

The Entrepreneurial Event Revisited: Firm Formation in a Regional Context

Maryann P. Feldman
Johns Hopkins University
136 New Engineering Building
3400 N. Charles Street
Baltimore, MD 21217
410 516 8324
maryann.feldman@jhu.edu

Abstract: This paper outlines the development of an entrepreneurial culture in the U.S. Capitol region and the formation of a regional industrial cluster. The conditions that the literature associates with entrepreneurship lag rather than lead the development of the cluster. Supportive social capital, venture capital and entrepreneurial support services as well as actively engaged research universities are conditions that reflect the successful establishment of an entrepreneurial culture, built by the actions of pioneering entrepreneurs who often adapted to constructive crisis.

(NOTE: Should be U.S. and National Capital Area/Region)

Keyword: entrepreneurship; biotechnology; ICT, social capital, venture capital, research universities

Prepared for the international conference on *Regional Economic Development: New Interpretative Paradigms and New Policy Instruments*, sponsored by LIUC University
The author wishes to acknowledge comments and suggestions from the anonymous referees and the editors as well as Johanna Francis, Diana Hicks, Ed Malecki, Franco Malerbo, Joshua Schaff, Roger Stough, Kingsley Haynes, Gunner Elliason, Pierre Desrochers and participants at a research seminar at George Mason University. This paper is indebted to the individuals who agreed to interviews and generously shared their time and expertise in identifying salient issues as well as providing and validating information. Special thanks to Bob Starzynski, former editor of TECHCapital and Thomas Kusner, formerly of Venture Economics for sharing data and information.

The Entrepreneurial Event Revisited: Firm Formation in a Regional Context

I. Introduction

Entrepreneurship and new firm formation is central to current thinking about economic growth, especially at the regional level and specifically in the formation of regional clusters of industrial innovation. Startup firms are the embodiment of innovation, especially for radical new technologies that are not easily absorbed into existing firms (Audretsch 1995). New industries such as semiconductors, microcomputers, biotechnology, and Information and Communications Technologies (ICT) have largely developed in geographically defined clusters and although this phenomenon is certainly not new, places with such colorful names as Silicon Valley, Medical Alley, or Research Triangle have captured the public imagination as the vehicle for industrial change and economic development. A focal point for development policy is creating attributes that mimic the characteristics of successful locations. Typically, government policy aims to leverage the presence of local research universities, increase the availability of venture capital, encourage a culture of risk taking and create strong local informational and business development networks.

Once established, industrial clusters benefit from virtuous, self-reinforcing processes. A critical question is how these entrepreneurial processes begin, take hold and transform a regional economy. Conditions that we observe in defined clusters tell us how these systems function and the policy prescriptions that follow from studying these environments may not be appropriate for regions that are trying to develop an entrepreneurial environment¹. Dubini (1989) characterized environment for entrepreneurship as either munificent or sparse. An important concern is how environments lacking an entrepreneurial tradition change and become munificent. Conventional wisdom about the factors that promote entrepreneurship is drawn from analysis of

munificent environments. Rather than viewed as causal factors, strong local networks, active research universities and abundant venture capital may be attributes of successful entrepreneurship in established clusters.

The genesis or initial formation of firms, the building of institutions and social relationships appears to be a distinct phenomenon. Teubal and Andersen (2000) argue for an appreciation of stages of regional development and propose evolutionary models that incorporate the rich context, diversity of experience, and uniqueness of regional systems. Increasingly, the actions of individuals as agents of change are not included in our examination of regional economies (see Appold 2000 for a review). This is at odds with our understanding of the importance of economic agents (Kay 2000), the co-evolution of technology and institutions (Nelson 1994) and way in which entrepreneurs actively interact with their local environments (Saxenian 1994).

This paper examines what Shapero (1984) described as the entrepreneurship event -- the decision to engage in the formation of a company and considers the ways in which this decision may be influenced by the regional context. This paper focuses on the transformation of one local environment that was able to develop an entrepreneurial culture and subsequent industrial clusters where no recognizable climate of entrepreneurship existed before. The specific case considered here is the development of the U.S. Capitol region², recognized as a birthplace of the Internet and as a prominent center for biotechnology and telecommunications. By any number of measures, this region previously lacked the attributes that the conventional wisdom associates with an entrepreneurial environment. We focus on the evolution of the region and specifically on the phase transition from an environment characterized as sparse to one that would now be characterized as munificent. By considering the early entrepreneurial efforts through which

biotechnology and ITC took root in the region, the approach taken is “appreciative history-friendly theorizing” (Malerba et al. 1999; Teubal and Andersen 2000). The emphasis incorporates a role for individual entrepreneurs as agents of change who make decisions to start companies, shape local environments and institutions and develop the resources and relationships that further their interests. It is argued in this paper that viewing entrepreneurs as agents of change is critical to understanding not only the entrepreneurship event but also the creation of a positive local environment. The findings suggest that many of the conditions the literature indicates should be in place to promote entrepreneurship appear to lag rather than lead its development and thus question our understanding of the dynamics of regional change and the implied policy prescriptions.

The next section of the paper considers the characteristics of entrepreneurial ‘hot-beds’ highlighted in the literature, and then examines whether these factors existed in the Capitol Region before early entrepreneurial activity in biotechnology or ICT. Section 3 provides an interpretive history of the genesis of entrepreneurship in the Capitol Region. Section 4 reconsiders the supportive factors the literature suggests promote entrepreneurship and argues that these factors not only followed the initial success but that they were also built by the efforts of entrepreneurs. Section 5 concludes with an examination of the conditions that may be associated with the acceleration of entrepreneurship. The intention is to provide prescriptive information for those regions that are trying to spark entrepreneurship and an economic transition.

II. Entrepreneurial Environments

Entrepreneurship has emerged as an important topic in economic development. Defined as the act of organizing resources to initiate commercial activity, entrepreneurship has been

studied extensively from a variety of perspectives (See Bhide 1999). One of the most notable features of entrepreneurship is its propensity to cluster spatially. Alfred Marshall (1890) noted this tendency and described the contextual factors associated with it (see Feldman 2000). More recently, Michael Porter's (1990) diamond of interrelated localized competition, demanding customers, linked supporting industries and supportive government policy provides a set of factors that improve the functioning of firms. Porter (1990: 655-6) perceives a strong role for government in providing a context for cluster development, however he does not address the topic of how policy might influence entrepreneurship or the practical question of how to promote entrepreneurship. Others in the literature have addressed this question and a conventional wisdom has developed. For example, Florida and Kenny (1988) describe a social structure of innovation that promotes the formation of new firms. Others like Bahrami and Evans (1995) describe the rich entrepreneurial environment of Silicon Valley as an ecosystem of institutions, venture capital, social capital and entrepreneurial spirit that reduces the difficulty of starting a new firm. These factors form a conventional wisdom in the popular press and public discourse.³

Table 1: Characteristics of Entrepreneurial Places

<i>Environmental Characteristic:</i>	<i>Representative Authors</i>
Availability of venture capital	Bruno and Tyebjee (1982); Florida and Kenney (1988); Sapienza (1992);
Supportive social capital	Abetti (1992); Barse (1981); Flora and Flora (1993); Roberts (1992)
Entrepreneurial expertise/support services	Bruno and Tyebjee (1982); Malecki (1990).
Research universities as growth engines	OTA (1984); Raymond (1996)

Table 1 provides a summary of environmental characteristics the conventional wisdom typically associates with locations strong in entrepreneurial initiative and some of the work highlighting these conditions⁴. Each of these characteristics will be examined in turn and in particular, will be related to the Capitol region in the formative years circa 1970. Studies of the development of technology clusters typically find that there is a long time lag between early business initiatives and the realization of commercial success (Link 1995, Trajtenberg 2000). The choice of the year 1970 as a baseline is admittedly somewhat arbitrary. It is selected due to data availability as well as to have a sufficiently long time line of events in order to observe how the region has changed. However, it is not completely arbitrary, as we will see below in the discussion of what particular events contributed to the explosion of biotechnology and IT in the region. . The objective of the next section is to provide a broad overview of the initial conditions characterizing the region in the early 1970's and then to move through the successful changes and developments as the biotechnology and IT sectors began to emerge.

Venture Capital

“Venture capital appears in virtually every inventory of necessary conditions for entrepreneurship” (Malecki 1997a: 174). In addition to providing funding, venture capital also provides management expertise for companies that have the potential to develop into significant economic entities but whose creators may have little initial commercial experience. Venture capital is also considered an important indicator of the innovative potential of a regional economy. Considerable state and local public policy initiatives have been directed towards developing public venture capital programs or towards attracting private venture capital to regions.

The measurement of venture capital typically considers the number of equity deals completed in a region in a given year and the amounts of equity involved. By this measure, in 1971 there were three investments in the Capitol Region for a total of \$1.5 million. Of course, in 1971, the venture capital industry in the US was in its infancy with 68 equity deals for approximately \$50 million nationally. The Capitol Region accounted for four percent of the deals and three percent of the capital invested.

Another indicator of the venture capital industry is the number of venture capital firms located or headquartered in a location. In 1976, Bill Gust was recruited from Silicon Valley to the Capitol region to run a venture fund for the Bonaventure family. This appears to be the first venture capital firm in the region. Gust notes that there was little activity to invest in locally and the initial investments that he made were in Silicon Valley or along Massachusetts' Route 128 where there was more promising activity. Thus, we can, anecdotally and by venture capital comparisons, that the Capitol region had little activity in the early 1970's and thus it cannot have been part of the initial environment.

Supportive Social Capital

When Marshall (1890) wrote that the "secrets of the industry are in the air" he was most likely referring to the intangible non-pecuniary factors that facilitate information sharing and the flow of ideas. Accommodating social capital, the aligned characteristics of thick local networks and a supportive local culture is central to our conceptualization of conditions that promote local cluster development (see Ashiem 2000 for a review). These factors are part of the success story of the Italian industrial districts and clusters of technology intensive regions in the U.S. (Lazerson and Lorenzoni 1999). For example, Roberts (1991), in writing about Route 128, emphasizes social and institutional support for entrepreneurship and the existence of a culture

that promotes risk-taking and creativity. Saxenien (1994) highlights the adaptive nature of supportive social capital in Silicon Valley that facilitated entrepreneurial activity and firm formation.

Social capital as a qualitative indicator of local networks and connectedness is difficult to quantify. We may, however, rely on quotes from individuals who were in a position to assess the depth of social capital in the region or to analyze proxy measures such as the composition of the local employment base, or evidence of collective or government action aimed at supporting or promoting entrepreneurship. These proxy measures combined with individual actor's assessments reveal that the Capitol Region did not have social capital that was supportive of entrepreneurship circa 1970.

In large part, the economy of the Washington region owes its existence to the U.S. federal government and correspondingly, the region has largely been dominated by government employment. In 1970, two-thirds of the local economy was dependent either directly or indirectly on federal expenditures and half the workforce was employed in the government sector (Stough 1999). The region benefited from a strong presence of federal labs and agencies such as the National Institutes of Health (NIH), the United States Food and Drug Administration (FDA), the Agricultural Research Service, the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the Department of Defense, including the Pentagon and the Defense Advanced Research Projects Agency (DARPA)⁵.

Federal employment is typically stable and offers job security and benefits that would not be expected to promote a social culture supportive of entrepreneurship. Star scientists in the region were interested primarily in doing basic research that would bring academic rewards rather than commercial rewards (Desrochers and Feldman 2000). Attempts to start a business

were seen as selling out and betraying scientific integrity (Eaton *et al.* 1998). There was not much interest in the commercial application of the region's resources and the business community was noted to have little "understanding or appreciation of the power of technology for creating small companies on little capital"⁶.

There were many individuals with high levels of individual intellectual capital in the region and they most likely were part of social networks. The relevant question for an environment that promotes entrepreneurship would be the presence of local linkages between individuals that would advance industrial activity or promote commercial interests. One frequently cited example of the type of social capital that promotes entrepreneurship is the Home Brew Computer Club in the San Francisco Bay Area, which began as an informal forum for individuals from different educational, social and professional backgrounds to get together and discuss their common interest in personal computer technology in the early 1970s. The Home Brew Computer Club is cited as an important institution in the development of the personal computer industry (Segaller 1998). Although such organizations have formed more recently in the Capitol Region, interviews have not revealed that any social or special interest groups of this type existed during the formative phase of the industry.⁷

One proxy for social capital may be governmental activity or other types of collective action to promote or encourage entrepreneurship such as interest or advocacy groups or technology councils. One structural limitation in the Capitol region is a jurisdictional problem as the region covers three states, Virginia, West Virginia and Maryland, and the federal District of Columbia. The fact that the region spans two states and the federal District gives it a special nature particularly because each state is constitutionally responsible for the welfare and education of its constituents (Stough 2000, p. 10) and by extension economic development. This

makes it difficult to coordinate government action across the jurisdictions even though they compose one region in terms of a unified labor market with strong interrelationships. Indeed, the two states of Maryland and Virginia are well known as competitors rather than collaborators and have been known to engage in bidding companies away from one another rather than promoting a regional agenda (Anderson 1996). Following a national trend, both states actively began promoting entrepreneurship in the mid-1980s, the midpoint of the period examined in this paper. Nevertheless, before this time, the support for entrepreneurship was small and re-enforcing social capital largely did not exist. The combination of secure federal jobs, star scientists' disdain for commercial activity, and weak government and social support for new business ventures created an environment which, if not outright hostile, did little to promote entrepreneurship or foster an entrepreneurial spirit until the mid-1980's when we began to see a change.

Entrepreneurial Support Services

Entrepreneurial expertise or support services provide resources to navigate starting a company with information about issues such as intellectual property, business formation and legal requirements as well as routine accounting and business compliance issues. Indeed, small firms are typically not able to engage these resources in-house. Access from their local external environment may augment small firm's internal capabilities.

In the 1970s and 1980s, Washington, D.C. certainly had a large concentration of lawyers but their expertise was not in corporate law or focused areas such as patent law that would facilitate new high technology business. Business support services may be represented by the presence of large corporations who are their major clients (Malecki 1990). Yet in 1970, there were only three Fortune 500 companies headquartered in the Capitol region: Fairchild Hiller, a producer of defense aircraft (number 299); Black and Decker, a manufacturer of household tools

(number 395); and, EASCO, an aluminum producer (number 448). The lack of a group of executives and managers and the earlier absence of well-known business schools in the region has been documented previously (Feldman 1994).

Research Universities

Research universities figure prominently in descriptions of Route 128 and Silicon Valley, yet others have noted that not every research university has spawned technology-intensive economic development (Feller 1990, Feldman 1994). We observe that universities have different academic cultures and offer various incentives and rewards for entrepreneurial activity. While the Capitol region is home to several prominent research universities, such as Johns Hopkins University, the University of Maryland, Georgetown and George Washington, among others, none of them had taken a role in technology transfer in the 1970s. Most notably, Johns Hopkins University was the single largest recipient of federal R&D expenditures, even larger than MIT, which is credited with the genesis of Route 128 (Roberts 1991) or Stanford University credited with the development of Silicon Valley (Leslie and Kargon 1997). In contrast to these two well-known examples, Johns Hopkins did not have policies to encourage commercial activity and the academic culture was relatively hostile to academic entrepreneurship (Desrochers and Feldman 2000). In addition, the intellectual property that was developed at federal labs was not available for commercial use.

III. Entrepreneurship Comes to Washington: An Interpretive History

In the thirty intervening years the region has undergone what might be best conceptualized as a transition or phase change from an economy characterized by little entrepreneurial activity to a fully functioning entrepreneurial environment. The Capitol Region

has established technological leadership based on entrepreneurial activity in biotechnology and the Internet⁸ – two new industries that have seeded and established themselves in the past twenty years. In this section, each of these cases is considered in turn. First, we describe our study methodology and consider some methodological issues related to our approach.

Methodology and Methodological Issues

Our analysis is an interpretive summary based on interviews with entrepreneurs in biotechnology and ICT. An important component of the interviews have been gathering information on where entrepreneurs were employed prior to starting their own companies, what the motivation was for starting their own companies, what resources they used in developing their companies and technologies and the subsequent spin-off activity these entrepreneurs have generated⁹.

There are some methodological issues to mention. First, it is important to note that this is a retrospective study. We are limited by being able to identify firms that are in existence now or that were at one time prominent enough to leave a trace. While we are able to trace these firms back in time to their founding, we have no knowledge of similar firms that were started but may have failed or been acquired or merged into other firms prior to our study¹⁰. This approach does allow us to consider the roots of successful entrepreneurship and the ways in which entrepreneurial activity took hold, but it cannot address the failure of enterprises that died without leaving a record. While each of these companies has its own unique and compelling founding story, the objective is to discern trends and patterns.

The Employment Histories of Capitol Region Entrepreneurs

The Capitol region is generally recognized as the third largest concentration of biotech companies in the United States (Price Waterhouse Coopers, 1998). Leading companies in the region include Human Genome Sciences (HGS) and Celera Genomics Corporation, two key actors in the international effort to map the human genome. In addition, another local company, MedImmune, is currently the world's eighth largest dedicated biotech company with six FDA approved products on the market. In total, there are approximately 300 Small and Medium Sized (SME) biotech firms currently in the region as of 2001.

Table 2 provides an overview of the genesis of new firm startups in biotech in the Capitol region, with the name of the founding entrepreneurs and their prior place of employment. We chose the mid-1970s to be the date for the establishment of the industry as Stanley Cohen and Herbert Boyer invented their genetic engineering techniques in 1973. These techniques have given rise to the modern commercial biotech industry. The earliest entrepreneurs in the Capitol region started firms during this recognized time of high economic opportunity stemming from Cohen and Boyer's techniques when many of the prominent national firms such as Amgen and Genentech were formed. The entrepreneurs documented in Table 2 were previously employed at large firms. Unlike other regions, the pharmaceutical industry did not have any significant presence in the region, thus individuals previously employed at prominent suppliers to the National Institutes of Health (NIH) formed the earliest firms related to biotech. The presence of the NIH in the Capitol region is a defining characteristic as it is the U.S. agency with the mission to oversee health and medical research. It employs a large number of researchers at the agencies' home campus in Bethesda, Maryland. The NIH has proven to be a spawning ground for new company start-ups, especially in the last ten to fifteen years. Other government institutes

and agencies, such as the Walter Reed Army Institute for Research (WRAIR) and the U.S. Food and Drug Administration have also been a significant source of biotechnology entrepreneurs. Although recently the region's universities have spawned new companies, this did not occur at the earliest stages. From this chart we begin to see that while the initial entrepreneurs came from government institutions and large corporations, the new start-up firms became particularly fruitful in generating second, third and fourth generation start-ups.

The Information and Communications Technologies (ICT) industry also has a strong presence in the Capitol Region with a concentration in Northern Virginia. According to some sources, the region may be regarded as the birthplace of the Internet¹¹. Prominent companies in the region include MCI, AOL, NexTel, Teligent and Wintel. Over 400 SMEs located in the area are ICT firms¹². Companies in the region supply half of the total worldwide Internet backbone (Price Waterhouse Coopers 1998).

Table 3 provides a sampling of ICT startups in the region with the name of the founding entrepreneurs and their prior place of employment. The modern computer networking technologies that are the backbone of the Internet and ICT emerged in the early 1970s from the U.S. Department of Defense Advanced Research Projects Agency (variously called ARPA and DARPA) (see Kahn and Cerf 1999 for more detail). Individuals leaving the Department of Defense (DOD) and the military services formed the earliest start-ups. In addition, individuals from private industry both within the region and outside figure prominently. Area universities are notably absent from this list.

While biotech and ITC are very different industries, the objective here is to discern patterns in the origins of the companies and to explore the temporal development of entrepreneurial activity. Several notable patterns emerge. First, entrepreneurs hail from a

variety of different prior organizations. Government agencies served an important incubator function in both industries; however, they were not the sole source of entrepreneurial talent. There is evidence of great diversity in entrepreneur's backgrounds. Second, the earliest start-ups were service firms that were not originally involved in the types of R&D activities that generate new industries. Firms such as Bethesda Research Labs and AMS were not launched as product development firms although they have evolved in that direction over time. Thus, the industry had rather humble beginnings – not the type of start-up that would attract much attention from investors, the media or local economic development officials. Third, entrepreneurship picks up momentum. Over time, generations of new firms spun-off from the earliest start-ups and entrepreneurs who cashed in from one new venture created other new companies.

Between 1970 and 1990, the Capitol region was affected by a series of exogenous shocks to its employment structure. Some of these shocks were government policy initiatives, such as the downsizing of the federal government, the initiation of federal outsourcing, especially services that could be adapted to the commercial sector, and changes that allowed access to intellectual property in high opportunity sectors. In addition, the favorable treatment of small firms with regard to securing government contracts or financing provided a further impetus for firm formation.

Federal Downsizing and Outsourcing

From 1970 to 2000, the employment structure in the Capitol region changed precipitously. Beginning during the Carter administration there was a pronounced downsizing in federal employment that continued during the Reagan presidency. The reasons were a perceived general dissatisfaction with the large size of federal government and the efficiency of the private sector relative to the public sector. As a result, federal employment became less secure and

employment conditions and future prospects deteriorated. Most importantly, compensation levels for members of the senior service declined. During the 1980s, public sector pay scales lagged badly behind those of comparable executives in the private sector (National Commission on the Public Service 1990). Many of the affected individuals were victims of location inertia – they had strong personal ties to the region. In addition, other regions that offered alternative technology-intensive private sector employment had significantly higher housing costs, which also limited mobility. Individuals in the prime of their careers found entrepreneurship a viable employment option. The threshold for such risk-taking was lowered by the exogenous shocks mentioned earlier – when the federal “cushion” was not so comfortable, the incentive to leave government employment was higher.

An opportunity for entrepreneurship was provided simultaneously as federal jobs were downsized. The Civil Service Reform Act of 1978, which defined limits on the size of the federal workforce, contained an initiative to outsource the production of goods and services to the private sector. Thus, there was an incentive as well as a relatively low risk level for highly skilled individuals to leave federal employment and start firms to provide goods and services to their former employers. For example, the procurement of design services for personnel systems reconfigurations, redesign of government payment and distribution systems were awarded to contractors in the Capitol Region (Stough 2000). These contractual arrangements created a need for proximity to the federal government that favored local firms.

Federal procurement spending in the metropolitan Washington area grew by 114.3% from 1983 to 1997, creating enormous opportunities for private sector firms (see Table 4). Nationally, federal procurement spending increased by 3.1% during this time (Haynes, Fuller and Qiangsheng 1997: 149). Most importantly, the Reagan administration was responsible for a

pronounced defense buildup that was coupled with this outsourcing to the private sector. The so-called Star Wars or Strategic Defense Initiative (SDI) was materially different from other defense build-ups as it focused on the technical and software attributes of armaments systems such as electronics, design and systems management. Thus, SDI funded broad-based technical expertise rather than armaments production¹³. While this initiative stimulated economic growth throughout the United States, the National Capitol Region was one of the major beneficiaries (Stough, Campbell and Haynes 1997).

For example, the earliest ITC entrepreneurs were systems integrators who provided a customized set of arrangements of procured items such as computer components and software to create a functioning deliverable product. These firms began working as contractors on complex government computing services and telephone systems and moved to the forefront of Internet development, electronic commerce, and satellite communications and wireless telephony. The ARPANET was built and developed by DOD contractors who invented the technology as they built the system. When the federal government removed commercial restriction on the use of the Internet in 1989, two for-profit companies were spun-off from then non-profit Internet Service Providers (ISPs). UUNET was re-formed as a for-profit firm and PSINET was spun-off from NYSERNET¹⁴.

The Capitol region was affected by other exogenous changes that affected entrepreneurship. The changes in employment structure and incentives were coupled with new opportunities for the commercial exploitation of intellectual property rights that accrued from publicly funded research. These legislative changes created new commercial opportunities that have lured many scientists into starting their own companies. Most companies appear to have started with

personal funds rather than venture capital, a finding that is consistent with the literature (Bhide 1999; Blanchflower, D.G., A. Oswald, and A. Stutzer, 2000)

Federal Legislation That Favored Small Business Formation

Table 5 provides an overview of a series of U.S. policy initiatives that favored small business in general but especially technology-intensive start-ups. Considered together with the downsizing of the federal workforce, these initiatives provided a mechanism for new firm formation.

In 1980, in response to declining American competitiveness, a new era in the transfer of publicly funded intellectual property to industrial firms began with the passage of the Stevenson-Wydler Technology Innovation Act, and the Bayh-Dole University and Small Business Patent Act. These policies were based on a belief that private access to and ownership of public research would ensure that research results would be widely disseminated and have the largest effect on commercial development, and subsequent economic growth. The Stevenson-Wydler Act in 1980 facilitated the transfer of technologies that originated in federal labs. The large number of federal labs in the Capitol Region was thus allowed to license their innovations to private firms. This allowed employees of those labs, faced with potential downsizing, to license technology that could form the basis for a new firm. Similarly, the Bayh-Dole Act in 1980 allowed universities to retain ownership rights to intellectual property arising from federally funded research and license the right to use this property to private firms. This provided an incentive to promote commercial development of university research discoveries.

The Small Business Innovation Development Act of 1982 established the Small Business Innovation Research (SBIR) Program. Under this Act, all federal agencies with an annual R&D budget greater than \$100 million are required to set aside a percentage of R&D funds for small

business. Small business, according to the Act, was defined as a firm with less than 500 employees and less than \$2.5 million in annual sales. Thus, the act greatly increased the funding available to technologically oriented small business. Lerner (1996) estimates that the SBIR program has provided over \$6 billion to small high-technology firms between 1983 and 1995.

The 1986 Technology Transfer Act amended the Stevenson Wydler Act to authorize Cooperative Research and Development Agreements (CRADAs) between federal agencies and private firms and specifically gave a major boost to the Capitol region's technology community (Stough 1999). The Federal Technology Transfer Act allowed companies for the first time to form partnerships with government agencies. This new ability to form CRADAs resulted in the creation of an array of new firms, especially in the biotechnology sector. Enterprising scientists licensed technology out of their own university or government research labs to start new companies and chose to locate the new companies near their existing homes. In other cases, venture capitalists and executives in large companies recognized the commercial potential in research and either licensed the technology directly or formed a partnership with the scientist to jointly develop new products or services based on the technology. Although each Federal agency maintains its own records, it appears that the first CRADAs went to companies in the Capitol region. It would also seem that in order to maintain such a partnership, at least in the initial stages, firms would need to locate near their federal lab or government agency partners.

In conclusion, entrepreneurship in the region was a response to exogenous factors: underemployed skilled labor brought about by changes in federal employment policy coupled with new opportunities for the private sector to contract with the federal government and commercialize new technologies. The two cases considered here responded to different pressures. The advent of entrepreneurship was reactive and adaptive. While both sectors

benefited from great opportunity for commercial products, biotechnology was more influenced by CRADAs and opportunities for licensing and joint product development while ITC benefited more from outsourcing opportunities. In both cases, locational inertia kept the entrepreneurs in the area. Over time, the region has developed the supporting conditions that the literature associates with entrepreneurial environments. The next section considers the ways in which these factors developed.

IV. Supportive Conditions Follow

An evaluation of the Capitol Region now finds that the conditions the literature associates with a rich and thriving entrepreneurial environment are in place. There are professional associations that support entrepreneurial activity, a strong local venture capital industry with a net inflow of investments, and supportive universities. This section considers the development of these factors.

Available Venture Capital

By all indications, venture capital lagged rather than lead entrepreneurship in the Capitol Region. Figure 1 demonstrates the growth of venture capital in Virginia, Maryland and the District of Columbia. We observe that there was little venture capital investment in the Capitol Region in the early 1970s but that it has increased substantially over time. At the initial startup phase entrepreneurs started by pursuing commercial projects that did not require high levels of investment and were unlikely to generate the types of large profits that would interest venture capitalists. They started with government contracting, producing rather mundane bread and butter products, such as medical test kits and reagents for biotechnology or services such as computer system integrations and maintenance work in ICT. In addition, the growing number

of related firms in the region provided opportunities for subcontracting, work and asset sharing thus making it easier for the start-up firms to bootstrap and steadily grow without large doses of new capital.

Of course, over this period, the amount of funding for venture capital grew significantly at the national level. Figure 2 presents the percentage of national venture capital (VC) that was invested in Capitol region firms. For perspective, consider that the region was home to an average of 3.3% of the U.S. population during this time. There are periods of high intensity in the 1980s that represent deals in specific companies in biotech and ITC. It is noteworthy that since the early 1990s there has been an upward trend of VC investment in the region. Venture capital seeks opportunity and when there are potentially profitable investment opportunities venture capital in a region may then be attracted. The need of venture capitalists to monitor the new firms in which they invest makes close geographic proximity valuable (Gompers and Lerner 1999).

There are now approximately a dozen venture capital firms headquartered in the region and firms located elsewhere have opened branches. In March 1999, Silicon Valley Bank, which primarily provides debt financing, opened a branch office in Northern Virginia with the comment, “We are trying to be ahead of the curve. As far as new startups, this is a real hotbed” (Montgomery and Bacon 1999).¹⁵ Successful entrepreneurs have also reinvested in companies in the region. In 1986, a group of business leaders formed the Mid-Atlantic Venture Association (MAVA) to facilitate the flow of capital to entrepreneurs. Other venture capital funds and venture angel groups have also been formed by successful entrepreneurs and companies in the region have formed corporate venture funds.

Supportive Social Capital

Over time, individual start-up companies grew, went public or were bought out and the dynamics of the region changed as well. Most notably, local entrepreneurs who made large fortunes engaged in institution building to support their activities and to encourage further entrepreneurship. Also important was the emergence of networks of supportive social capital that began as membership or sponsorship organizations. These activities were primarily private sector initiatives, financed with private funds. These initiatives working with state and local government programs resulted in cross-fertilization and a common mission to promote the development of industry in the Capitol region.

Ceruzzi (2000) documents the development of a community of consulting firms in proximity to the U.S. Pentagon, around the newly opened Route I-495, the Washington Beltway. The earliest government contractors were labeled with the unflattering name of *Beltway Bandits*. The name was coined in the 1970s to reflect the location of the community of consulting firms around the Washington Beltway whose work proved lucrative. The firms formed a trade association, the Professional Services Council to address and defuse this type of criticism and promote their interests. Once established, the organization served as a focal point for common benefit. Ceruzzi reports that the term *Beltway Bandits* eventually became the name of a Fairfax country softball team, implying a sense of perverse pride in the term. The use of similar terms such as *Nerds and Geeks* provide definition to a social group or network. The term *Beltway Bandits* implies a unique local group.

A group of Virginia businesspeople organized a broad campaign to advocate state tax increases in order to address a noted shortage of technology workers and provide greater infrastructure funds (Baker 1995). This initiative attempted to build infrastructure to support the

development of local industry. Rather than seeking specific requests for their own business, the business leaders were promoting a broader, collectively responsible social agenda (Feldmann 1997). The group, called *Virginia First*, argued that the drop in per capita state spending in Virginia from twenty-second in the nation in the mid-1980s to forty-third in the mid-1990s was troublesome and would not provide sufficient resources for future economic growth.

Other private sector-driven initiatives have provided venues for interaction and information sharing. For example, the Indian CEO High Tech Council of Washington was formed as a social and networking organization. This organization, despite its name, links a membership of 950 high-level executives, the vast majority of whom are not Indian. This was a private sector effort to provide a venue where entrepreneurs could interact with their peers¹⁶. Another initiative is the Potomac KnowledgeWay Project with a mission to increase the region's awareness and understanding of the Internet. Specifically, "the Potomac KnowledgeWay was a not-for-profit leadership organization that acted as a catalyst, thought leader and idea incubator to help the Greater Washington region to be a global leader in advanced telecommunications, content, and Internet-related industries, and the new opportunities their convergence is creating in the region."¹⁷ Initiatives undertaken include the weekly *Netpreneur News*, which has a subscription of 7000 individuals¹⁸. In addition, state and local government formed technology councils such as Northern Virginia Technology Council (NVTC) and the Maryland High-Tech Council to promote networking and local industry interaction.

Older style quasi-public organizations such as the Washington Board of Trade and the Greater Baltimore Committee have broadened their agendas and spun-off new organizations directed at technology intensive industry. Other government-financed programs found greater success by collaborating with the privately organized networks (Guidera 1996).

Legislative programs also followed and addressed the needs of industry. For example, in 2001, the state of Maryland passed twelve legislative acts focusing on providing a supportive environment for technology-based economic development. These cover the full gamut of infrastructure development, training programs and tax incentives.

Entrepreneurial Expertise and Support Systems

The literature has emphasized the importance of support services. While it is true that agglomeration economies broadly conceived often play a crucial role for the startup firms, the emergence of the Capitol Region as a dynamic private-sector economy demonstrates that entrepreneurs adapt and assemble what they need as they build their ventures. Rather than talk about specific support services the emergence of systems to support entrepreneurship was spontaneous and followed the region's success.

Entrepreneurs have also mentored the development of industry. Several entrepreneurs sold their companies and then started private incubators to nurture other companies. These founders were motivated to share their expertise and to build the region – “to give something back,” as one said. In addition, at least three angel networks have formed in the last five years by cashed-out entrepreneurs. The Private Investors Network (PIN), the Capital Investors Club and the Washington Dinner Club are organizations of experienced entrepreneurs who actively invest in new companies and offer management advice. An industry devoted to outsourcing services to startups has also come into prominence, holding seminars and breakfast meetings to recruit clients.

Universities as Growth Engines

Universities in the region have responded to the increased entrepreneurial activity by offering new programs and building branch operations closer to commercial activity. For

example, Johns Hopkins University offers a Masters degree in Biotechnology in Silver Spring, Maryland about 50 miles away from the main Baltimore campus. Virginia Tech University opened a branch campus in Northern Virginia about 250 miles from their main campus. The draw has been the number of workers seeking additional training, the opportunities for industry-funded research and interaction with industry. Notably, the local universities have benefited from the philanthropy of the local entrepreneurs. For example, George Mason University began in Fairfax, Virginia in 1950 as a commuter school. It has grown into Virginia's second-largest university with 18 doctorate programs and a focus on technology. Donors have given the university millions of dollars to endow forty-three professorial chairs, allowing the university to recruit high-profile professors (O'Harrow and Lipton 1996). All of the universities in the area have responded with incubators and other programs to encourage entrepreneurship.

V. Reflective Conclusions and Appreciative Theorizing

The economic success of Silicon Valley in terms of individual wealth creation, corporate profits and job creation, has been so impressive it has pushed government officials in locations across the nation to try to imitate or replicate its success. Many government policies are aimed at replicating the conditions that exist in the region today in the belief that their local areas may also capture the benefits of new high technology firm formation and the attendant economic growth. As a result, many regions attempt to identify themselves as the next Silicon Valley. However, much of this prevailing conventional wisdom is based on a snapshot of the advanced stage of Silicon Valley's development, that is, on the workings of a fully functioning innovative system. Looking at a successful region in its full maturity, however, may not provide prescriptive information about the process of how such regions do develop. That is to say, the

conditions that we associate with an entrepreneurial environment are the result of a functioning entrepreneurship and do not illuminate the early efforts by which such entrepreneurship first took hold and cluster initially developed.

A critical question is how regions change and develop into areas with higher growth potential. Is replication of a mature entrepreneurial environment sufficient to foster entrepreneurship? Saxenian (1994) analyzes Silicon Valley from the perspective of how this regional industrial system adapted to restructuring in the semiconductor and computer industry and establishes the importance of social relationships in defining the capacity of the region to evolve and accommodate new demands. The example presented here represents an examination of how one region, initially lacking an entrepreneurial tradition, accomplished the transformation to a functioning rich regional system. Such a transformation entails a fundamental shift or phase change from an inert innovative system to a more active system. Certainly, the Capitol Region was the site of large government research infrastructure, classified as a State-anchored region using Markusen's (1996) typology. In this regard, the concentrations of resources and highly skilled labor plus access to sophisticated, demanding technology users were pre-existing conditions in the region. The transformation to private sector entrepreneurial growth did not appear to represent movement along a technological trajectory (Kenney and von Burg 1999) but instead was a sustained effort at capacity building that involved human agency, adaptation and evolution. Not only this, a critical point was reached in the development of the region where it jumped from virtually no high technology start-up activity to intense activity with start-ups per year numbering in the hundreds.

Certainly, in the development of an industrial system of innovation, there are many individual complex stories and personal motivations. The prevailing wisdom was that

government employees and contractors could never become successful private businesses – the incentives were very different. Government workers were, the logic went, too removed from the pressures of the market and were not profit-oriented. Government contracts followed a practice of placing a low bid in order to get the job and then making a profit by demonstrating a need for change orders in the absence of competition. This is a very different philosophy from trying to do a job right the first time and completing a job at lowest cost. However, the earliest entrepreneurs in biotechnology and ITC were government contractors and employees who proved this logic wrong. What is critical is that the region did provide opportunity for individuals. They began working for the government but then realized that they could adapt their products for dual-use commercial markets. Therefore, they developed commercial products and with this development came innovations and they eventually succeeded. In essence, this was a phase change from latent to active entrepreneurship.

The entrepreneurial event in the Capitol Region was a response to and adaptation to changes that were exogenous to the regional system. In this regard, Federal policies such as downsizing created slack and surplus resources that could find new and more productive uses. Thus, the gales of Schumpeter's creative destruction were unleashed. Policies that created a supply of potential entrepreneurs would not have been sufficient. A complementary set of government policies aimed at creating demand for ICT and biotechnology services, through government procurement policies that facilitated the transition. Other exogenous conditions were the policies that provided mechanisms or tools to enable companies to access resources. These affected the supply of new ideas by creating access to intellectual property from government investment.

Both biotechnology and ITC are high opportunity technologies that face growing product demand and are attractive to investors. This indicates that firms working in these technologies faced favorable market conditions. The degree to which this is exogenous may be debated. Good entrepreneurs may create their own opportunity and thus define the industry. The idea that technology development is endogenous to cluster development and that the actions of key individual change agents define both the cluster and the industry seems to warrant more investigation. Abbate (2000) finds that the attributes of the Internet reflect the characteristics and values of the individuals involved in its development. This suggests that companies, regions and industries may benefit from the same factors and decisions -- their evolution may be intricately interwoven. Currently, a myriad of economic development policies attempt to encourage entrepreneurship. Nevertheless, we have shown that rather than being actively promoted and encouraged by economic development policies, the early stages of these activities had much more humble and pedestrian beginnings. The conditions that we associate with entrepreneurship developed over time. In the early stage of these new technologies, the way in which they would develop was unclear and it would have been difficult to anticipate the types of specific assistance that entrepreneurs needed. Individual entrepreneurs were in the best position to move the technology, the industry and the region forward. This is not to say that there is no role for local government policy in promoting entrepreneurship. No early examples presented themselves in this region; however, we have not directly examined that question.

Are there general lessons to be learned from the development of the Capitol Region or is this case unique and is every case unique? Certainly, this region benefited from high average individual and household incomes and higher than average education levels, giving it very different resource endowments from other underdeveloped regions that face the lack of an

entrepreneurial culture. The general lesson is that entrepreneurs adapt and when they are successful, they build the types of resources that support their activities. A distinction should be drawn between the conditions that support innovation and the conditions that support entrepreneurship. The two concepts are certainly related: entrepreneurship is one way in which innovation is realized as firms are formed to commercialize and advance new ideas. External environments and resources may make it easier for innovation to be realized but may not be sufficient to induce new firm formation which is where the concepts diverge.

Once established, industrial clusters become virtuous, self-reinforcing circles. Yet, we know less about the conditions and factors – the initial spark or the entrepreneurial events– that influence the establishment of these clusters. Context, institutions and social relationships are certainly areas for public policy intervention in terms of creating a supportive and positive environment for entrepreneurship. Specifically relevant are the conditions that affect the decisions of individuals to become entrepreneurs, and the ways in which an entrepreneurial culture develops and takes hold. Much of the economic development discourse appears informed by attempts to replicate the characteristics associated with fully functioning regional system in what may be considered a mechanistic economic development machine – line up the inputs and economic development will follow. Such a view ignores the rich context, diversity of experience, uniqueness of and adaptation of regional systems.

Our understanding of regional economic systems may be enhanced by a consideration of entrepreneurs as economic agents who actively interact with their local environments, adapt to new situations, crises or opportunities using place-specific assets, and finally, build and augment local institutions. Certainly, this is not the last word on this topic. It is my hope that this historically informed appreciative theorizing will inspire others to take a more detailed look. It is

only through an appreciation of the nuances of cluster development that we may begin to inform policy.

References

- Abbett, J. (2000). *Inventing the Internet*. Boston: MIT Press.
- Abetti, P. A. (1992). "Planning and Building the Infrastructure for Technological Entrepreneurship." *International Journal of Technology Management* 7: 129-139.
- Anderson, T. (1996). "Maryland Develops Plan to Beat Virginia: A new economic development strategy will focus on making Maryland business-friendly" Washington Technology, (http://www.wtonline.com/archive/1996_APRIL_25/front_news/front_news3.html)
- Appold, S.A. 2000. "The Control of High-Skill Labor and Entrepreneurship in the Early US Semiconductor Industry." *Environment-and-Planning-A* 32(12): 2133-60
- Archibugi, D. and M. Pianta. (1992). *The Technological Specialization of Advanced Countries*. Boston: Kluwer Academic Publishers.
- Ashiem, B. (2000). "Industrial Districts: The Contributions of Marshall and Beyond" in G. Clark, M. Feldman and M. Gertler, eds. *Oxford Handbook of Economic Geography*, Oxford: Oxford University Press
- Audretsch, D.B. 1995. *Innovation and Industrial Evolution*. Boston: MIT Press.
- Bahrani, H, and S. Evans (1995) "Flexible re-cycling and high-technology entrepreneurship", *California Management Review*. 37: 62-89.
- Baker, P (1995). "Giving Allen the Business on Colleges: Executives Say Extra \$200 Million a Year Is Needed for Education." The Washington Post. July 25, page A1.
- Bearse, P. J. (1981). *A Study of Entrepreneurship by Region and SMSA Size*. Philadelphia, Public/Private Ventures.
- Bhide, A.V. (1999). *The Origin and Evolution of New Businesses*. Oxford: Oxford University Press.
- Blanchflower, D.G., A. Oswald, and A. Stutzer. (2000). "Latent Entrepreneurship across Nations" Manuscript – August 27.
- Blumenthal, M. S. (1998). "Federal Government Initiatives and the Foundations of the Information Technology Revolution: Lessons from History", *American Economic Review*, 88(2), pp. 34-39, May.

- Braunerhjelm, P. and B. Carlsson. (1999). "Industry Clusters in Ohio and Sweden, 1975—1995". *Small Business Economics* 12 (4):279-293.
- Bruno, A. V. and T. T. Tyebjee. (1982). "The Environment for Entrepreneurship." In Kent, C. A., Sexton, D.L, Vesper, K. H. (eds.) *Encyclopedia of Entrepreneurship*. Englewood Cliffs, NJ, and Prentice-Hall: 288-307.
- Ceruzzi, P. (2000). "Tysons Corner, Virginia" *Knowledge, Technology and Policy*. 13:86-102.
- Copeland, L. (2000). "A Capital Idea for the High Tech Elite" Washington Post, Friday, May 26, 2000; Page C01
- Desrochers, P. and M. Feldman (2000). "The Practical Application of "Truth for Its Own Sake": A Short History of University-Industry Technology Transfer at the Johns Hopkins University", working paper.
- Dubini, P. (1989). "The Influence of Motivations and Environment on Business Start-ups: Some Hints for Public Polices." *Journal of Business Venturing* 4: 11-26.
- Eaton, B., M. Feldman, L. Gerstley, M. Connolly, and G. Mangels. (1998). "Biosciences in Maryland: A Closer Look." MDBio.
- Eisenberg, R. (1996). "Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research." *Virginia Law Review* 82: 1663-1727.
- Feldman, M. P. (2000). "Location and Innovation: The New Economic Geography of Innovation, Spillovers, and Agglomeration" in G. Clark, M. Feldman and M. Gertler, eds. *Oxford Handbook of Economic Geography*, Oxford: Oxford University Press.
- Feldman, M. P. (1994). The University and High-Technology Start-ups: The Case of Johns Hopkins University and Baltimore. *The Economic Development Quarterly*. 8:67-77.
- Feldman, M. P., and C. R. Ronzio. (1999). "Closing the Innovative Loop: Moving from the Lab to the Shop Floor in Biotech." (Johns Hopkins University Institute for Policy Studies, Occasional Paper No. 22).
- Feldmann, L. (1997). "In Virginia, Businesses Argue For Taxes" *The Christian Science Monitor* September 9, Pg. 4.
- Feller, I. (1990). "Universities as Engines of R&D-based Economic Growth: They Think They Can" *Research Policy* 19:335-348.
- Flora, C. B. and J. L. Flora. (1993). "Entrepreneurial Social Infrastructure: A Necessary Ingredient." *Annals of the American Academy of Political and Social Science* 529:48-58.

Florida, R. and M. Kenney. (1988). "Venture Capital-financed Innovation and Technological Change in the USA." *Research Policy* 17: 119-37.

Fuller, S. S. (1998). "The Northern Virginia Economy and its Near-Term Outlook" paper presented at the Sixth Annual Conference on the Future of the Northern Virginia Economy, George Mason University, May 12 1998.

Glasmeier, A. K. (1988). "Factors Governing the Development of High Tech Industry Agglomerations: A Tale of Three Cities." *Regional Studies* 22: 287-301.

Gompers, P.A. and J. Lerner. (1999). *The Venture Capital Cycle*. Cambridge, MA, MIT University Press.

Guidera, M. (1996). "Start-ups finding it easier to get paired with 'angels'; University of Maryland's Dingman Center joins Investor Network in matchmaking effort" *The Baltimore Sun* August 21, page 1C.

Haynes, K., S. S. Fuller and L. Qiangsheng. (1997). "The Northern Virginia Economy: The Changing Role of Federal Spending" *Research in Urban Economics*, 11: 145-161.

Henderson, R. (1994). "Managing Innovation in the Information Age." *Harvard Business Review*, 72:100-5, Jan/Feb.

Kahn, R. E. and V. G. Cerf (1999). "What is the Internet (And what makes it work)" Paper prepared for the Internet Policy Institute, December.

Kay, N. (2000). "Searching for the Firm: The Role of Decisions in the Economics of Organization" *Industrial and Corporate Change*, 9:683-707.

Kenney, M. and U. von Burg. (1999). "Technology, Entrepreneurship and Path Dependence: Industrial Clustering in Silicon Valley and Route 128." *Industrial and Corporate Change*, 8:67-103.

Lazerson M.H. and G Lorenzoni. (1999). "The firms that feed industrial districts: A return to the Italian source" *Corporate and Industrial Change*, 8: 235-266.

Lerner, J. (1996). "The Government as Venture Capitalist: The Long-Run Effects of the SBIR Program, NBER Working Paper No. W5753.

Leslie. S. and R. Kargon. (1997). "Recreating Silicon Valley". *Business History Review*.

Link, A. N. (1995). *A Generosity of Spirit: The early history of the Research Triangle Park, Research Triangle Park: The Research Triangle Foundation of North Carolina.*

Lohr, Steve (1999). "Paradox of the Internet Era; Behemoths in a Jack-Be-Nimble Economy". *The New York Times*. Week in Review, September 12

Malecki, E. J. (1990). "New Firm Formation in the USA: Corporate Structure, Venture Capital, and Local Environment." *Entrepreneurship and Regional Development* 2: 247-65.

_____ (1997a). *Technology & Economic Development*, Essex: Addison Wesley Longman Limited.

_____ (1997b). "Entrepreneurs, Networks, and Economic Development: A Review of Recent Research," in J. A. Katz, ed. *Advances in Entrepreneurship, Firm Emergence and Growth*, vol. 3. Greenwich, CT: JAI Press, pp. 57-118.

Malerba, F., R. Nelson, L. Orsenigo and S. Winter. 1999. "History-Friendly Models of Industry Evolution: The Computer Industry." *Industrial and Corporate Change*, 8:3-40.

Markusen, A., (1996). "Sticky Places in Slippery Space: A Typology of Industrial Districts" *Economic Geography*, 72: 293-313.

Mansfield, E. (1995). "Academic Research Underlying Industrial Innovations: Sources, Characteristics, and Financing." *The Review of Economics and Statistics*, 77:55-65, February.

Markusen, A., P. Hall, S. Campbell, and S. Dietrich. (1991). *The Rise of the Gunbelt*. New York, Oxford University Press.

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

Montgomery, D. and J. A. Bacon. (1999). "How Green is Our Valley?" Virginia Business, March. <http://www.virginiabusiness.com/vbmag/yr1999/march99/howgreen.html>

National Commission on the Public Service. (1990). *Leadership for America: rebuilding the public service / the report of the National Commission on the Public Service and the Task Force reports to the National Commission on the Public Service*, Paul A. Volcker, Chairman. Lexington, MA. Lexington Books.

Nelson, R. and S. Winter. (1982). *An Evolutionary Model of Economic Change*. Harvard University Press: Cambridge, MA.

Nonaka, I. R. Toyama and Akiya Nagata (2000). "A Firm as a Knowledge-creating Entity: A New perspective on the Theory of the Firm" *Industrial and Corporate Change* Vol 9:1: 1-20.

O'Harrow, R., Jr. and E. Lipton (1996). George Mason U. Embroiled In Debate About Its Mission, Washington Post February 14: p A1.

O'hUallachain, B. (1984). "The Identification of Industrial Complexes." *Annals of the Association of American Geographers* 74: 420-36.

_____ (1989). "Agglomeration of Services in American Metropolitan Areas." *Growth and Change* 20 (3): 34-39.

OTA (Office of Technology and Assessment). (1984). *Technology, Innovation, and Regional Economic Development*, Washington, US Government Printing Office.

Porter, M. (1990). *The Competitive Advantage of Nations*. New York: Free Press.

Prevezer, M. (1997). "The dynamics of industrial clustering in biotechnology". *Small Business Economics*, 9: 255-271.

Price Waterhouse Coopers (1998). *Toward a New Economy: Merging Heritage with Vision in the Greater Washington Region*. Washington, D.C.: Potomac Knowledge Ways Project. (<http://knowledgeway.org/voice/newecon/homepage.html>)

Raymond, S. (ed.). (1996). "The Technology Link to Economic Development", *Annals of the New York Academy of Sciences*, Vol. 787. New York: New York Academy of Sciences.

Roberts, E. B. (1991). *Entrepreneurs in High Technology*. New York, Oxford University Press.

Sapienza, H. J. (1992). "When Do Venture Capitalists Add Value?" *Journal of Business Venturing* 7: 9-27.

Saxenian, A (1994). *Regional Advantage*. Cambridge, MA, Harvard University Press.

Segaller, Stephen. (1998). *Nerds 2.0.1: A Brief History of the Internet*. New York, TV Books.

Shapero, A. (1984). "The Entrepreneurial Event." In Kent, C. A. (ed). *The Environment for Entrepreneurship*. Lexington, MA, Lexington Books: 21-40.

Stough, R. R. (2000). "The New Generation Technology Economy: Comparative Regional Analysis and the Case of the U.S. National Capital Region" paper presented at the American Association for the Advancement of Science meeting in Washington, D.C., February 2000.

_____ (1999), "Building and Embedding an Innovative Culture in the Regional Economy" paper presented at the Seventh Annual Conference on the Future of the Northern Virginia Economy, George Mason University, May 26, 1999.

Stough, R. R., H. Campbell and K. E. Haynes. (1998). "Small business entrepreneurship in the high technology services sector: An assessment of edge cities of the U.S. National Capital Region". *Small Business Economics*, V10, pp 61-74.

Teubal, M. and E. Andersen (2000). "Enterprise Restructuring and Embeddedness: A Policy and Systems Perspective" *Industrial and Corporate Change*,9:87-111.

Trajtenberg, M. (2000), "R&D Policy in Israel: An overview and Reassessment." Paper presented at the NBER Summer Institute 2000.

von Hippel, E. (1994), "Sticky Information and the Locus of Problem Solving: Implications for Innovation." *Management Science*, 40: 429-439.

Wells, P. (1987). "The Military Scientific Infrastructure and Regional Development." *Environment and Planning A* 19: 1631-58.

Zucker, L. G. and M. R. Darby (1996). "Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry." *Proceedings of the National Academy of Science* **93** (November): 12709-12716.

Zucker, L. G., Darby, M. R., and Armstrong, J. (1998). "Geographically Localized Knowledge: Spillovers or Markets?" *Economic Inquiry* 36(1): 65-86.

¹ Much of our understanding of the development of environments for entrepreneurship is based on the analysis of successful regions after they have achieved success. Historians document the development of these areas yet this line of inquiry has not been well integrated into how we conceptualize regional change and economic development.

² The U.S. Capitol Region is considered here as the Consolidated Metropolitan Statistical Area (CMSA) which includes Washington D.C., Northern Virginia and the Maryland Suburbs including Baltimore City and its environs. Two counties in West Virginia were added in 1990.

³ See for example, Steve Lohr in *The New York Times*, September 12, 1999 or a recent speech in the state of Maryland that stresses the examples from successful regions http://www.inform.umd.edu/pres/speech_techshow.html

⁴ The environments that support entrepreneurship, especially in technology intensive firms, have been subject to extensive study (See Malecki 1997b for a review).

⁵ Other authors have found that high levels of federal expenditures are associated with technology-based economic development (O'hUallachain 1989; Wells 1987; Glasmeier 1988, Markusen *et al.* 1991).

⁶ Quote from William M. Gust, currently Managing General Partner of Anthem Capital L.P., who came to the region in 1978 from Silicon Valley to manage the Boventure Company, Inc., a family-owned venture capital business.

⁷ It is difficult retrospectively to investigate the existence of social networks. Our interviews did not uncover any evidence of formal or informal organizations that attempted to unite individuals along some common interest.

⁸ Within the region, there is evidence of geographic differentiation. Biotechnology is primarily concentrated in the Maryland suburbs in Gaithersburg and along the I-270 Corridor. The Internet companies are concentrated in the Northern Virginia suburbs.

⁹ Beginning in 1996, we began investigating the origins of biosciences in the region (Feldman and Ronzio 1999, Eaton *et al.* 1998). We maintain a database of bioscience companies that tracks their growth and development. When it became clear that the concentration of ICT companies in Northern Virginia followed a similar pattern of development we began similar interviews of ICT companies. Roger Stough at George Mason University monitors these companies and has provided information and suggestions.

¹⁰ Such a study would involve access to a source of historical data on firms such as tax or employment records to discern when the firms came into existence and when they ceased to exist. This approach would be limited because the smallest and most typical form of startup, the sole proprietorship, might not be captured.

¹¹ For example, the Virginia Economic Development Partnership (<http://yesvirginia.org/wva-be.html>) uses this slogan.

¹² There is no accepted definition of the ICT industry and estimates of the number of entities in the region vary widely and appear to be influenced by media-hype. This is the author's conservative estimate.

¹³ This affected ITC but also biotechnology. Consider the firm Martek that is a spin-off from the defense contractor Martin Marietta and was funded by DOD.

¹⁴ UUNET was formed as a non-profit by a grant from the UNIX Users Group (USENIX) acquired by Metropolitan Fiber Networks in 1995, which was acquired by WorldCom in 1996. WorldCom merged with MCI to form MCI WorldCom in 1998.

¹⁶ See (<http://www.c2mm.com/indianceo/indianceo.htm>) for more details.

¹⁷ This quote is taken from the organization's web page <http://knowledgeway.org/>.

¹⁸ The Potomac KnowledgeWays project officially ceased operations in March 2000, as was the organization's original intention. The Netpreneur Project is now operated out of and supported by the Morino Institute.