibility, thus depriving the industry of enduring investment confidence (Laird and Stefes 2009).

Venture Capital Myopia

The investment profile of a VCF is usually narrow, focusing on industries with strong growth prospects and match up with the practical expertise of its senior partners (Zider 1998). Problems can arise when the VC community lacks the command of a nascent industry, and are lured away from their core areas to pursue the "hot" sector. When capital chases investments, with little follow-on expertise to offer the entrepreneur, erratic valuations and expectations usually follow. This is particularly true as younger fund managers are eager to establish a track record thereby hastening their quest for an exit, but doing so in a way that handicaps their portfolio companies (Gompers 1994).

Sahlman and Stevenson (1987) chronicled the first modern VC bubble when investments in Winchester disc companies surged and busted in the 1970s. With so much capital flooding a new industry, due diligence is less rigorous and asset bubbles more likely (Gompers and Lerner 2000). There have been several examples since the Winchester disc, including energy in the early 1980s, software in the later 1980s, the internet in the 1990s, or biotechnology in the first half of the new century. Some industry valuations inflate rapidly and burst (disc drive or internet), while others (software) evolve into more mature industries where VC is no longer needed. Since 2006, Cleantech represents the latest example of a scalable technology industry with a growth profile that is well suited for VC, where deal volume has been escalating.

VC has become a victim of its own success, transitioning from retired professionals that had run successful corporations with expertise to share, into a field of generically trained MBAs with limited industry experience (Cornelius 2005, Dizzard 1982). These newcomers are more risk tolerant, but lack the capacity to play leadership roles on the boards of small firms, and so their investment decisions are often driven by profit potential rather than technological promise. There is also competition for later round financing. With fewer companies making it to later financing stages, the opportunity to fund technologies so close to an exit creates an environment where VCF are willing to offer more lucrative valuations for the chance to participate in the deal. This sets in motion the spiraling valuations that make the remaining limited worthy investment even more in demand. Geography aggravates this problem as VCF prefer investments that are nearby; the result has been a more dramatic impact on prices and valuations in the VC hotspots of California and Massachusetts (Gompers and Lerner 2000).

METHODS AND DATA

This study has two main research goals. The first is to describe the geography of cleantech firms as well as the VCF that are the source of their funding. Understanding how VC unfolds across space has long tradition in economic geography (Wray 2011). The second objective is to describe the regional nature of these investment relationships. Proximity between the cleantech firm and VCF needs to be understood as well as aspects related to various technologies that are funded, and the size of the investments as a sector matures. Exposing the preliminary geographic footprint of cleantech may foretell how any expected employment and regional economic benefits will unfold.

Data for this research were collected from several sources. First, broad venture capital industry data were collected from the National Venture Capital Associations (NVCA 2009). The National Venture Capital Association (NVCA), along with PricewaterhouseCoopers and Thompson Reuters, aggregates VC activity, including economic sector, investment round (series A, series B, etc), VC exits, performance, and fundraising. This study only used the data on economic sub-sectors and investment round.

Second, a database was built in order to understand and describe the temporal, geographic, and technology of VC cleantech investing. The database was constructed by combing through online databases and press releases to determine the date, financial commitments, and structure of VC investments. Four separate database tables were built on cleantech firms, VCF, the relationship between them, and the nature of the investment.

The starting point for this database is the list of all VCF in the country as registered with the NVCA, and was subsequently parsed to find only those with a current or former investment in a cleantech company. VCF that are not registered with NVCA, but participated in a financing round, were subsequently included in the database. The second table was a list of all the domestic privately-held cleantech firms that have received VC, and the table included the firm's specific technological focus[1]. The third table was a relational table VCF and cleantech company. The final table was the sequence and dollar amount each cleantech firm received.

Three sources were used to confirm data integrity. First, nearly every cleantech firm issues a press release to tout the investment from a VCF. They do this because it provides a short-term visibility boost, and to some extent, it validates their technology because it was promising enough that outside experts put some money behind it[2]. Second, VCF also issue press releases when they make an investment. VCF are always preparing to raise their next round of funds and it usually enhances their credibility to be seen as active investors with promising ideas. The last form of verification was to check the data against the information maintained by Venturebeat (2009), a VC activity clearing house. Comprehensive databases that track VC investments in

[1] Thirty different technologies were identified, with an additional category, cleantech noc (not otherwise classified), accounting for other types of ambiguous companies.

[2] Some companies prefer to stay in stealth mode (not issue press release). This study does not account for those investments. In such cases, it is likely that no databases would be able to confirm VC relationships or investments.

all sectors do exist (like VentureExpert or the Cleantech Group) but they are for-profit subscription businesses and their fees were beyond the financial capacity of this study.

One potential shortfall of this study is the degree to which some VCF or cleantech firms were not counted. While it is likely that some companies were missed, the accuracy of the database is rooted in two facts. Since so many VC investments are made in syndication, missing an investment would mean missing it while combing through the portfolios of multiple VCFs; some companies were missed, but they were unlikely to be larger firms obtaining significant investment dollars, and therefore would not materially impact this study. Second, when compared with the aggregated cleantech data compiled by the NVCA, the data integrity is clear, particularly in the last three years when VC activity in cleantech accelerated (see Table 2).

The years when this study undershoots the NVCA can be explained because they have been tracking these data in real time since 1995. In the first five years, this study's deficit is best explained by the fact that most of those companies have found exits or gone out of business – yet investments were made and captured by industry analysts at the time. The overshoot in 2007 and 2008 is explained by a categorization discrepancy. This study may classify a smart-grid software company as cleantech, whereas the NVCA may classify it as part of the software sector.

This study adhered to some strict data collection rules. First, the company had to be privately held at the end of 2008; companies were omitted if they received VC at some point in its history, but had since been acquired or gone public. Second, only domestic companies were used, so if a cleantech company listed an international address for its headquarters, it was not used. Since this study's aim was not to document the activity of international VCF, domestic companies that had received VC funding from an international VCF were included, but their relationship with the VCF was with a generic "international VCF". Third, private companies in the cleantech space that are funded through non-VC channels were excluded[3]. Finally, any subsidiary investment activities funded in-house at major corporations are excluded. In other words, GE is a leader in wind technology, and it is possible that they are investing in high-altitude wind, but it would be impossible to determine their transaction history, because GE does not break down R&D for its subsidiaries when it releases earnings.

With data running through the end of 2008, this study corresponds to a period when VC investment activity in cleantech hit its apex, and therefore marks a useful delineation point. Looking forward, some of the companies will suffer some near-term financial hypoxia but survive, while other companies will run out of cash and go bust. This pause will force the participants on both the innovation and financing side to take stock of the market viability for these new technologies and ultimately the landscape for cleantech is likely to be different once the credit crisis has passed.

[3] Some companies have in-house venture arms, but investment information is undisclosed and therefore excluded from this study.

Table 2. Data Comparison: VC Dollars from NVCA vs. Study Figures

Year	NVCA - Cleantech	This Project	Difference	% difference
2000	$596	$10	- $586	(98.3%)
2001	$400	$26	- $374	(93.5%)
2002	$391	$29	- $362	(92.6%)
2003	$271	$69	-$202	(74.5%)
2004	$444	$209	- $235	(52.9%)
2005	$550	$263	- $287	(52.2%)
2006	$1,440	$1,367	- $73	(5.1%)
2007	$2,666	$2,802	+ $136	5.1%
2008	$4,115	$4,490	+ 375	9.1%

All monetary figures are in $ millions.

RESULTS

According to the NVCA, there are 714 VC firms in the United States managing $257 billion in 2007 (NVCA 2009). Since 1995, VC firms have invested $428 billion in 52,000 different funding rounds with the industry peaking in 2000 at the height of the dot.com bubble when 7,900 deals totaling $104 billion were done (Figure 2). The ramp at the end of the 1990s is clear, with the total dollars and deals suffering steep declines in the years since 2000. In fact, both have failed to recover half of where the industry peaked, with 2008 registering 3,808 deals totaling just over $28 billion.

Within the 17 broad economic sectors, a large percentage of cleantech investments fall within the 'industrial/energy' sector. In 1995, VCFs invested a total of nearly $8 billion, with the industrial/energy (IE) sector securing $544 million, or 6.8% of total investments. By 2008, IE investments more than doubled its share of the total to 16.4% of the $28.3 billion, trailing only 'software' as the most attractive sector destination for VC money (Table 3). Since VC investments peaked in 2000, only three sectors have eclipsed those highs, IE (+83.5%), Medical Products and Equipment (+39.9%), and Biotechnology (+5.9%); the other 11 sectors have attracted only a small fraction of the investments they secured at the start of the decade.

That the VC industry invested only $28.3 billion in 2008 is evidence of the capital destruction that followed the bursting of the dot/com bubble in 2000. When looking specifically at the IE sector however, and the cleantech industry in particular, a very different picture emerges (see Figure 3). IE was stuck between 4-7% with money funding traditional manufacturing and legacy energy ideas (enhanced fossil fuel recovery technologies, chemicals, etc); meanwhile cleantech was out of favor for many of the years that that overall VC industry frothed. In the years since the internet bubble burst, the alignment of IE and cleantech is evident as almost all VC money in IE is concentrated in the related products and services of the more narrowly defined cleantech category. In 1995, when cleantech captured only $79

Table 3. Total VC Investments by Sector, 1995 and 2008

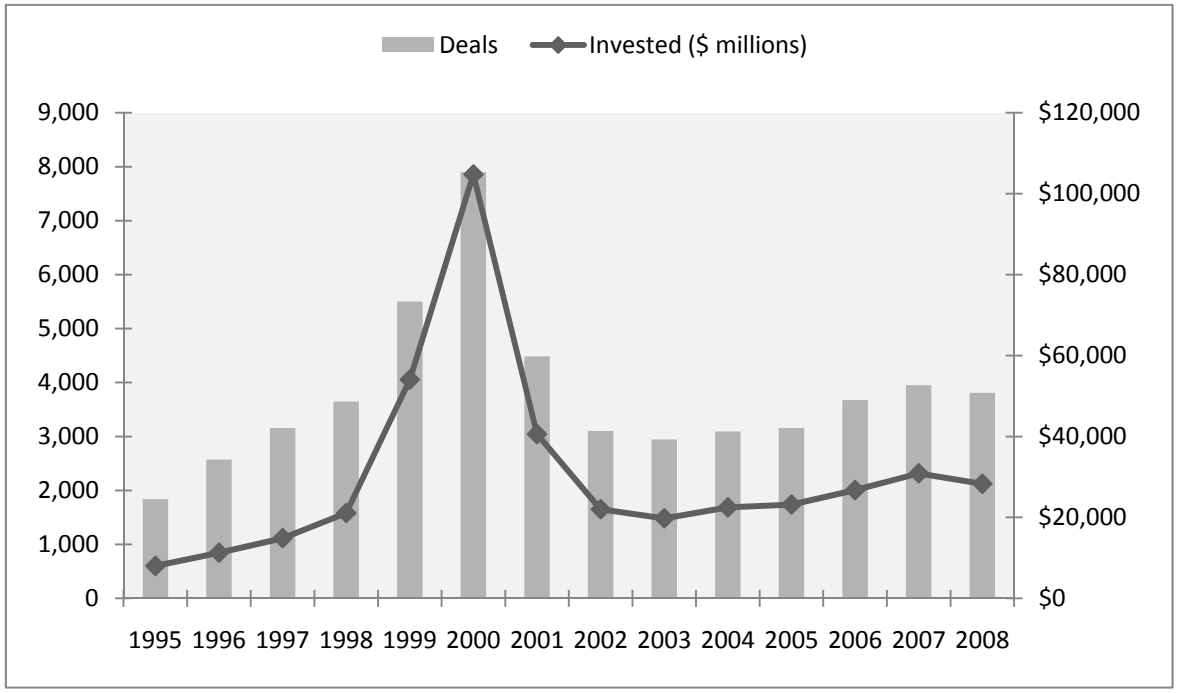
Industry	Invest. 1995
Software	$1,164
Telecommunications	$957
Media & Entertainment	$916
Biotechnology	$829
Medical Devices / Eq.	$662
Consumer Products & Srvs	$556
Industrial/Energy	$544
Healthcare Services	$456
Networking and Equipment	$354
Computers & Peripherals	$326
Retailing/Distribution	$318
Semiconductors	$207
Financial Services	$194
IT Services	$185
Business Products & Srvs	$178
Electronics/Instrumentation	$137
Other	$12
Grand Total	**$7,996**

Industry	Invest. 2008
Software	$4,919
Industrial/Energy	$4,651
Biotechnology	$4,500
Medical Devices / Eq.	$3,460
Media & Entertainment	$2,039
IT Services	$1,832
Telecommunications	$1,688
Semiconductors	$1,651
Networking and Equipment	$645
Electronics/Instrumentation	$573
Financial Services	$534
Business Products & Srvs	$482
Consumer Products & Srvs	$436
Computers & Peripherals	$409
Retailing/Distribution	$268
Healthcare Services	$195
Other	$15
Grand Total	**$28,298**

All monetary figures are in $ millions.
Source: *NVCA 2009*

million, or 14% of the $544 million taken in by IE sector companies, compared with 2008, when cleantech investments totaled $4.1 billion, or 88% of the $4.6 billion taken in by the broader IE sector companies. And unlike other economic sectors which remain down sharply from their 2000 highs, cleantech is surging, up more than 10X since 2001.

And while the total dollars and deals associated with the cleantech is promising for the future of this industry, it is more telling that the level of VC activity in the first sequence investment round– the Series A round – has surged. First sequence investments are a critical leading indicator for an industry and two things have been triggered as a result of cleantech's rise. First, VCF with a cleantech focus have been emerging; just as investors were quick to divest themselves from investments associated with the tobacco industry or companies operating in Sudan (due to the Darfur genocide), many are eager for some exposure to renewable energy, carbon mitigation, and sustainability. The second trigger has been by the entrepreneur, where this favorable funding environment has spawned incubation activity. Internet companies were funded with limited scrutiny in the late 1990s as VCF feared they would miss the boat; the same herd mentality might be at play in cleantech. First sequence investing in this sector has grown substantially over the last four years (Figure 4). It turns out that 2007 was an a milestone year as the software sector, which had commanded the largest



Source: *NVCA 2009*

Figure 2. All VC Investments, 1995-2008

percentage of first sequence investment dollars every year since 1995, was eclipsed. IE expanded its lead in 2008, when it secured 20.2% of all the first sequence investments dollars, compared with 14.7% for software.

Since 2001, $9.3 billion has been invested in cleantech, but 94% ($8.7 billion) was invested in just last three years, 2006-2008. 270 different VC firms participated in at least one cleantech investment round while 299 cleantech companies received funding. Of the 225 companies that obtained a Series A round, half secured at least one additional round of funding. The other half, as of 2008, had not secured further financing. A major imbalance exists with respect to both the geography and density of investments (Figure 5). California has secured more than half of all VC investments during is the only other state to amass more than $1 billion. In sum, 31 of the 50 states had at least one cleantech firm obtaining some VC financing. As far as clusters of cleantech activity, several obvious yet important regions are evident. With more than $5 billion in California, firms are concentrating in expected places (i.e., the San Francisco, Los Angeles, and San Diego metro areas). The Route 128 corridor of Massachusetts, which like Silicon Valley became a VC destination hotspot during the internet bubble, is home to many of cleantech companies. Elsewhere, clusters of cleantech activity are identifiable in Colorado's Front Range, in the New York/New Jersey/Philadelphia region, and in the Washington DC metro area.

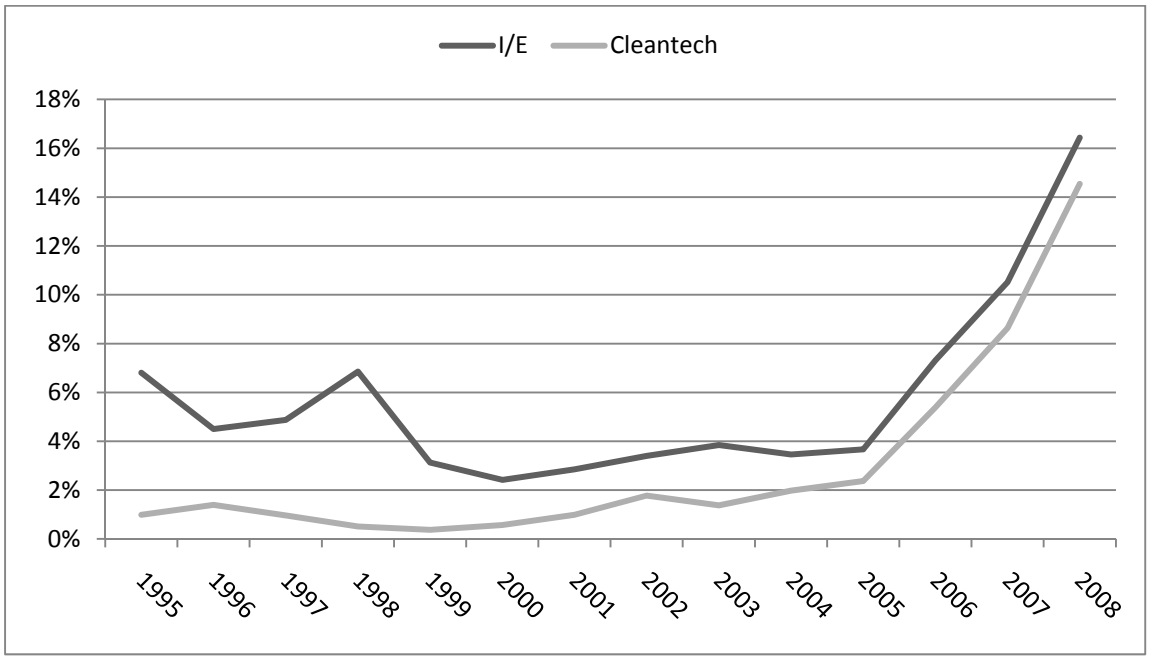


Figure 3. *Industrial/Energy* and *Cleantech* Investments as a Proportion of Total VC Investments, 1995-2008.

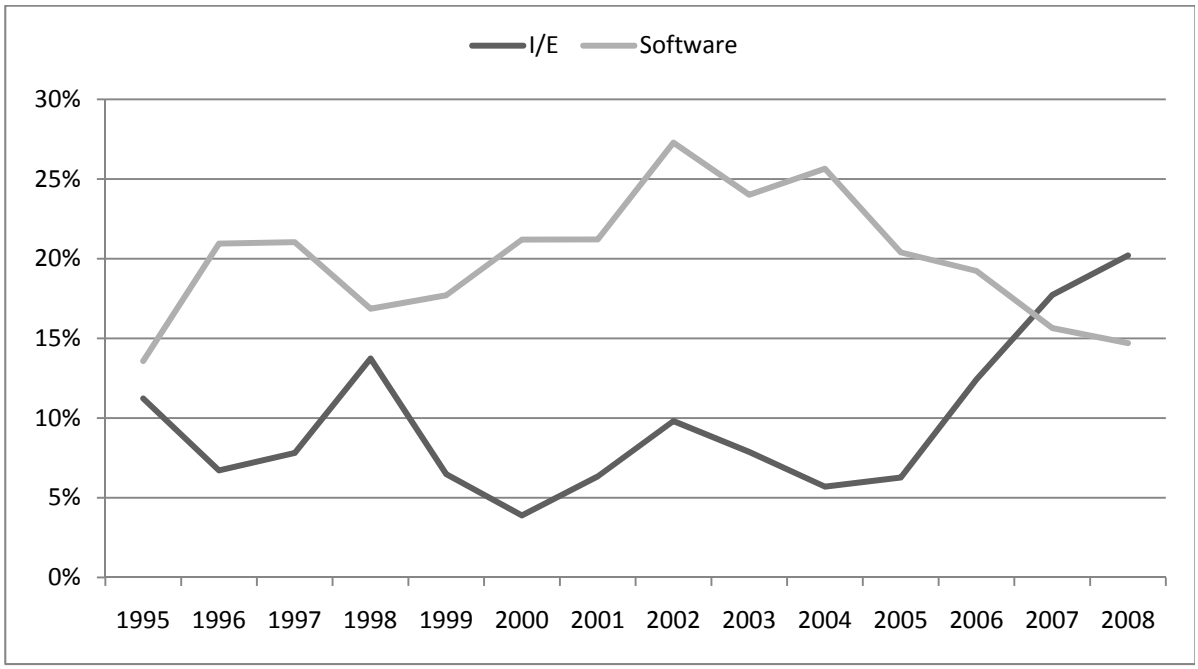


Figure 4. Proportion of First Sequence Investment in *Industrial/Energy* vs. *Software*

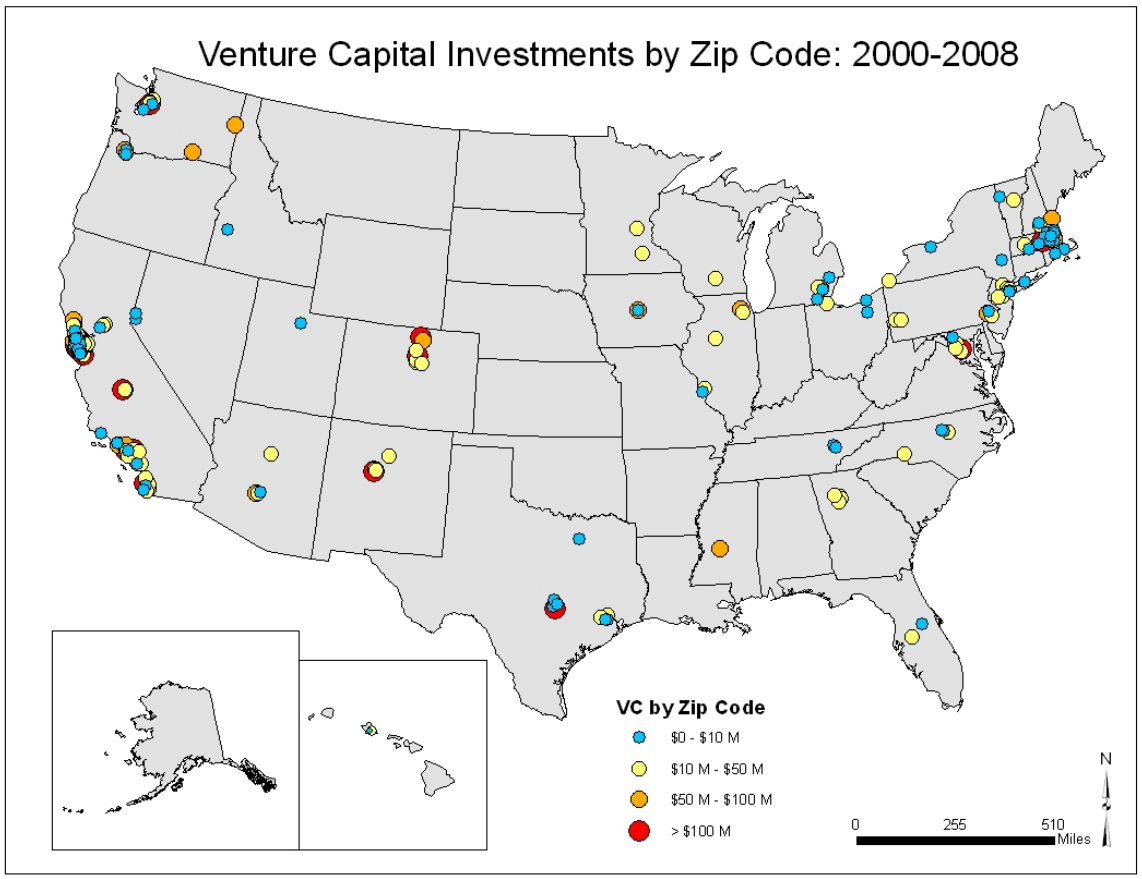


Figure 5. Combined VC Investments by Zip Code, 2000-2008

In terms of agglomeration effects, the clustering of cleantech firms in California should be even less surprising since 115 of the 270 cleantech VCFs are located in California (Figure 6). Furthermore, the high concentration of cleantech firms in Silicon Valley might also be partially explained by the proximity to the VCFs that have made Sand Hill Road such a famous concentration of VC activity; the data show that of the 115 VCF, 48 are in either Menlo Park or Palo Alto. New York (31) and Massachusetts (30), rank second and third respectively as states which are home to the VCF that have made the most cleantech investments. This study ignores the international component of syndications, of which 54 cleantech companies received money from an foreign-based VC. While much has been made of capital's footloose characteristics, 22 states have sourced no VC, with most of the funds originating in three logical locations of New York, Boston, and the Bay Area.

The relationship between the investment and their VCF confirms some of the key findings of the literature on VC geography (Gompers and Lerner 2004). The average distance between the portfolio company and the VCF, as calculated from zip-code centroids, was 570 miles. But this figure is misleading, as a handful of cleantech

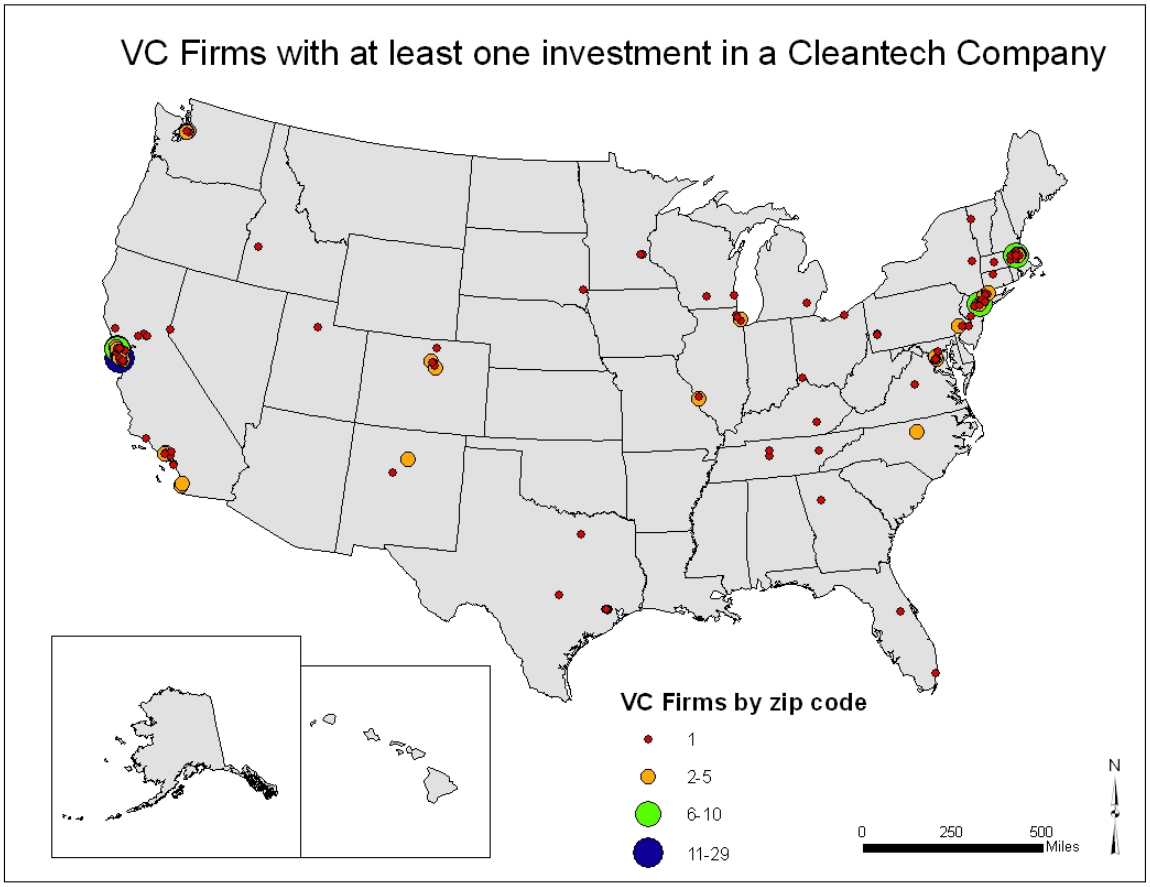


Figure 6. Location of VC Firms with at Least One Cleantech Investment

firms secured financing from VCF across the country; the median distance between VCF and its cleantech investment as measured by the closest VCF involved in the syndication (though perhaps not the lead VCF) was only 69 miles, dominated by a concentration in northern California (see Table 4).

VC Investments in cleantech have been most robust over the last three years of this study period, and with improved product viability companies were able to secure additional working capital. From 2006-2008, the average size of follow-on investment rounds was larger than preceding rounds (Figure 7). And while the capital commitments increased as companies showed more promise, fewer companies were able to secure additional funding. An average of 61 series A deals were done each year, 36 series B deals, 17 series C deals and 7 series D deals, thus confirming that VCFs like to place a lot of bets early on, and that overtime better companies and technology survive and are able to command additional VC attention and resources. Later rounds were also securing larger piles of money; for the entire study period, the 225 Series A rounds averaged $12.7 million while the 22 Series D rounds averaged $53.3 million.

Table 4. Median Distance Between VCF and Cleantech Firm, by Technology

Sector	Cleantech Firm Count	Median Distance (Miles)
Lighting	15	15
Solar	61	20
Biofuels	37	36
Water	11	60
Storage	40	66
Software	22	71
Buildings	15	86
Transport	10	228
Recycling	7	370
Wind	13	395
Other	35	410
Geothermal	5	430
Average		**69**

In an effort to determine the technology with the greatest promise in the eyes of the VC community, this study created several different categories. To obtain a better gauge of the more viable technology choices by VCF, this study identified 31 specific technologies, subsequently consolidated into 12 broader categories. For example, investments in wind, materials-wind, high-altitude wind, and micro-wind were consolidated into one category – wind. Through 2008, the breakdown of these various technologies reveals how solar, as measured by VC activity, received the most money (Figure 8). Of the 496 total investments, 19 individual deals of $100 million or more were placed into cleantech firms, and 10 were solar companies; and within those ten, six were thin-film firms and four were concentrating solar power companies. These data reaffirm the void of any large-scale publicly traded company dominating the solar space – unlike the more established industries where clear industry leaders that have emerged such as wind (Vestas, GE, and Gamesa) or ethanol (Pacific Ethanol, Green Plains Renewable). While there are a variety of publicly traded solar manufacturers, a market leadership role is still very much up for grabs. And yet, there is room for other solar companies to enter the market, given the competition among residential solar companies, or for that matter, the untested utility-scale solar thermal technologies, where only a few pilot projects are in demonstration mode.

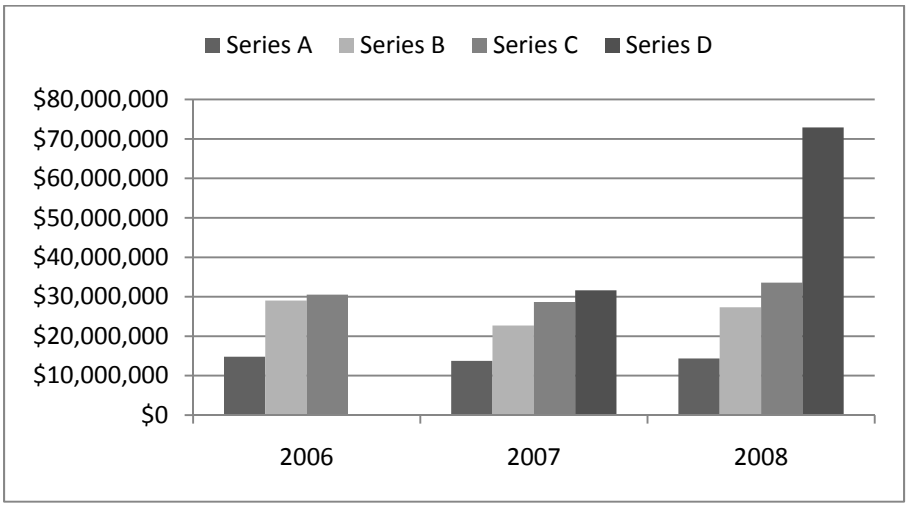
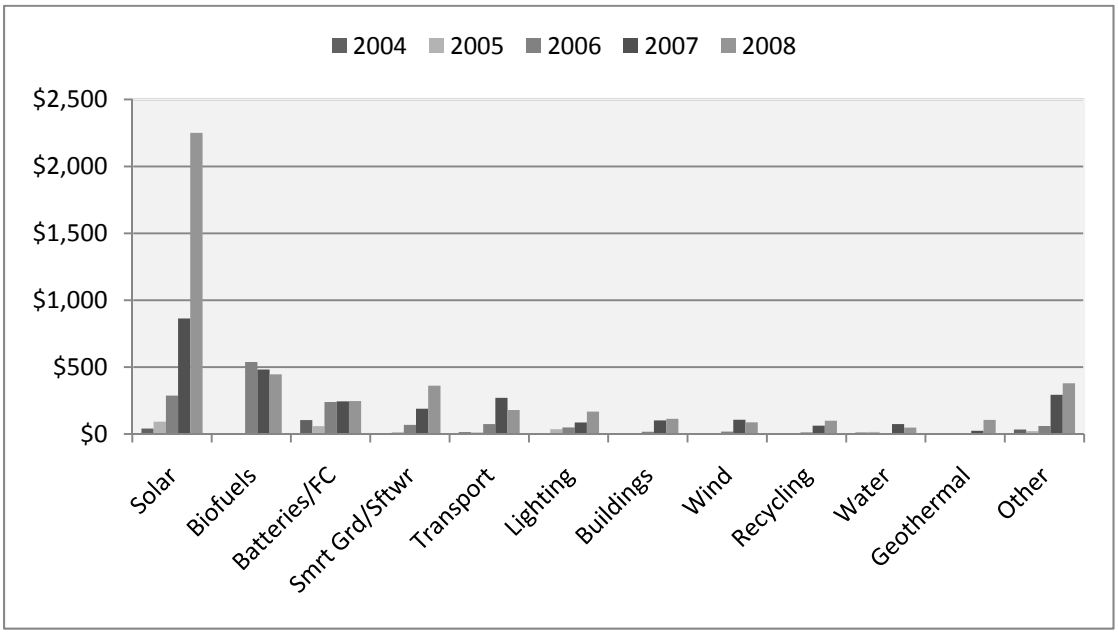


Figure 7. Average Deal Size by Investment Round



$ in millions

Figure 8. Technology Investments by VCF, 2004-2008

The location of firms engaged in solar mirrors the overall comprehensive VC funded cleantech map (Figure 9). As expected, many of the companies are located in northern California, but four very promising companies, with sizeable VC backing have emerged elsewhere; Austin, TX (Heliovolt); Ft. Collins, CO (AVA Solar), Albuquerque, NM (Advent Solar); and Lowell, MA (Konarka). Two of these firms have their origins in

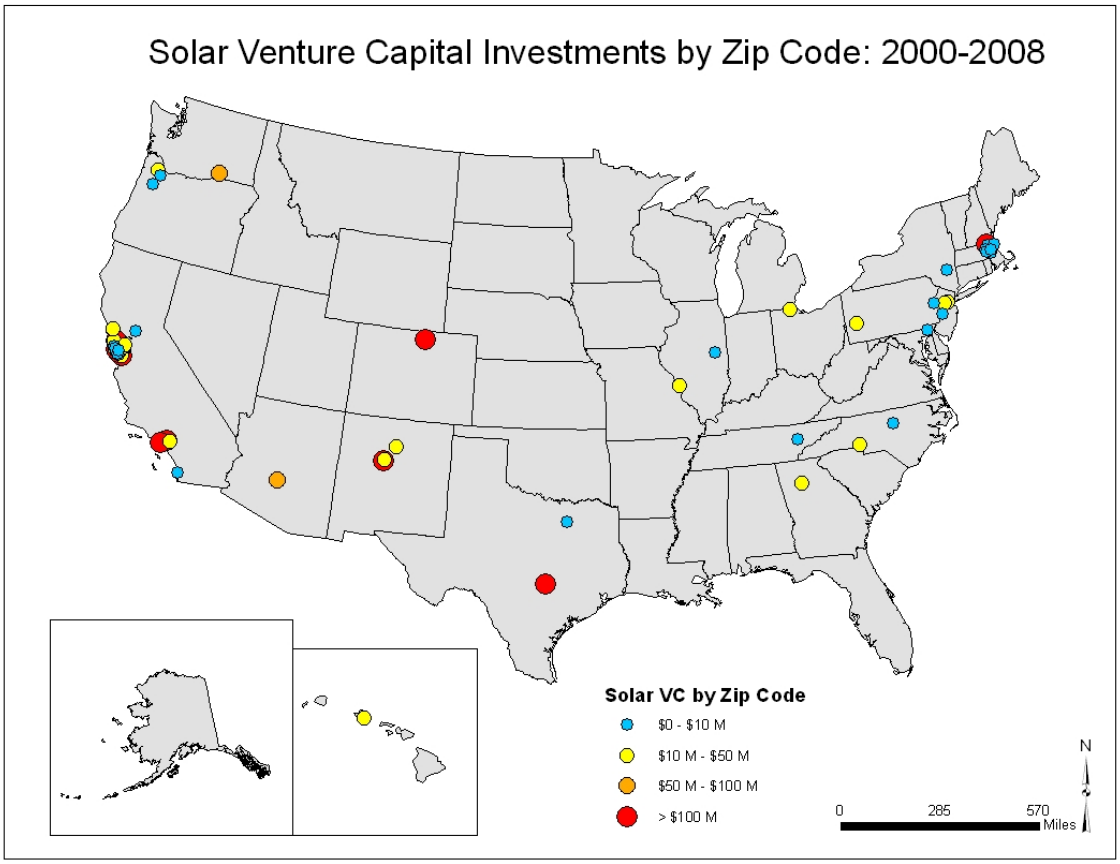


Figure 9. VC Investments in Solar Technology by Zip Code

University research labs (Colorado State and University of Massachusetts, Lowell) and a third was spun out of Sandia National Lab. In fact, 18% of the cleantech firms in this study have their roots in some local University or national laboratory partnership, led by MIT (11 firms), University of Texas (3 firms), and Los Alamos National Laboratory (3 firms).

DISCUSSION AND CONCLUSION

Although energy is only one component of cleantech, the 2006-2008 acceleration in cleantech VC coincided with George W. Bush declaring that 'America is addicted to oil'. Oil peaked at $147 per barrel in July of 2008 and fell sharply the following year. So did cleantech investments. We have been here before, most recently with the OPEC oil embargo; when the embargo ended, cheap oil undercut any momentum that had taken hold in the renewables sector. There are similarities and difference between today and the 1970/1980s. Overall VC activity for 2009 had significant contraction, with IE investments shrinking by more than 50% year-over-year. And yet, the largest VC investment in 2009 was $285 million for

Solyndra, a solar manufacturer. The third largest placement was a $105 million in Silver Springs Networks which designs smart-gird software (NVCA 2010). Cleantech's medium-term industry dynamics are less correlated to the price of oil and more tied to the fate of the economy, the capital markets and political landscape.

In addition to the threat of gyrating fossil fuel prices, cleantech will also suffer if the recession persists. During periods of economic dislocation, public support erodes for what remains a more expensive technology option. Successful exits are crucial, and if the climate for cleantech IPOs is indefinitely delayed because there is no market acceptance, VCF will hesitate to invest further in the sector. Cleantech faces a third, unique hurdle that has not obstructed other techno-economic paradigms like mobile communications or air transportation. For previous shifts, we were willing to pay for new technologies that improved our lives and enhanced productivity. With cleantech, its benefits are more abstract; we already have reliable water and uninterrupted power, so there are no tangible improvements in our lives. The cleantech community has to overcome the additional challenge of convincing people to pay more, in the short-run, for something they currently take for granted.

VCF may well play a part in attempting to sway public opinion, but there is also a chance that VC will be less useful in cleantech even in the near-term. Typically, the relationship between VC and any new industry wanes once the companies and technologies mature and the growth prospects plateau. Although the cleantech product life cycle is still young, there are three potentially disruptive events that could interrupt that traditional progression and sever the relationship between VC and cleantech. The first would be the passage of a federal cap-and-trade law. Backed by federal mandates or renewable portfolio standards, a host of new money would find the investment profile for a majority of the cleantech segment companies a lot more palatable. Many of these entrepreneurs may be able securitize their companies through traditionally conservative banking institutions, forcing VCF into unfamiliar competition.

There is also the potential for the in-house venture subsidiaries at large firms like Siemens, Applied Materials, First Solar, SunTech Power, Mitsubishi, BP, or any number of utilities that could undercut the portfolio of VC investments. These multinationals have made substantial commitments to cleantech and possess sizable R&D budgets will be able to support and scale new technologies more effectively than the smaller venture back firms. Finally, the great recession/recovery remains fragile, and several external events could cause an economic shock that dries up funding and prevents these technologies from reaching commercialization.

Should the status quo persist in the political and economic sphere however, financing for this high-risk / high-reward sector will likely remain dominated by more aggressive VCF. This study provides evidence of a symbiosis between cleantech firms and the VCF that finance them, a well documented phenomenon in economic geography. A majority of VCFs remain concentrated in California and the Northeast, and so do the companies they fund. But a growing number of

investments are being made in more distance locations as the map of cleantech investments show activity in the South and Midwest, cities or regions with few if any VCF to support them. VCF are willing to invest in distant places, especially as university and national lab partnerships continue to produce technological breakthroughs.

If there is an asset bubble and it bursts, similar to the internet industry, cleantech might consolidate in the hands of a few key players before diffusing again on more solid financial footing, at which point VC money returns to incubate cleantech 2.0. However, if there is no bubble, but rather these investments mark the early stages of creative destruction in energy/materials, many of these early industry leaders will capture new markets and the VCFs that supported them will be financially rewarded. Either way, cleantech and VC seem destined to collectively thrive or falter. For cleantech to achieve market acceptance, it must move down the cost curve, so the virtues of capitalism and VC will remain crucial to ushering in the technologies needed for a carbon conscious world.

References

Bottazzi, L., Da Rin, M., and Hellmann, T. 2008. Who are the active investors? Evidence from venture capital. *Journal of Financial Economics*. 89 (3) 488-215.

Brander, J., Amit, R., and Antweiler, W. 2002. Venture Capital syndication: improved venture selection vs. The value-added hypothesis. *Journal of Economics and Management Strategy*. 11 (3) 423-452.

Byrne, J., Hughes, K., Rickerson, W., and Kurdgelashvili, L. 2007. American policy conflict in the greenhouse: divergent trends in federal, regional, state, and local green energy and climate policy. *Energy Policy*. 35 (9) 4555-4573.

Casamatta, C. 2003. Financing and advising: optimal financial contracts with venture capitalists. *Journal of Finance.* 58 (5) 2059-2085

Cornelius, B. 2005. The institutionalization of Venture Capital. *Technovation*. 25 (6) 599-608.

Davis, C., 2003. Venture capital in Canada: a maturing industry, with distinctive features and new challenges. In Çetindamar, D. (Ed.), The Growth of Venture Capital: A Cross-Cultural Comparison. Quorum Books. Greenwich, CT, pp. 175–206.

de Bettignies, J.E., and Bander, J.A. 2007. Financing entrepreneurship: bank finance vs. venture capital. *Journal of Business Venturing*. 22 (6) 808-832.

Dizzard, J.W., 1982. Do we have too many venture capitalists? *Fortune*. October 4, 106–119.

Dorflinger, T. and Rivkin, J. 1987. Risk and reward: venture capital and the making of America's great industries. New York. Random House.

Florida, R.L. and Kenney, M. 1988. Venture capital, high technology, and regional development. *Regional Studies*. 221 (1) 33-48.

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

Fritsch, M. and Schilder, D. 2008. Does venture capital investment really require spatial proximity? An empirical investigation. *Environment and Planning A.* 40 (9) 2114–2131.

Global Insight. 2007. Venture Impact; The economic importance of venture capital backed companies to the US economy. Online at: http://www.nvca.org/pdf/NVCA_VentureCapital07-2nd.pdf. (Last accessed on March 31).

Gertner, J. 2008. Capitalism to the Rescue. *New York Times Magazine*. October 8.

Gielecki, M., Mayes, F., Prete, L., 2001. Renewable Energy 2000: Issues and Trends, Energy Information Administration, DOE/EIA-0628 (2000), February 2001.

Gompers, P. 1994. The rise and fall of venture capital. Newcomen Prize Essay. University of Chicago, Graduate School of Business.

Gompers, P. and Lerner, J. 2000. Money chasing deals? The impact of fund inflows on private equity valuations. *Journal of Financial Economics*. 55 (1) 281-325.

_____. 2001. The venture capital revolution. *Journal of Economic Perspectives*. 15 (2) 145-168.

_____. 2004. *The Venture Capital Cycle. Second Edition*. Cambridge, MA: MIT Press.

Griffith, T., Yam, P. J., Subramaniam, S. (2007) Silicon valley's 'one-hour' distance rule and managing return on location. *Venture Capital.* 9 (2) 85-106.

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

Inderst, R. and Mueller, H.M. 2009. Early stage financing and firm growth in new industries. *Journal of Financial Economics*. 93 (2) 276-291

Kaplan, S.N. and Stromberg, P. 2004. Characteristics, contracts, and actions: evidence from venture capital analyses. *Journal of Finance*. 59 (5) 2177-2210

Kenney, M. 1986. Biotechnology: *The University-Industrial Complex.* Boston; Yale University Press.

Laird, F. N. and Stefes, C. 2009. The diverging paths of German and the United States policies for renewable energy: sources of difference. *Energy Policy.* 37 (7) 2619-2629

Lerner, J. 1994. The syndication of venture capital investments. *Financial Management.* 23 (3) 16-27.

Lerner, J. 1995. Venture Capitalists and the oversight of private firms. *The Journal of Finance.* 50 (1) 301-318.

Lungren, D. 1984. *Foreword, Venture Capital and Innovation.* A study prepared for the use of the Joint Economic Committee. Congress of the US 98th Congress, 2nd Session, S. Prt 98-288. 28 December. US GPO, Washington DC.

Manigart, S., Lockett, A., Meuleman, M., Wright, M., Lanstrom, H., Bruining, H., Desbrieres, P. and Hommel, U. 2006. Venture capitalists' decision to syndicate. *Entrepreneurship Theory and Practice.* 30 (2) 131 – 153.

Martin, R. 1999. The new economic geography of money. In R. Martin (ed).

Money and the Space Economy. New York. John Wiley.

Martin, R., Berndt, C., Klagge, B. and Sunley, P. 2005. Spatial proximity effects and regional equity gaps in the venture capital market: evidence from Germany and the United Kingdom. *Environment and Planning A.* 37 (7) 1207 – 1231.

Mason, C. and Harrison, R. T. 2003. Closing the regional equity gap? A critique of the Department of Trade and Industry's regional venture capital funds initiative. *Regional Studies*, 37 (8) 855–868.

Menz, F.C. 2005. Green electricity policies in the United States: case study. Energy Policy. 33 (18) 2398-2410

NVCA 2009. National Venture Capital Association. Online at: http://www.nvca.org/. (Last accessed on February 15).

NVCA 2010. National Venture Capital Association. Online at: http://www.nvca.org/index.php?option=com_content&view=article&id=78&Itemid=102 (Last accessed on January 4)

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

PricewaterhouseCoopers. 2008a. MoneyTree™ Report Definitions and Methodology https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=definitions (Last accessed on January 4)

Rosenberg, N.C. 1972. Technology and American Economic Growth. New York: Harper & Row.

Sahlman, W. and Stevenson, H. 1987. Capital Market Myopia. *Journal of Business Venturing*. 1 (1) 7-30.

Saxenian, A. 1996. Regional advantage: Culture and competition in Silicon Valley and route 128. Boston: Harvard University Press.

Sorenson, O. and Stuart, T.E. 2001. Syndication networks and spatial distribution of venture capital investments. *American Journal of Sociology*. 106 (6) 1546-1588.

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

Von Burg, U. and Kenny, M. 2000. Venture capital and the birth of the local area networking industry. *Research Policy.* 29 (9) 1135-1155

Wray, F. 2011. Rethinking the venture capital industry: relational geographies and impacts of venture capitalists in two UK regions. *Journal of Economic Geography*. 2011: 1-23.

Zider, B. 1998. How Venture Capital works. Harvard Business Review.76 (6) 131- 139

Zook, M.A. 2002. Ground Capital: Venture financing and the geography of the internet industry, 1994-2000. *Journal of Economic Geography*. 2 (2) 151-177.

Zook, M. A. 2004. The knowledge brokers: venture capitalists, tacit knowledge and regional development, *International Journal of Urban and Regional Research.* 28 (3) 621 – 641.

Zucker, S., Deutsch, C., Hoerr, J., Jonas, N., Pearson, J., and Cooper, J. 1982. The reindustrialization of America. New York. McGraw Hill.