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Does Technology Incubation Work?

A Critical Review

David A. Lewis
Rutgers University

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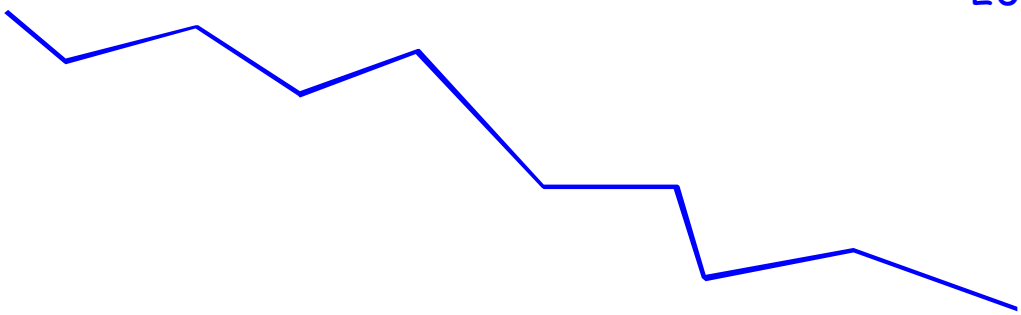

U.S. Economic Development Administration

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David A. Lewis

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The National Center for Neighborhood and Brownfields Redevelopment
Edward J. Bloustein School of Planning and Public Policy
Rutgers University

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EXECUTIVE SUMMARY

Technology business incubators became a popular economic development strategy in the United States beginning in the late 1980s as a result of the confluence of a number of factors. These factors include (1) economic restructuring, (2) the evolution of the theory of innovation, (3) the rise of "technopoles," and (4) new insights regarding the role of small businesses and entrepreneurialism in the growth of the U.S. economy. Though many believed that small entrepreneurial businesses were key to economic success, policy makers understood that the vast majority of new enterprises failed as a result of three common problems: lack of capital, poor managerial skills, and insufficient understanding of the marketplace. This was the starting point for the growth of business incubators. As the popularity of business incubation grew and technology incubator beginning in the 1990s, researchers sought to document the best practices and evaluate the social and economic contributions of public investment in incubators.

A review of the literature suggests there is a well-developed theory of technology business incubation. Researchers have also developed a set of best practices that have demonstrable positive effects on tenant firms. However, the evidence regarding the social and economic contributions of business incubation is still murky. On the one hand, the public sector cost per direct job created by investments in incubators in general, and technology incubators specifically, is relatively low, ranging from about $3,000 to $12,000 per job, and the survival rate of incubated firms is roughly three times that of the general population of new enterprises. In addition, approximately 84% of the incubated firms tend to locate locally after graduating from an incubator. However, the evidence is mixed regarding the long-term effects on the graduates and the local economy. Based on our current knowledge, it appears premature to argue for the withdrawal of state funding for technology business incubators in hopes that the for-profit model will achieve the same economic development goals as state-supported technology incubators

Finally, though theoretically there are locational factors that may affect the performance of a technology incubator, there has been little empirical work to test this hypothesis. One factor is complementary state and local level economic development policies, since there is some evidence that indicates that tax incentives for R&D and loan funds are contributing to the success of technology incubators. Other potentially important location factors, however, have not been examined with any rigor.

The limitations of the body of research result in part from the nascent nature of the technology incubator industry. As the industry matures future research should focus on expanding our knowledge of the long-run effects of technology incubation on both the client firms and the local economy, examining the impact geography may have on the performance of a technology incubator, and comparing for-profit technology incubators to the not-for-profit model.

INTRODUCTION

Beginning in the 1970s, economic restructuring left many formerly prosperous communities economically devastated and searching for responses. Faced with bleak economic prospects, federal devolution (budgetary and policy), and mounting constituent pressure, states transitioned their economic development policies toward more "entrepreneurial" strategies. The essence of this strategy was that local innovation and new firm formation will result in endogenous growth (Eisinger 1988; Massey et al. 1992; Atkinson 1991).[1] The dramatic shift in the geography and organization of production, combined with the emergence of "technopoles"—such as Silicon Valley—inspired researchers to concentrate on understanding the linkages between technological innovation, industrial location, and regional development. The allure of technopole development in state-level public policy is evident by the fact that by 1995 all 50 states had—or were in the process of implementing—technology development programs, in comparison to just a handful of pioneering states in the 1970s (Coburn and Berglund 1995).[2]

In considering how to create new enterprises to replace those that had perished or were swept to lower-cost regions, policymakers understood that they needed to address the common reasons for failure of new ventures. These reasons included (1) insufficient access to capital, (2) lack of managerial expertise, and (3) insufficient marketing expertise. This knowledge was the starting point for the practice of business incubation. The goal of business incubation is to provide a supportive environment, where new entrepreneurs receive training in business management skills and marketing, buffered from stiff market forces with below-market rent, reduced fees for services, and greater access to seed capital (Gatewood et al. 1985; Peterson et al. 1985; Allen 1985).

A typical business incubator is a multitenant facility with common office equipment and a shared conference room. There is also an on-site full-time manager to assist in the delivery of business assistance training and services.[3] Some services commonly provided in an incubator include (1) business plan development; (2) accounting, legal, and financial planning; (3) aid in attracting investors; (4) marketing; and (5) common shared services, such as secretarial support and facility maintenance (Allen 1985). Once a fledgling business is financially viable—and the individual entrepreneur has developed the necessary survival skills—it is hatched into the open market, where it hopefully hires new employees and begins to contribute to the local (regional) economy.[4]

State and local economic development officials have embraced the creation of business incubators. From 1986 to 1996, the population nearly quadrupled from roughly 140 established sites to 548 (McKinnon and Hayhow 1998), and the current count is approximately 900 business incubators in the United States.[5] The current expansion among incubators has been driven by strong public and private investment in the technology segment of the incubation industry.[6]

A technology incubator fosters the growth of new technology ventures by helping to close the gaps[7] in the innovation process and correct for market failures. If 50% of the client base are "technology firms" then an incubator can be considered a technology incubator.[8] There are some important differences between most technology incubators and the general population of business incubators, perhaps the most important of which is that operating and startup costs

are greater for technology incubators. Wolfe et al. (1999) estimate that the average annual operating cost of a technology business incubator is $320,701, which is 25% higher than the industry average.[9] Other differences between technology incubators and the general population of business incubators include the size of the facility, number of staff members, and the average period of incubation. These differences are explored in Table 1.

Table 1: Technology Incubators Compared to All Business Incubators

Variable	Industry Average	Technology Average
Square footage	24,375	38,988
Number of tenants	12.0	13.9
Number of employees per tenant	4.5	5.1
Number of graduates per year	3.3	1.7
Number of graduates per employee	22.4	30.4
Percent of firms remaining in the community	82.2	86.0

Sources: Culp (1996), Wolfe et al. (1999 and 2000)

The theory of technology incubation and recent industry trends raise some important research questions:

(1) Do incubated technology firms outperform similar non-incubated firms in economic terms (sales, employment, patents/copyrights, etc.)?

(2) Are there locational characteristics that can enhance or dampen the performance of a technology incubator? Some argue that the location, in terms of industrial and occupational mix, educational attainment, level of public support, and presence of institutions of higher education, contributes to the success or failure of incubators. In other words, does the technological capacity of a region impact upon the success of a technology incubator? In addition, do interinstitutional linkages, cultural milieu, and public policy play significant roles in the trajectory of an incubator?

(3) Are there complementary policies at the state, regional, or local level that improve the returns on public investment? [10]

(4) Is there still a need for public investment in incubation?

Each of these questions has important ramifications for economic development officials faced with decisions regarding how to invest scarce public resources to spur economic growth. The literature review that follows searches for evidence to answer these questions. This paper also examines the growth of business incubation, focusing on technology incubators and the theoretical and evaluative research that has accompanied its development. In addition to reviewing the literature, I interviewed incubator managers, academic researchers, officials of public agencies that fund incubators, administrators at universities that sponsor incubators, and directors of incubator networks, and their comments are noted within the paper.

The next section will examine the social, economic and political factors that spawned the business incubation industry, the theoretical arguments for technology incubation, and the literature that outlined the prevailing definition of an incubator. The third section reviews the best practices for business incubation and outlines a typology of incubators. A review and

critique of the evaluative literature is presented in the fourth section. The Conclusion summarizes the current knowledge regarding technology incubation and proposes some potential directions for future research.

CONTEXT AND THEORY FOR TECHNOLOGY INCUBATION

Theoretical arguments that innovation fosters economic growth have been fundamental to the emergence of technology incubation as an economic development strategy (DiGiovanna and Lewis 1998; Shahidi 1998; Smilor and Gill 1986; Tornatzky et al. 1996). In theory, technology incubators stimulate the innovation process by linking technology development with market demands, while providing capital for innovation, particularly in startup enterprises that are deemed too risky for many investors (Tornatzky et al. 1996; Smilor and Gill 1986). Theoretically, the benefits of public sector support of technology incubation include:

(1) increased pace of new job formation;

(2) fostering an entrepreneurial spirit that will result in new firm formation and increased private investment in innovation; and

(3) greater incentives for highly skilled individuals to reside in the host region.

Furthermore, industrial innovation (product or process) can create first mover benefits to the innovating firm, which, in turn, tend to lead to new agglomeration. New agglomeration increases the prospect for additional wealth generation in the host region (Weber 1929; Markusen 1987; Marshall 1987).[11] Thus, the combination of these factors will enhance the regional economy (DiGiovanna and Lewis, 1998).

The growth of technology business incubation as an economic development tool is grounded in the theory of small businesses' contributions to growth, the demonstrable effect of innovation on economic growth, and changes in perspectives of the innovation process beginning in the 1970s. It has been asserted that small businesses are the engine of growth for the U.S. economy (Birch 1987). As early as the 1960s, economist Ben Chinitz theorized that the presence of small and mid-sized firms increases the level of entrepreneurial activity in a region (Chinitz 1961).[12] More recently, analyzing Dunn and Bradstreet data on corporate history, Birch (1987) concluded that small entrepreneurial companies created approximately 80% of new jobs in the U.S. between 1969 and 1976. While many of Birch's conclusions have been discredited, one cannot underestimate the influence his original thesis had on the public policy agenda (Harrison 1997; Shahidi 1998). This fascination with small firms resulted in public policies designed to help small businesses (Osborn 1988; Harrison 1997; Eisinger 1988).

Changes in the theoretical arguments regarding economic development and regional growth developed simultaneously with new insights regarding our understanding of the innovation process. Since the end of World War II, innovation has been primarily understood as a linear process, starting with basic research, to applied research, through development, to tech-transfer, proto-typing, commercialization, and diffusion (Massey et al. 1992; Kline 1995; Bijker et al. 1987).[13] While this clearly is not the only path to industrial innovation, public policy, particularly at the federal level, has been dominated by this model (Stokes 1993; Massey et al. 1992; Kline 1995, 1988).

Technology incubator supporters argue that incubation increases the rate of industrial innovation by intervening in the innovation process and tightening the links between market and innovating firm as well as between innovating firm and basic and applied research. This happens

through interfirm cross-fertilization, correcting for market failure in the innovation process, and establishing new firms. Some failures in the marketplace that are addressed by the business incubation process include restricted capital flows, lack of technology transfer, and unequal access to and cost of information (Campbell et al. 1988). Many mainstream economists suggest that there is an undersupply of capital in regard to investment in new technologies (Freeman and Perez 1988). Furthermore, it is well documented that undercapitalization of small startup firms is a primary reason for failure, thus state action in the incubation process is justified on this front as well. As part of the government response to these issues of market failure and gaps in the innovation process, the federal government established the Small Business Innovation Research program. The goals of the program include (1) redistribution—to address a perceived government failure in R&D procurement policy (small firms were unfairly excluded)—and (2) innovation—to address the market failure of underinvestment in R&D by providing funds to small firms (Wallsten 1998, 195).[14]

The theory of business incubation also assumes that public sector assistance to early stage enterprises will catalyze a spirit of entrepreneurialism, which, in turn, will improve the general business climate. This improved business climate will then draw private investment capital into the region and, in the case of technology incubation, increase investment in emerging technologies. In the case of technology incubators, there is the potential for additional spillover effects at the national and regional levels. For example, nationally the development and adoption of new technologies may also increase productivity, as in the case of the computer, or advance the field of medical science, leading to an increase in life expectancy and decreased medical expenses. From both the national and regional perspectives, the continuous investment in innovation can mitigate business cycles and prevent regional decline (Marshall 1987; Booth 1987). These positive externalities provide a public goods argument for public sector investment in technology incubators.

Economic development officials' observations of real-world examples—such as the Japanese economy; Orange County, California; Research Triangle, North Carolina; Route 128, Massachusetts—provided concrete evidence that industrial innovation had a profound effect on regional development and that success in these centers could be influenced by public policy interventions. In addition, stories of industrial giants with humble beginnings, such as Apple Computers, Cisco Systems, and Microsoft, have been compelling case stories for incubator enthusiasts as well as policy officials. While it is true that only a tiny percentage of all small entrepreneurial firms will emerge as industry leaders—and more than 75% actually fail in the first five years—the emerging new technologies of new media, bio-technologies, wireless and broadband communications, e-commerce, and environmental technologies provided ample reason for optimism. Kleinknecht and Reijnen (1991) and others demonstrated that the traditional R&D measurement techniques used by the Organization for Economic Cooperation and Development (OECD) countries undercounted the R&D activities and contributions to innovation by small and medium-sized firms (Pavitt et al. 1987; Kamien and Schwartz 1982; Kleinknecht 1987). In the case of the U.S., Stuart and Abetti (1985) argue that small entrepreneurial firms provide a disproportionately high share of technological innovation, citing the U.S. Small Business Administration, U.S. Department of Commerce, and *The Wall Street Journal*. These findings increased interest in technology incubation since the late 1980s.

Also fundamental to technology incubation emerging as an economic development strategy are theories regarding the innovation process and the environmental context in which

innovation occurs. Some potentially important environmental factors that affect the pace of innovation are the degree to which a community is open to change, the level of public sector support for innovation, and the diversity of industries and workforce skills (Willoughby et al. 2000; Malecki 1997; Storper 1997; Harrison et al. 1996). In addition, Castells (1996, 72) argues that "technological change can only be understood in the context of the social structure within which it takes place."[15] The pace with which new ideas are generated and adopted is, in part, determined by cultural values, the degree of interaction between different strata of society, governmental structure and activities, prevailing investment strategies, and historical interactions amongst established institutions. These social characteristics determine who has access to education, receives the benefits of technological progress, and structures the incentives for technological change.

Tornatzky et al. (1996), building on the work of Smilor and Gill (1986), state that technology incubation can accelerate the transfer and commercialization of technology by linking talented entrepreneurs with ideas for industrial innovations to individuals with the market wisdom to commercialize their innovations, as well as with economic resources. Technology incubators unite technical expertise and managerial, marketing, and financial skills, which are transferred to the client firm through the incubator manager, advisory board, technical advisor(s), and access to university faculty and laboratories (DiGiovanna and Lewis 1998).[16] There are a variety of ways that technology incubators provide economic resources including: 1) below-market rent for physical space with the basic equipment, 2) access to more sophisticated equipment at no or reduced cost,[17] 3) free or subsidized business services, saving the startup firm operating capital, and 4) improved access to capital markets. While not all incubators have internal seed or venture funds, potential lenders are aware of the advantages of incubated firms. A financial officer with the New Jersey Economic Development Authority Seed and Venture Capital Program, stated anecdotally that financial officers at the Authority "view the incubator managers as knowledgeable screeners of loan applicants, and having firsthand knowledge of the client firm, in the judgment of the Authority, lends credibility to the [loan] application [for state-sponsored seed or venture capital funds]" (Conte 1998). In addition, commercial lenders carefully screen potential loan applicants based on managerial skills, which the incubator provides (Camp and Sexton 1992).

THE BUSINESS INCUBATION INDUSTRY: BEST PRACTICES AND TYPOLOGY

The commonly accepted birth date for business incubation in the United States is 1959, when the citizens of Batavia, New York, in conjunction with their local government, responded to the loss of a major manufacturing plant by establishing a mixed-use incubator in one of the abandoned buildings. In the 1970s and 1980s, other Northeastern communities responded to the economic crisis of the deindustrialization of core manufacturing centers by also establishing incubators (Allen and Bazan 1990). Between 1975 and 1985, the number of incubators blossomed from approximately 20 to about 150 nationwide, though they were concentrated in the Northeast and other old industrial areas (NBIA 1991).[18]

As public awareness expanded regarding the role of incubators in promoting small-firm development and innovation so did academic attention to the subject. Starting in the early to mid-1980s, editors of the journal, *Frontiers of Entrepreneurship Research*, dedicated a session to the subject of business incubation each year at their annual conference. It is from these proceedings that the definition of "incubator" used by much of the industry began to emerge. In 1985, three papers presented at the conference asserted that an incubator must have a physical plant with below-market rents, shared services, logistical support, and business consulting assistance (Gatewood et al. 1985; Allen 1985; Peterson et al. 1985).[19] Incorporating the empirical evidence of Allen and Weinberg (1988) and building on the knowledge from the practice of incubation, the industry has shifted the focus to value-added business services, away from site development and subsidized rents. Discussions with industry experts indicate that the draw of below-market rents has been reduced, particularly in the case of technology incubators, where it is value-added services that attract new tenants. Client cost savings are captured by the efficient and effective delivery of a menu of business services, which reduces the cost of searching for the services on the open market. In addition, technology entrepreneurs are seeking the managerial expertise that is imparted via entrepreneurial training programs and networking opportunities (Lichtenstein 1992).

It is commonly understood since Allen's (1985) work that "incubation without walls" does not meet the industry standard; some building site—new or redeveloped—with multitenant occupants must exist. Incubation without walls lacks the potential for day-to-day interactions with peers, an element that creates an environment that has been touted by some as a key ingredient to success.[20] Furthermore, the ability to deliver the menu of business services is reduced because of the distance between entrepreneur and incubator manager.

To paraphrase a Small Business Development Center (SBDC) veteran, incubation without walls is more analogous to the SBDC's mission and practice than incubation programs that have the advantages of a physical space.

Best Practices

Marc Rice, in collaboration with Jana Matthews, published a book in 1995 on best practices based on interviews with managers of successful incubators. They discuss the need to embed an incubator program into the host community. In order to integrate the incubator into

the local community, Rice and Matthews lay out a plan for managing stakeholder[21] involvement. The authors assert that a broad spectrum of community stakeholders is often necessary for the survival of an incubator. The many interviews conducted for this research also indicated that an incubator's success is often predicated on its "champions." In the development phase, community support, in the form of a community advisory team (CAT), catalyzes incubator sponsors to invest financial resources. The CAT also takes the lead in developing wider community support and raising funds for a feasibility study. As the incubator matures, the relationship to community stakeholders must evolve. This evolution should include focusing community resources on assisting client and graduate firms in their survival and growth. In addition, the CAT also evolves and often these champions transition into members of the incubator's advisory board.

Local embeddedness is also critical in the technology transfer process. Developing positive relationships with technology generators in the region facilitates access to commericializable technologies and technical expertise, as well as builds a stronger potential client base. Embeddedness with local investors can be developed if they trust that the incubator provides a screening function for new investments and delivers high quality clients.

In general, there are three components to business incubator best practices: (1) the facility, (2) the type and quality of services provided, and (3) the operation and management of the incubation program (see Table 2). The facility should provide flexible space so that an emerging company can expand (or contract) within the facility during its period of incubation, as well as be able to accommodate new firms. In the case of technology incubation, high speed broadband Internet access is now considered critical for attracting clients. Technology incubators may also provide specialized laboratory space or other unique research, design, or production capacity and, where possible, access to university research facilities.[22]

The common types of complementary business services provided by incubators may include, but are not limited to: 1) business plan development, 2) intellectual property protection assistance, 3) legal services, 4) secretarial assistance, 5) accounting and bookkeeping services, and 6) presentation training.[23] Business assistance services may by supplied to client firms through a variety of mechanisms and through various cost structures. These services may be provided by:

- incubator manager and staff;
- advisory board or host institution (such as a university's faculty);
- local Small Business Development Center; and/or
- arrangements with area professional service firms.

The cost of these services may be at or below market rate and the quality varies from incubator to incubator. The client firm may pay for the services directly on a billed fee-for-service basis or as part of rent to the incubator facility. Firms may need to take out a loan for services or exchange equity in the firm for services (Allen and Bazan 1990; Hayhow 1997b).

In 1998, the NBIA identified 587 business incubators in North America, 548 of which were in the United States. Within the incubator industry, the NBIA has identified the following types of incubators: 1) mixed-use, 2) technology (general), 3) manufacturing, 4) targeted, 5)

service, 6) empowerment, and 7) other (see Table 3). A brief description of each type of incubator is provided in Appendix A.

Table 2: Business Incubation Best Practices

Physical Plant	General Office Services
Multitenant facility	Shared office equipment (copier, fax machine)
Flexible space	Flexible leasing arrangements
Shared conference room	Internet access
Shared telecommunications equipment	Secretarial services
Designed to encourage interactions	
Include common kitchen area	
Careful site selection*	
Feasibility study to confirm viability, location, etc.	

Business Assistance Services	Technology Incubator Specific
On-site management	Broadband high-speed Internet access
Business plan development	Access to university facilities, labs and their staffs[†]
Mentoring programs	Technology commercialization assistance
Marketing assistance	Assistance in acquiring SBIR funding[‡]
Copyright and patent assistance	Provision of specialized work spaces[§]
General legal assistance	
Presentation training	
Business management training	
Networking	
Accounting, bookkeeping assistance	
Access to capital	

Organizational Attributes

Advisory board with representation from local government, state/local economic development official, local professional service providers network (including a general practice lawyer, patent attorney, accountant, and the investment community), host institution, local entrepreneurial community, tech-commercialization specialist, and a graduate firm

Have well-developed mission statement and goals

Careful selection of manager. Manager should have local knowledge, be motivated, able to multitask, and be a team player, among other assets (Hayhow 1999).

Have entrance and exit criteria for client firms designed to lead the enterprise to self sufficiency

Ongoing evaluation of incubator performance

Sources: NBIA (2001), Hansen et al. (2000), Campbell et al (1988), Allen (1985), Peterson et al. (1985), Kang (1991), Rice and Matthews (1995), Smilor and Gill (1986), Hayhow (1996), and interviews with industry experts.

Notes: * Site selection criteria will vary by incubator type, size of potential client pool, and characteristics of host community (i.e., rural vs. urban), among other factors.

[†] Government laboratories and their staffs or private research facilities and their staffs may be substituted for university facilities.

[‡] This includes SBIR (Small Business Innovation Research) grants as well as other grant application preparation.

[§] At the minimum the structure should be equipped to accommodate wet labs, ventilation hoods, and perhaps other specialized areas such as clean rooms.

Table 3: Incubators by Type

Type	Number	Percent
Mixed-use	252	43%
Technology	147	25%
Manufacturing	59	10%
Targeted	53	9%
Service	35	6%
Empowerment	29	5%
Other	12	2%
Total	587	100%

Source: McKinnon and Hayhow (1998).

Typology of Incubator Industry

The latest published industry-wide survey identified 147 technology incubators in the United States, the majority of which have opened in the last seven years (McKinnon and Hayhow 1998), and one or two new Internet incubators are opening per month (Adkins 2000). More recent data indicate that of the approximately 900 incubators in the United States technology incubators are rapidly becoming the dominant segment of the industry, growing to 40% of the population, while mixed-use incubators have declined to 30% (Loftus 2000).[24] Of the 900 incubators, the NBIA estimates that 75% are not-for-profit and 25% for-profit ventures.[25] Using various membership directories in combination with contact letters and phone calls, 146 currently operating technology incubator programs were identified that were established by 1998, have a physical plant, and are not of the e-commerce variety[26]. This suggests that there has been a recent mushrooming in the technology incubator segment of the industry. There were also 21 cases of technology incubators that had closed[27] or scaled back their operations to the point that they could no longer be considered incubator programs because they had ceased to provide a full complement of business assistant services.

Incubators can also be described by their organizational structure. This term refers to the host organization and the revenue streams that support the facility. Industry-wide, there are five major categories of organizational structure: (1) economic development organizations, (2) institutions of higher education, (3) for-profit entities, (4) not-for-profit entities, and (5) public-private partnerships. In many cases, the incubator is a hybrid that has more than one sponsor. In general, state-supported nonprofit incubators are the most popular, followed by university-hosted incubators, though for-profit models have increased dramatically since the late 1990s.[28] In the specific case of technology incubators, the majority are hosted by academic institutions (McKinnon and Hayhow 1998).

Stability and success of an incubator program are dependent on reliable funding streams (Peterson et al. 1985; Rice and Matthews 1995; Campbell et al. 1988; Allen and Bazan 1990). The revenue streams that support an incubator vary over time, by lead organization, and across different incubators of the same age, type, and lead organization. The temporal change is related to three factors. First, the revenue from rent and fees for services increases as a percentage of total revenue over time, eventually becoming the largest portion of revenue. Second, the level of private and public grants received fluctuates over time. This fluctuation forces a manger to devote considerable effort to fundraising and may compel an incubator to relax entrance criteria or extend tenancy to a firm ready to graduate in order to increase rent revenue.

A trend gaining popularity is for incubators to make equity investments or receive royalty payments from tenant firms. Currently, 22% of all incubators have royalty agreements with and/or have taken an equity stake in their incubator clients and graduates. Royalty agreements are becoming particularly common in the technology and Internet incubator segments of the industry (Molnar et al. 1997; Wolfe et al. 2000; Hanson et al. 2000).[29] This trend should benefit university-associated technology incubators. Though their research was not conducted with university technology incubator clients, Bray and Lee (2000) found that universities taking an equity stake in spin-off companies realized a greater return in the long run, relative to the average revenues generated from licensing university-developed technologies. Revenues also vary by lead organization. For instance, most for-profit incubators do not receive a public sector subsidy.

In contrast to their highly varied organizational structures, most incubators have a relatively common managerial structure (Hayhow 1997b). The typical managerial structure of the incubator is that of a full-time manager in charge of day-to-day operations, delivery of complementary services, coordination of support staff activities, and a substantial portion of the marketing of the incubator at the local level. In the majority of cases, an advisory board also acts as the board of directors and supervises the manager. Often, advisory boards have the authority to assist the manager in various decision-making issues. For example, the advisory board may form a committee to evaluate potential incubator clients or establish criteria for client entry.

The typical advisory board has representation from the host organization, state or local economic development organization, local professional services network, and various community leaders. These community leaders provide complementary services pro bono or at substantially reduced rates and market the incubator to the larger community. Community leaders and representatives from the professional service network usually include other experienced local entrepreneurs, a patent and copyright attorney, an accountant, a general legal council, someone from the banking and financial community, an advertising and media representative, and, in the case of a technology incubator, various experts regarding the technical aspects of commercializing technology. The host community may also be represented by an elected or appointed official. The inclusion of a local government official may ensure revenue from the local government as well as market the benefits of the incubator to the local community and public officials.

EVALUATIVE RESEARCH ON TECHNOLOGY INCUBATORS

Growing use of the technology incubator strategy derives, in large part, from the observation that industrial innovation has had demonstrable positive effects on regional economic growth (Solow 1957; Kondratiev 1979; Marshall 1987; Freeman and Soete 1997). Given the estimate that 80% of technology incubators receive some public subsidy (Wolfe et al. 1999), it is important to assess the evidence evaluating public investment in this economic development tool. A survey of metropolitan-level economic development officials from 151 U.S. cities found that they perceived business incubation to be one of the less effective strategies for spurring growth (Clarke and Gaile 1998). Quittner (1999) echoes this perception from the general public's point of view and questions the wisdom of continued public subsidies for incubators and their client firms.[30]

Any consideration of the evaluative literature must take into account the following limitations:

- lack of consistent measures of success (Mian 1997; Grob 1998; Markley and McNamara 1995);
- failure to compile reliable data on graduates (Mian 1997; DiGiovanna and Lewis 1998);
- nascent nature of technology incubator industry (Mian 1997);
- lack of research on incubators that have failed or are less successful (Bearse 1998); and
- selection bias and small sample sizes (Bearse 1998).

Also, the lack of reliable graduate data makes it difficult to measure the economic contributions of client firms. Making such estimates may lead to small samples and a selection bias because only the more successful incubators have the resources to track their graduates. Another reason for selection bias and small sample sizes is that a significant amount of the evaluative research has been funded by state government agencies that sponsor incubators, so their evaluations focus on the incubators within their administrative boundaries. The nascent nature of the technology incubator industry has also contributed to small sample sizes and the use of inconsistent measures of success.

The remainder of this section is structured in five parts. The first part critically analyzes the research regarding the lessons learned from successful incubators. The second part reviews the evidence supporting continued public investment in business incubation, focusing on technology incubation. The third part addresses the questions whether for-profit incubators[31] have filled the market gap that catalyzed the growth in public support for technology incubators and whether the for-profit model achieves the same economic development goals as the state-supported, not-for-profit model. The fourth part examines literature on the role of the region in the performance of a technology incubator. Finally, the fifth part examines the lessons that can be learned from less successful incubator programs.

Evaluating the Best Practices: Lessons Learned from Successful Incubators

Social scientists and economic development officials eager to understand what factors contribute to the success of business incubation—and how to replicate these practices—have focused their research on successful incubators (Peterson et al. 1985; Campbell et al. 1988; Smilor and Gill 1986). [32] These best practices guidelines have had demonstrable positive impacts on incubated firms (Kang 1991; Rice 1992; Campbell et al. 1988; Lichtenstein 1992).

One of the earliest evaluation pieces, sponsored by the Council for Urban Economic Development, surveyed 50 successful business incubators, stratified the survey sample by external affiliation (i.e., public nonprofit, university related, or private), and analyzed the types of firms and their needs relative to the services provided (Peterson et al. 1985).[33] It concluded that the range of services provided by the incubator were determined, in part, by the lead organization, its location (urban versus rural/small town), and the target population (mixed-use, retail, technology, etc). Another important finding was that a key factor in the success of a business incubator was its level of financial stability.

Allen and McClusky (1990) demonstrate that to achieve new firm formation, graduation, and job creation by business incubator clients requires patience from government sponsors or investors. From a governmental economic development perspective, the variables of graduation level and job creation closely approximate the goals of public investment.[34] While firm survival and employment growth are important, however, these measures fail to capture the long-run effects of business incubators (Campbell et al. 1988). Graduation rates and job creation do not account for what happens to firms after they leave the incubator and stop receiving subsidized benefits. Using a multiple regression analysis on data from a survey of 127 incubators, Allen and McClusky (1990) conclude that the two most important variables in new firm formation and job creation are age and size of the incubator.[35] Among the other variables they examined, only one (presence of tenant firms in the light manufacturing sector) helped explain differences in firm formation and/or job creation among incubators, but its statistical significance was weak.[36]

Kang's (1991) statistical analysis of business incubators in Michigan concluded that the public-private partnership[37] activities that contributed to success were shared general administrative services, tax exemptions, loans, and reduced rents.[38] This research also investigated variables related to business services provided, composition of advisory board, facility attributes, lead organization, revenues streams, and local community embeddedness. However, the public-private partnership variables were statistically more important and found to be more significant than incubator location, age, size, staff size, and client type. These findings are contrary to Allen and McClusky's (1990) conclusions that the two most important variables for graduating firms and new job formation are size and age of an incubator program. The difference in Allen and McClusky's and Kang's (1991) conclusions may have come about because Kang focused on understanding which elements of an incubator program contributed to the success of a client firm whereas Allen and McClusky provide a preliminary examination of the relationship among incubators' structure, policy, services, and performance (61). Narrow focus, difference in sampling frames, and use of different outcome measures (Kang used growth of sales, while Allen and McClusky used graduation and employment) are probable explanations for their conflicting conclusions.

Meeder (1993) and Bearse (1993) both argue that the evaluation of an incubator's success must be shaped by the program's design and goal. In the case of Allen and McClusky (1990),

analyzing the outcomes from different types of incubators hinders the ability of the research to evaluate each program based on its merits. In addition, it may have led to a skewed distribution of outcome measures that could be the result of program planning at some incubators, the quality of services provided, the type of firms serviced, or the environmental contexts in which they operate. Another possible explanation is that the mission of some of the incubator programs was not job creation, thus they may have been deemed successful if the evaluators' outcome measures matched the incubators' goals (Bearse 1993). Finally, the analysis of data from many different types of incubators provides little insight on the effectiveness of technology incubators to create jobs and spur regional growth. One also should expect different outcomes, in terms of employment growth in client firms, based on the type of client firms and location of the incubator (Campbell et al. 1998; Molnar et al. 1997; Peterson et al. 1985).[39]

Similar to Kang, the work of Mark Rice at Rensselaer Polytenic Institute (1992) and Gregg Lichtenstein at the University of Pennsylvania (1992) made important contributions to understanding the public-private partnership activities, processes, and structures associated with incubating successful firms in all types of incubators.[40] Rice's investigation of nine incubators, which included in-depth interviews with managers and clients, concluded that shared facilities (they saved clients' time and capital), flexible space, and affiliation with the business incubator were effective for achieving program goals. Entrepreneurs and managers of university-supported incubators and/or high-tech incubators noted, at a significantly higher rate, that affiliation with the incubator program provided credibility for the client firm in the marketplace.

Rice (1992) also determined that incubator managers' counseling of client firms contributed to the success of firms, but that managers often didn't spend enough time with clients because of inappropriate organization and financial constraints. Dedication of managers' time to activities not directly related to providing client services explains the unfulfilled demand for proactive interventions such as educational programs and training. Though gleaned from a small sample, the findings may explain why Kang (1991) found management services to be insignificant to the success of an incubator in his regression results.[41]

Lichtenstein (1992) provides empirical evidence that the networking and relationships provided by an incubator lead to improved client firm performance (in terms of increased sales, lower cost, enhanced capabilities, and reduced risk).[42] The benefit most frequently mentioned by entrepreneurs was moral and psychological support derived from being part of an incubator. They also mentioned the benefit of acquiring skills and generating new ideas derived through opportunities to observe and ask questions of other entrepreneurs and incubator staff. Firms also benefited from the opportunity to network with similar firms, as well as from relationships with the incubator manager and other individuals associated with the incubator.

Lichtenstein (1992) concludes that eight factors collectively influence the development of relationships and interactions that enhance an entrepreneur's survival skills. They are: (1) type of business, (2) personal characteristics of entrepreneur, (3) stage of firm's development, (4) existence of critical mass of firms, (5) layout of incubator space, (6) existence of forums for discussion, (7) norms and attitudes of participants, and (8) actions of the incubator manager. Lichtenstein cites the actions of the incubator manager as the most important factor in determining the types of interactions that occur within an incubator. The sentiment that the manager is a critical factor was consistent with the vast majority of interviews conducted for this research. One former practitioner, now an academic, stated that "the right person could make an

incubator work in the most undesirable location, while the wrong manager can result in failure, even if all other best practices are in place."

Paralleling this research, Hernandez-Gantes et al. (1995) probed the role of two-year colleges as providers of entrepreneurial training in the incubation process using a stratified random sample among National Business Incubation Association members. In addition to the survey, the results are based on nine case studies of incubators with one of each type of lead organization (community college, university, and no academic affiliation) from urban, suburban and rural locations.[43] The research concluded that there was a mismatch between managers' perception of clients' managerial and entrepreneurial skills and clients' assessment of their own talents. In general, entrepreneurs had a higher assessment of their skill level than managers. This mismatch, combined with managers' lack of funding to provide training, resulted in clients' poor assessment of this resource. This mismatch is also noted by Rice (1992). These results coincide with the findings of both Kang (1991) and Rice (1992) and underscore the need to provide consistent, reliable funding to incubators (Peterson et al. 1985; Allen and Bazan 1990; Campbell et al. 1988) since managers spend a significant portion of their time fundraising, which could go towards providing client services (Hernandez-Gantes et al. 1995).

Research by Shahidi (1998) tested the hypothesis that there are more networking opportunities for technology incubator client firms than for similar nonincubated firms and that these networks enhance the performance of technology incubator client firms. Shahidi concluded that these networks had demonstrable positive impacts on client firms.[44] The opportunity to access customer networks offered incubated firms more informal sales contacts. Also, the range of consultants and advisors associated with incubators provided client firms with an advantage. These benefits led to statistically higher rates of equity capital, grants, and seed fund financing for incubated firms than for similar nonincubated firms. However, access to external funding from traditional commercial sources tended to favor the control group.

Tornatzky et al. (1996, 5), in an effort to develop a set of best practices for technology incubation, surveyed 50 technology incubators that were perceived by their peers as leading-edge or best-in-class. The survey focused on nine key aspects of incubation, namely, (1) business planning, (2) finance/capitalization, (3) management development/selection, (4) research and technology, (5) markets and products, (6) legal, (7) monitoring and decision making, (8) infrastructure, and (9) management and operation of the incubator. (See Table 2 for list of best practices.) The analysis suggests that, on average, urban incubators provide more finance and capitalization services, as well as more opportunities for assistance in the area of technology and research, than rural incubators.[45] In the case of university-hosted technology incubators, the services designed to assist firms with research and technology development were more readily available and finance and capitalization services were provided at a slightly higher rate than nonuniversity technology incubators.[46]

Research sponsored by the Council for Urban Economic Development in 1985 concluded that university partnerships can make technology incubators more effective because the association of the client firm with a university is valued by the client firm and potential customers, partners, and suppliers. Mian (1994, 1996, 1997) has tested this argument in some detail, systematically analyzing (1) the hypothesis that universities provide significant benefits to client firms, (2) the differences between public and private university technology incubators, and (3) methods for evaluating a university-hosted technology incubator. Mian (1996) surveyed tenant firms from six successful university-led technology incubators.[47] The findings conclude

that university image,[48] laboratories and equipment, and student employees add the greatest value to tenant firms and make universities a viable location for nurturing new technology-based businesses. In addition, he concluded that the incubator provides opportunities for university faculty and students, as well as the potential for generating revenues for the university. DiGiovanna and Lewis (1998) found similar evidence in the case of some university-hosted technology incubators in New Jersey.[49] These results also confirm Smilor and Gill's (1986) research, which indicates technology incubators associated with universities generally focus on commercializing university-developed technologies and that the advantages of being associated with a university include (1) access to library facilities, (2) access to student labor, (3) a creative environment, and (4) exposure to state-of-the-art facilities and expertise. Administrators at public and private universities may have different motives for establishing university-hosted technology incubators, which potentially could lead to variations in the organizational design and outcomes.[50] Mian (1994) found no statistically significant differences in the outcomes, designs, organizational operations, funding sources, and menu of services offered between public and private university-hosted technology incubators.[51]

Is Incubation an Effective Use of Public Resources?

As business incubation proliferated in the 1980s, research sought to demonstrate its effectiveness as an economic development tool. Campbell et al. (1988) probed the question of business incubators as an effective job creation strategy.[52] The conclusion was that incubators had a public sector cost per direct job created that ranged from $3,500 to $10,000. Results also indicated that new enterprises that receive the benefits of a business incubator have low failure rates (13.9%), and upon graduation 87% locate locally.[53] In addition, this research concluded that the effective provision of space and business services, in combination with the supportive environment created by the business incubation process, is beneficial to the survival and growth of new enterprises. Furthermore, the research suggested that the "direct job creation function of incubators is [a] long-term [effect] at best" (Campbell et al. 1988, 67).

Research of public sector–supported technology incubators indicates that they have been a cost-effective economic development tool in terms of public sector cost per direct job created. Though these studies are limited by their small sample size and bounded by state lines, they document that incubators have been productive state investments. DiGiovanna and Lewis (1998, 6) calculated that the average public sector cost per direct job created by six technology incubators in New Jersey was approximately $3,000, significantly less than "traditional industrial recruitment programs," which had an average public sector cost per job of over $40,000.[54] Other evidence of the public sector cost per job created by a technology incubator in the period from 1990 to 1994 indicates that it ranged from a low of $3,000 to a high of $11,353 (see Table 4). This said, the cited works are descriptive in nature and do not address the question of whether public sector investment in the incubator programs was causal in the formation and survival of new firms.

Allen and Bazan (1990) probed the performance of incubated versus similar nonincubated firms in Pennsylvania.[55] This research compared 226 client firms across Pennsylvania to a control set of 277. The authors conclude incubator tenants have a better survival rate and out-perform nonincubated firms in terms of growth of sales and employment, but postgraduation there is no significant difference in performance between incubated and

Table 4: Public Sector Cost per Direct Job Created by Technology Incubators

Author	Year	State	Public Sector Cost per Job
Maryland Department of Economic and Employment Development	1990	Maryland	$3,000
Digivonna and Lewis	1998	New Jersey	$3,000
Culp	1996	Georgia	$3,785
Roberts at. el.	1990	Iowa	$5,916
Human Resource Investments	1994	Ohio	$6,609
Human Resource Investments	1994	random	$11,353

Sources: Culp (1996), Robets et al. (1990), Human Resource Investments (1994), Digiovanna and Lewis (1998), and Maryland Department of Economic and Employment Development (1990)

nonincubated firms. However, the authors also suggest that incubators may provide benefits that were not captured by their analysis. Some of these benefits include the neighborhood effects that public investment may have, such as the emotional lift a community may experience as a result of seeing an abandoned facility converted to an incubator and providing new opportunities for employing local residents. Included in the report is the Pennsylvania Incubator Association (PIA) response, which criticized it on a number of fronts. PIA questioned the comparability of the control group because the data for the control group were collected two years prior to the study and the questions asked of client firms were designed to be compatible with the earlier study. The PIA claimed that this introduced a bias that arbitrarily limited the scope of the evaluation, thus missing many of the contributions of incubator programs to their clients and communities. Furthermore, there was a potential to introduce error into the results because the data for the control group were collected under different economic conditions and the geographic distribution of firms was skewed to favor the control group.[56] As Allen and Bazan acknowledge, the aggregation of client data may hide local benefits, but it also distorts the results for other reasons. Combining the data for all incubator programs creates the potential for skewed results because of diversity among incubators.

In an examination of the Georgia Advanced Technology Development Center's (ATDC) incubator, Culp's (1996) conclusions are similar to Allen and Bazan (1990). Using statistical methods to compare ATDC clients to a control group of similar, young (less than three years old) technology firms also located in the Atlanta region, results indicate that while receiving subsidized benefits as tenants, incubated firms out-performed the control group in terms of employment and sales growth rates. However, evidence from the comparison of graduate firms to a control group of similar firms calls into question the long-term benefits of incubation programs to their client firms. There was no statistically significant difference in employment and sales growth rates between treatment group (ATDC graduates) and control group.

Though Culp (1996) controlled for age, location, and type of firm, her sample sizes are small. The number of ATDC clients was 11 (six tenant and five graduates) and there were 13 in the control group (seven compared to the tenants and six to the graduates). In the analysis of growth in sales, Culp excluded the fastest-growing firms in all groups. By discarding the fastest-growing firm in the graduate group, the average rate of increase for sales dropped from 116% to 32%. While the control group's rate decreased as well, the difference was a significantly smaller decline from 40% to 28%.[57] Although the exclusion of outliers is a common practice in statistical analysis, in the case of analyzing the growth of young technology firms it is problematic because the marketing skills and financial assistance provided by ATDC may have been integral to this firm's success. The typical growth pattern of a startup technology firm is

that it has accelerated growth once it introduces its newly developed product or service to the market, provided it has the marketing skills to identify a substantial customer base and adequate financing to ramp up production to meet demand.

Culp (1996) also explored the rate of university-developed technology transfer to ATDC clients relative to the control group. Her results indicated that there was a higher degree of university technology transferred to the ATDC clients. However, the time from development to market—a critical factor in the success of startup technology firms—indicated that there was no significant difference between the two groups, with each group averaging approximately three years.

Culp's (1996) evaluation raises some doubts regarding the capacity of technology incubators to significantly change the rate of innovation and the performance of its client firms after graduation. However, it can be argued that the small sample sizes and the single case study are insufficient evidence and a large empirical analysis needs to be conducted, as suggested by Tornatzky et al. (1996, 157–158).

In 1997, the NBIA joined with the Southern Technology Council, the University of Michigan, and Ohio University in a study funded by the Economic Development Administration (Molnar et al.1997; Sherman and Chappell 1998).[58] This research demonstrated that incubated firms vary in their growth rates and aggregate sales, depending on their incubator type. For example, average annual sales across the sampled technology incubator clients were found to grow 10% faster than the sample of empowerment incubator clients, and 6% faster than the sample of mixed-use incubator clients. Aggregate sales for the sample of technology incubator clients were also substantially larger (Molnar et al. 1997, E-4).[59] In addition, the research concluded that, for all types of incubators, the average return was $4.96 per $1.00 of public support, the average public sector cost for both direct and indirect jobs created was $1,109, and the average regional job multiplier was 1.5.

This research has been criticized because of its small sample size (51 incubators, 11 of which were technology incubators) and biased sample selection (only successful facilities) (Bearse 1998).[60] Use of the regional econometric forecasting model (REMI) as the economic evaluation technique without specifying study areas or informing readers of the other assumptions used when running the model diminishes the credibility of the results.[61] With any regional economic forecasting model, impacts will vary significantly between incubators in urban and rural regions, or between a technology incubator and an empowerment incubator, or between regions defined as labor market area and a single county. It is also likely that in an urban region the impacts of an incubator (average sales multiplied by average number of clients) will be undetectable using a regional economic forecasting model because of the sheer size of the economy in which the facility is hosted.[62]

Markley and McNamara (1995) also utilize a regional economic model to estimate the returns on public investment from a single business incubator.[63] Responses to the survey of client firms suggest that the most prominent reasons why a tenant locates at an incubator are (1) reduced rents (46%), (2) the nurturing environment (20%), and (3) the space meeting their needs (16%). Over the seven-year period of analysis, there were 319 direct jobs created by incubator clients and the public sector cost per direct job created was $6,580. The local economic impact, as estimated by IMPLAN,[64] a regional input-output economic assessment model, were as follows: (1) 152 indirect jobs created, (2) approximately $22.5 million in sales and wages of

client firms resulted in an estimated $8.7 million additional income in the region, and (3) state tax coffers benefited by an increase of $363,138 in average annual taxes collected. However, the authors recognize that the ability to generalize these results is weak because the data input for the forecast was from a single incubator.

For-Profit Incubators

Attendees of the 2000 Annual NBIA Conference in Cleveland included a proliferation of individuals associated with for-profit incubators, indicating that there has been dramatic growth in this industry segment. The model for a for-profit incubator ranges from what looks rather like a real estate venture (by the definition used in this research and the industry in general these facilities would not be categorized as incubators) to incubator programs run by venture capital firms that provide the full gamut of services discussed above. The investor extracts profit from the facility through different strategies. Often several strategies are combined. In the real estate model, the sole source of revenue is rental income from the client. In some cases, fees-for-services are another source of revenue, but in many cases the investors take an equity stake in the tenant firms.

While there are many similarities between the for-profit and not-for-profit models of business incubation, there are also some crucial differences. One difference is that the average number of tenants housed at a for-profit incubator (40) is more than double that of the not-for-profit sector (17) (Nash-Hoff 1998). For-profit incubators also tend to have much more space, an average of 87,000 square feet compared to roughly 24,000 square feet for not-for-profit incubators. Since the amount of space dedicated to administration and shared uses is relatively the same, it appears that tenant firms at for-profit incubators tend to occupy more space. This occurs, in part, because for-profit incubators have less incentive to graduate firms and prefer to let them expand within their facilities, thus continuing to collect rent (Nash-Hoff 1998). It can be argued that this indicates one of the central tensions in the for-profit model.

Nash-Hoff (1998) explores the set of best practices for a for-profit incubator. Her descriptive analysis of the data regarding size, employees, etc., is presented and four typical development models are outlined, as well as a list of suggestions regarding building requirements, entrepreneurial services, and organization structures.[65] The list of planning elements, building requirements, and entrepreneurial services provided reflects the findings in Meeder (1993) and are listed in Table 2.

The most telling theme in the Nash-Hoff report is the need to balance the desire for profit with the provision of value-added services for clients, which increases costs (Nash-Hoff 1998, 25). While "wealth generation" for client firms is not necessarily in conflict with economic development goals, the means to achieve it may be. For example, an incubator program may achieve wealth generation for clients without achieving job growth in the host region. In public sector–sponsored incubators, in the interest of local job creation, there is an incentive to work to assist the client firm to stay and grow within the host region. In contrast, if a for-profit incubator can maximize profits by selling a developed technology to an entity outside the region, it will do so without regard for broader economic consequences. To date, there is no research that compares performance or locational behavior of graduates from non-profit incubators to graduates from for-profit incubators.

Furthermore, the desire for profits may lead to "creaming" the available pool of new enterprises. This practice may mean that some of the firms receiving assistance could survive in the open market without that help. Because of the potential that for-profit incubators cream the entrepreneurial pool and the not-for-profit incubators may be weighted towards nurturing earlier-stage enterprises, any analysis comparing the two populations must explore and control for this bias. At three public sector–supported technology incubators in New Jersey, managers indicated that client firms entered their incubator at varying stages in the commercialization process, often with not much more than an idea regarding the technology they hoped to commercialize, suggesting that these incubators take clients at a very early stage in their development (Harmon 1998; Lisowsky 1998; Gaburo 1998).

Nash-Hoff (1998) interviews with 50 for-profit incubators revealed that nearly one in five had closed or was in the process of closing. There is no analysis of why these programs failed. A number of industry analysts have stated that the for-profit incubators are currently in a phase of "cannibalizing themselves" since the market is collapsing after a period of overexpansion. Furthermore, some analysts predict that only one in four of the for-profit incubators that sprang up over the past three to four years will survive the next three to four years (Schubarth 2000).[66] The rate of closures among for-profit incubators, as indicated in the research by Nash-Hoff (1998), is over double the average rate of closures (9.7%) among the technology incubator population studied in this research.[67] It can be argued that it is unfair to compare incubator closure rates between the for-profit and not-for-profit models because not-for-profit incubators are somewhat shielded from competition in the market. However, this view also suggests that not-for-profit incubators are better positioned to assist earlier stage technology entrepreneurs who face a longer time to market, thus delayed return on investment.

Though Quittner (1999) argues that the public support of incubation should be curtailed because the market is currently filling the demand for incubators, he fails to address the high rate of closures among for-profit incubators and the effect that the different motives of for-profit and not-for-profit incubators may have. Anecdotal evidence from Dallas, Texas—where two for-profit incubators that were established in 1992 during a difficult economic climate failed while the not-for-profit incubators survived—suggests that the fundamental differences in the two models need to be further investigated. Clearly it is premature to eliminate public support given our present knowledge of the for-profit incubator model and limited comparative research.

Regional Effects

An evaluation of the potential of technology incubators to spur economic growth is particularly important in relatively rural regions, where investment capital is scarcer and the region lacks the forward and backward economic linkages of larger metropolitan regions (Glasmeier 1991). This issue touches on a long-running national debate regarding where to invest in science and technology. Should investment be focused in areas that have the strength to capitalize on relatively larger economic multipliers, thus giving a greater return to public investment? Or, alternatively, knowing the difficulties, should investments be made in more rural areas seeking long-term returns and increased diversification of economic activities in a rural location (Calzonatti and Gatrell 2000)? Historically this has been a national debate. With fiscal and policy devolution the emphasis has shifted to increased state and local responsibility, forcing state policy makers to grapple with this thorny question (Parker 2001). [68]

The effect of an "urbanized economy" on the pace of firm growth, the development and diffusion of technology, and the relationship between innovation and regional economic health has been the subject of study among regional economists, geographers, and planners for more than a century. An urbanized economy can be characterized as a location with sufficient density of economic activity to benefit from co-location of a diverse array of industries. The benefits (and cost) of the dense heterogeneous mix of industries accrue as a result of functional specialization, close proximity, and spatial interdependence (Harrison et al. 1996). These locations are more likely to attract universities, industrial research laboratories, trade associations, and other knowledge-generating institutions. Furthermore, the diversity improves the opportunity for interaction with others in both similar and different industries, increasing the likelihood that one will copy the practices used by trend-setting peers or transfer knowledge from one industry to another, thereby increasing the pace of industrial innovation. These activities, in turn, generate a diverse range of skills in the workforce and are conducive to new skill formation, which perpetuates the cycle and increases the pace of investment, innovation, and economic growth. Finally, the diverse set of industries and skill sets in the workforce increase the potential for local supplier networks, which increases the multiplier effect of investment in an urbanized economy.

Wolfe et al. (1999, 2000) developed a theory about the characteristics of a region that will increase the likelihood of successful incubation of start-up technology firms. Some necessary, but not sufficient, regional characteristics for successful incubation include:

(1) Presence of one or more technology generators. A technology generator is an institution—such as a university, national laboratory, or private research and development laboratory—that ensures a sufficient concentration of human capital and engages in an adequate amount of R&D to produce numerous opportunities for new commercialization ventures.[69]

(2) A sufficiently skilled labor force that can provide potential clients with employees who have the critical skills to fill the newly created technology-oriented jobs.

(3) A technology culture in the community, that is, a location where failure at one new technology venture is not considered the final opportunity for an entrepreneur. In other words, investors and the community-at-large understand the risk of technology ventures and thus applaud the attempt and encourage second chances. Wolfe et al. (2000) cites Silicon Valley as an example of a location that has a technology culture.

(4) Sufficient investment capital activity in the region, including angel investors, venture capital, traditional financial markets, SBIR grants, state-funded seed and venture funds, and corporate partnership money.

Campbell et al. (1988) provide some evidence that the host region will affect outcomes. They found that the exact cost per job varies based on some regional characteristics and the type of firm incubated. Client firms in regions that have large corporations that purchase from them appear to have higher growth rates. Also firms that provide products or services purchased by the government or are highly specialized have a relatively greater potential for faster growth (Campbell et al. 1988). Similarly, the presence of a university has been demonstrated to have positive correlation with client firm success (Peterson et al. 1985; Mian 1996; Smilor and Gill 1986). The host region may determine the types of services provided by an incubator program (Peterson et al. 1985; Tornatzky et al. 1996).

Provided the region can support a technology incubator and it follows the guidelines established by the best practice literature, a technology incubator can function as an economic catalyst that serves as a focal point for a broad array of policies that can help establish a new economic cluster in the region or support an existing cluster. However, theory and experience suggest that for less diverse regions this is a long-run strategy and will require a sustained commitment by the community. In addition, since profitability requires several years of operation, establishing a technology incubator in a less desirable region will probably also require significant initial public investment for both startup expenses and operating costs. In more developed regions, a technology incubator can accelerate growth through improving the success rates of new technology ventures and preparing them for fast growth (Wolfe et al. 2000, 9).[70]

Lessons from Closures

The literature in support of business incubation has been criticized for not investigating "less successful" or closed business incubators. Though some of this research provides lessons regarding why an incubator program may fail (Wolfe et al. 2000; Smilor 1996), we currently do not have enough empirical evidence to support these claims. Smilor (1996) suggests five potential reasons for failure that are, in essence, the flip side of the best practices, thus not offering a tremendous amount of new insight. The reasons are (1) inflated expectations, (2) selection of the wrong manager, (3) overestimation of the incubator's role in an economic development plan, (4) overspending, and (5) a failure to leverage resources. Meeder (1993) suggests that communities need to understand that business incubation is a long-term strategy, thus inflated expectations and the overestimation of their contributions to local economic development goals can be avoided through the feasibility study process. Feasibility studies should also provide a reasonable estimate of development costs, future revenue streams, and the cost-benefit ratio of the investment. Increasingly, the incubator community has begun to develop a better understanding of the skills an incubator manager needs (Hayhow 1999).[71] Some characteristics and skills that are common amongst good incubator managers include (1) a diverse skill set, (2) good problem solving skills with an ability to prioritize and expedite action, (3) a passion for detail yet coupled with the ability to multitask, (4) a team player with a good knowledge of the community, and (5) someone motivated by a challenge. Two important traits that are related to the best practices are that the manager has local knowledge and is motivated. Local knowledge will help integrate the incubator program into the community and find the right connections for clients, while motivation helps champion the program.

In the course of this research, I have compiled anecdotal evidence to suggest that there may be other reasons for failure. In one California case, the location of a technology incubator facility deterred client entry because rush hour traffic patterns discouraged entrepreneurs from leasing space there. In another case, it appears at a cursory view that the lack of relationships with local institutions—as well as management brought in from outside the region—was the primary reason for the failure of a technology incubator in the southeastern United States. In Florida, a number of technology incubators have recently cut back staffing—in at least one case the manager is now only a part-time position—and no longer provide the full array of business services as a result of the withdrawal of public support for their programs. Allen and Bazan (1990) conclude that many incubator programs may never reach self-sufficiency, thus the need

for continued public investment. These three examples suggest that we need a more complete understanding of the factors that may lead to less-than-optimal operation of a technology incubator.

CONCLUSION

To this point I have focused on the findings of research that has, with varying degrees of rigor, argued that incubators are effective economic development tools that contribute to the formation and success of new firms as well as job creation. I have also reviewed research that empirically tested theories regarding the industry's best practices.

The literature reveals that there is a set of best practices that enhance the performance of business incubators. Networking opportunities are an unmistakable component of successful business incubation. More states are increasing their attention to the provision of value-added services in their review of funding applications for business incubators. In the case of technology incubators, states are also increasingly aware of the importance of understanding technology incubation as part of a broader technology-driven development strategy. However, the literature offers less evidence regarding complementary state development programs. Though Kang (1991) found that tax credits and loans were significant complementary programs at the state level, there may be other state or local policies that enhance business incubation. Scholars must now examine the relationship between locational factors and the successful incubation of new technology ventures. By pursuing these areas of research, we may understand (1) the appropriate government role for supporting technology business incubation as a piece of a technology-driven economic development strategy with complementary polices and/or continued funding, (2) the regional characteristics that enhance technology incubation, and (3) the factors that lead to less-than-optimal technology incubation.

To assess economic contributions and confront the criticism of Quittner (1999), there is a need for research comparing incubated firms to similar nonincubated firms on the basis of age, size, economic sector, business organization, and location. Past attempts to do this have been hampered by issues of cost, lack of reliable data to identify a control group of similar nonincubated firms, or insufficient time. In addition, future research needs to assess whether the new wave of for-profit incubators is filling the same market space as the not-for-profit ones and achieving the same economic development goals that catalyzed state investment in technology incubation. Furthermore, there is the question whether not-for-profit incubators are crowding out for-profit incubators.

In conclusion, business incubation can be considered a cost-effective economic development strategy for state and local governments in terms of public sector cost per job. The evidence suggests that if a thorough and objective feasibility study is performed, the best practices are followed including the patient provision of sufficient funding, business incubators can ensure the survival of graduate firms at a significantly higher rate than the general population of new ventures. Furthermore, there is a high probability that the incubated firms will locate in the region of the host incubator, so they are likely to provide some return on the public investment through taxes paid by the firms and their employees. There is also some evidence that business incubation may help regenerate public confidence in the face of the loss of a major employer and overall decline (Allen and Bazan 1990).

Results regarding the long-term performance of graduates are less clear. As the trend to take an equity stake or have a royalty agreement with client companies continues to grow, the

opportunity to increase returns on public investment should increase. This is particularly true for university-based technology incubators. Finally, based on our current knowledge of the for-profit incubator model, it would be premature to withdraw public investment in technology incubators in hopes that the for-profit incubators will accomplish the same economic development goals.

ENDNOTES

[1] The states' policy action was a response to both federal devolution and structural arguments that local and state governments have limited control over the majority of economic forces as a result of increasing mobility of capital and labor.

[2] Feller (1992, 1997) and Coburn and Brown (1997) present evidence that states are increasing their role in the national innovation system both as a result of federal devolution and as a catalyst for economic growth.

[3] For details regarding optimal physical layouts, common physical needs, evaluating re-use of existing buildings, and other "brick and mortar issues" see NBIA (1992) and Gerl (2000).

[4] Firms that are "hatched" into the open market—having met predetermined goals—leave the incubator at a prearranged time. These firms are commonly referred to as graduates. (See Appendix A for a glossary of terms.)

[5] This estimate is from the latest, soon-to-be-published industry survey completed by the NBIA.

[6] This is an unconventional use of the term "industry" but, for the sake of convenience, the collective of all business incubators and the subset of technology incubators are referred to as the business incubation and technology incubation industry, respectively.

[7] Between each of the steps in the innovation process there is a potential gap. For example, if research scientists are not effectively communicating the potential commercial uses of new discoveries, then a gap between basic and applied research will emerge.

[8] Some incubators are self-defined as technology incubators even though only 20% to 30% of their client base is technology oriented. Complicating the issue is the fact that there is no standard definition of "technology firm." See Appendix C for a review of the literature on defining a technology industry/firm.

[9] The average annual operating cost of a targeted incubator is $448,629, which is 40% above the industry average. The significant majority of targeted incubators are technology focused (Wolfe et al. 2000). A software incubator would be an example of an incubator that is classified as a targeted incubator that would also be considered a technology incubator.

[10] See Appendix B for a typology of economic development policies. Theoretically, policies in the "entrepreneurial" category should enhance technology business incubation efforts.

[11] Harrison et al. (1996), Malecki (1997), and Markusen (1987) all provide good reviews of the regional development literature regarding innovation and agglomeration.

[12] Bennett Harrison, in his book, *Lean and Mean*, presents a theoretical and empirical critique of small business as the current and future economic engine of the economy. However, he does acknowledge the role of well-developed supplier networks (small and medium-sized firms) in the locational calculus of new large firms' production facilities.

[13] The linear model of innovation became the dominant theoretical paradigm with the publication of Vannevar Bush's report, *Science—The Endless Frontier: A Report to the President on a Program for Postwar Scientific Research*.

[14] Wallsten (1998) argues it may not be true that small firms have been unfairly excluded from government funding. He also argues that SBIR funding crowds out industry R&D.

[15] Smith (1991), Schumpeter (1989), Pinch and Bijker (1987), Castells (1996), and Kline (1995) all stress the fact that technological change and innovation need to be understood in relation to the social structure in which they occur. Kline (1995) sees the need to create a new term, "socio-technical system," to describe the interactive process between science, innovation, and the social structure in which they are embedded.

[16] In some cases, technical expertise and laboratory access are provided by linkages to a private firm or government-owned laboratory.

[17] In general, startup technology firms cannot afford to purchase expensive, cutting-edge testing and prototyping equipment. In a technology incubator, this equipment is often provided by the lead organization.

[18] By 1985, a critical mass had formed and the National Business Incubation Association (NBIA) was founded as the principal nationwide advocacy group for the industry. In brief, the NBIA provides technical assistance to incubators and communities that desire to establish an incubator and serves as the nerve center of a network through which industry actors can share experiences and learn from one another. The NBIA also sponsors and organizes national and international incubator conferences, publishes and distributes a quarterly newsletter and industry directory, as well as funds and conducts research regarding the performance of the industry, best practices in the industry, and other critical areas of research. Currently, there are 18 state and one regional incubator associations in the U.S. that provide similar services to the industry.

[19] The NBIA and Small Business Administration also include in their definition the need for a multitenant facility with reduced rent for client firms and on-site management to deliver a menu of business assistance services designed to lead new enterprises to self-sufficiency (NBIA 2001; US Small Business Administration 1986, 3–4).

[20] Saxenian (1994) emphasizes these informal networks as a critical difference in two technology regions and asserts that they were causal in the growth of Silicon Valley. Much earlier, Marshall (1920) coined the phrase "information is in the air," emphasizing the importance of proximity.

[21] Stakeholders include local government officials, professional service providers, members of the finance industry, entrepreneurs, etc.

[22] Other research institutions, including large firms, national laboratories, or private research laboratories, are sometimes hosts for technology incubators. Access to their research capabilities can be substituted for those of a university.

[23] In a small number of incubators, a group medical plan is provided for client owners and employees.

[24] The NBIA is still compiling the data from a recent survey of the industry and has not released final calculations which, will give further details regarding the breakdown by industry segments (Vellena 2001).

[25] The latest survey also indicates that roughly 45% are in urban settings, 19% in suburban areas, and 36% in rural settings.

[26] There is a need to distinguish between "technology" incubators and "e-commerce/Internet" incubators because discussions with many industry experts cite significant differences between them. As electronic commerce moves into the mainstream, it can be argued that, while these firms utilize a technology, it really is a sales platform analogous to catalog sales with a more sophisticated inventory, marketing, and distribution system.

[27] Closure was confirmed by following up on contact letters returned without forwarding address and non-responses. The follow-up had three strategies. The first stage was to call the incubator. If the number was no longer listed, I searched the latest incubator association's membership list. The final step was to speak with an incubator industry analyst at the state or national level to confirm a closure or, in many cases, contact economic development officials in the host region to ask if they could confirm the closure.

[28] This statement is based on interviews with industry analysts and recent data collected by the NBIA.

[29] Kalis (1997) suggests that equity and royalty agreements may be a good practice for incubators and provides a framework for structuring equity and royalty agreements, as does Wolfe et al. (2000).

[30] Quittner's (1999) evidence has been questioned by experts in the field. Nonetheless his work is a refreshing deviation from the overwhelming majority of 100-or-so popular press articles reviewed. The vast majority of articles in major newspapers and business magazines are stories regarding the opening of a new facility or touting the success of an existing incubator. A typical example is that when Charleston, South Carolina, opened a technology incubator, the local media sung its praises regarding the future of the region (McDermott 1997). However, the facility closed a short time after the opening and I could not locate a single article on the closure. Phone calls to local reporters and economic development officials confirmed the observation that there were no published articles. This anecdotal story played out in three other cities (San Diego, California; Vienna, Virginia; and Aiken, South Carolina), where technology incubators opened and subsequently closed.

[31] Incubators organized as a for-profit business entity will be referred to as the "for-profit model."

[32] Successful incubators were usually defined as those graduating firms or selected by peers and industry experts.

[33] Definition of an incubator matched that of Allen (1985) and Gatewood (1985). The authors label their sample as successful incubators based on a consensus of industry experts.

[34] From the investors perspective, new firm formation and graduation are prerequisites to turning a profit.

[35] The authors do control for the fact that older facilities and facilities with relatively larger numbers of tenants have had more opportunities to graduate firms and create more jobs (Allen and McClusky 1990, 72).

[36] The authors suggest that the reason why the light manufacturing variable presented itself as a somewhat relevant variable is because these firms tend to have higher numbers of employees.

[37] Public–private partnership activities are governmental policies, with supportive investments, designed to encourage entrepreneuralism and private investment.

[38] Results based on a survey of 173 client firms and 93 graduates from 11 different incubators.

[39] Duda (1993) examined the effects of program design, implementation, and bureaucratic motives on the public policy outcomes of the Ben Franklin Partnership Program in Pennsylvania. The research documents that differences in motives and program design impede successful implementation of incubator programs. In Duda's work, the outcomes chosen for measurement were dependent on the stated goals of the incubator. For example, since the goal of the Bridgework Incubator in Allentown, Pennsylvania, was new company formation and jobs, outcome measurement utilized survival rate of new firms and number of jobs created.

[40] These researchers do not provide insight into the impact of an incubator on a regional economy, the pace of innovation, or the locational context appropriate for this economic development tool.

[41] Tornatzky et al. (1996) also assert that the management of an incubator program is one of eight critical factors that successfully nurture new technology enterprises.

[42] Lichtenstein's (1997) thesis is a detailed case study of two incubators (Fulton-Carrrol Center in Chicago and the Enterprise Development Center, Boston).

[43] The research was designed to include in the sample 25 incubators with a community college as the lead organization, 75 university-sponsored facilities, 100 incubators with no academic affiliation, and 1,000 client firms. The response was 160 client firms and 74 managers.

[44] Shahidi (1998) surveyed 383 nonincubated, small, high-tech firms less than eight years old and 284 technology incubator clients. The response rate was 23% and 25%, respectively. He did not control for region.

[45] The analysis does not test for statistically significant differences. The measures are strictly descriptive average differences. In addition, the research did not look at any outcome measures or attempt to benchmark the quality of services provided.

[46] This pattern of university and urban incubators providing relatively more services than their counterparts was fairly consistent for all relevant categories.

[47] The survey of firms had a response rate of 32% (47 of 150).

[48] Client firms believe that association with the university image confers legitimacy in the marketplace.

[49] Interviews conducted with administrators of universities that host technology incubators as well as other industry analysts support this conclusion.

[50] Gwynne (1998) asserts that universities provide entrepreneurial assistance to faculty members and business incubators for a number of reasons including (1) job creation in their local area, (2) opportunities for the university to license technologies or take equity stakes to develop a revenue stream, and (3) as a faculty development and recruitment tool.

[51] Mian's (1994) conclusions are based on a survey of 30 university-hosted technology incubators.

[52] Included in this case study were 13 incubators in the U.S. and Canada that had been in operation for at least three years, housing a total of 71 client firms. Though efforts were made to identify a control group to benchmark the difference between client firms and the general

population of startup enterprises, they were unsuccessful because of cost, lack of time, and unavailability of reliable data.

[53] Smilor and Gill (1996) and Allen (1985) also found that 85% or more of firms plan to or did locate locally after graduation.

[54] See Appendix B for a list of traditional industrial recruitment economic development policies.

[55] Similarity of firms was determined by SIC code, age of firms, startup problems experienced by firms, startup resources, and characteristics of entrepreneurs (in terms of age, education, and experience). There was a geographical bias that favored the control group.

[56] To be an accurate evaluation, the firms must be similar in size, age, business organization, economic sector, and regional location (Bearse 1993).

[57] The level of significance used in the Mann-Whitney two tail test of difference of means was relaxed to .2. By relaxing the level of significance, smaller differences in the means will be statistically significant.

[58] Sherman and Chappell (1998) provide a detailed explanation of the methodology and restated Molnar et al.'s (1997) conclusions. Sherman is one of the co-authors of the original work.

[59] The authors attempted to identify a control set of firms to which to compare incubator clients but were unsuccessful because of cost and time limitations.

[60] Bearse (1998) also criticizes this work for its failure to acknowledge and build on directly relevant previous work, such as Bearse (1993).

[61] A Regional Economic Modeling, Inc. (REMI) model is used to generate an economic forecast for a region (or multiple regions) based on national econometric forecasts that are scaled down to regions. It incorporates econometric estimates of the relationships between key factors such as population, employment, income, wages, prices, trade, and migration by industry and by region in order to produce regional economic forecasts. Built upon the baseline economic forecast by the US Department of Labor, REMI allows users to model how the forecast would change in response to different stimuli that occur within a region including, though not limited to, changes in the final demand for regional products, labor, or investment. In order to measure regional impacts, the national forecasting of the US Department of Labor is systematically adjusted according to the historical performance of the region, from 1969 to 1997, relative to national indicators, to generate regional purchase coefficients, regional trade coefficients, and other important characteristics regarding migration and population growth.

[62] At an average of 17 clients per incubator and 10 graduates with sales of $10 million per firm, the total economic activities would be $270 million annually. If the location of the incubator were Chicago, where the gross regional product for the labor market area is nearly $291 billion, incubator activities would be slightly less than 1% of the economy. Thus it is difficult to discern its impacts. I would argue that it is necessary to use a labor market area as the correct spatial scale, since this ensures that one captures the wage effects without artificially concentrating their effect in a single county or two. The same can be argued regarding supplier networks. The regional gross estimation is from a 26-region REMI model using the CMSA of Chicago as the region and reported in 1999 dollars for the calendar year 1999.

[63] The host region had a population of 117,206 and was centered on the small metropolitan area including the hinterlands, where 18% of the population was classified as living in rural counties

(Markley and McNamara 1995). Given that the authors specify the size of the region, which captures the commuting area, and provide the reader with the assumed multipliers for manufacturing (1.57) and service (1.29) jobs, and given the relatively small size of this regional economy, this use of a regional economic model is not open to the criticisms that diminish the validity of Molnar et al.'s (1997) findings.

[64] IMPLAN is an economic impact assessment model that allows users to estimate the effects of economic changes (investments or job losses) on their states, counties, or communities. Its core is a local-level input-output model that generates the effect of a change in the specified regional economy based on historical economic data that includes interindustry purchases, regional purchase coefficients, exports from the region, and employment (IMPLAN 2001).

[65] Nash-Hoff's (1998) findings are based on a survey from a sampling frame of 52 for-profit incubators with a minimum of 10,000 square feet and in operation for three years.

[66] Schubarth's (2000) conclusions are based on the research of Hanson et al. (2000). The population of incubators examined by Hanson et al. was international, though the majority were located in the US. Another important aspect of their sample is that it was heavily weighted towards Internet/e-commerce incubators.

[67] This is not a direct comparison between for-profit and not-for-profit technology incubators because the population analyzed for this research contained both models.

[68] Calzonatti and Gartell (2000) describe the challenges for West Virginia in developing its first statewide science and technology plan for economic growth.

[69] According to Devol (1999, 13), "Research centers and institutions are undisputedly the most important factor in incubating high-tech industries."

[70] Wolfe et al. (1999, 2000) provide evidence to support this statement from a survey of successful technology incubators as well as citing other relevant literature.

[71] Nash-Hoff (1998) asserts that to be successful an incubator needs an "entrepreneurial champion." This champion does not necessarily need to be the manager, though the incubator manager is a likely candidate.

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APPENDIX A: GLOSSARY OF TERMS

Advisory/Management Board: Individuals who sit on the board of the incubator. Some incubator programs have both a management board that directs the "business activities" of the incubator program—such as budgeting, personnel matters, etc.—and an advisory board that is responsible for providing value-added business services to client firms and assisting the manager in her/his duties. In most cases these functions are combined in one board, which may have either title. An advisory board usually has representatives from the finance community, legal profession, and host institution as well as economic development professionals, the manager, members of the entrepreneurial community, and, in the case of technology incubators, technology commercialization specialists, among others. When constructing the board, it is desirable to ensure that it can assist in providing value-added service to client firms and help to embed the incubator program in the local community. The networks established by the board should benefit client firms and increase the potential of capturing the firms in the local economy after they graduate.

Affiliate Firm: A client firm that does not lease space at an incubator facility but does participate broadly in the incubator program's entrepreneurial training programs and receives business services from the incubator.

Anchor Tenant: A stable enterprise that does not participate in the entrepreneurial training programs. Usually anchor tenants are long-term and lease space at market rates. The cash flow provided by an anchor tenant's rent helps the incubator meet its financial obligation. Anchor tenants may or may not play another role in the incubation process. For example, an anchor tenant may be a professional service provider and be available for client firms.

Angel Capital Investor: A private investor who invests in earlier stage companies sums typically ranging from $250,000 to $1.5 million. Angel investors tend to be individuals or small groups of investors that help entrepreneurs bridge the capital gap between the entrepreneurs' resources and traditional financial markets, including venture capital markets.

Business Incubation: A dynamic process of business enterprise development that seeks to fill the gaps in entrepreneurial development by providing a supportive environment where new entrepreneurs receive training in business management skills and marketing, buffered from stiff market forces with below-market rent, reduced fees for services, and improved access to necessary seed capital (NBIA 2001).

Business Incubators: Facilities designed to nurture young firms, helping them survive and grow during the startup period, when they are most vulnerable. Incubators provide hands-on management assistance, access to financing, and orchestrated exposure to critical business or technical support services. They also offer entrepreneurial firms shared office services, access to equipment, flexible leases, and expandable space—all under one roof. An incubation program's main goal is to produce successful graduates—businesses that are financially viable and freestanding when they leave the incubator, usually after two to three years (NBIA 2001).

Client Firm: Any firm that utilizes the incubator program as either tenant, affiliate, or graduate.

Development Team/Community Advisory Team: A group of community members that are interested in establishing an incubator program. There should be broad representation that increases as the development progresses. Often there is an informal leader(s) who champions the cause. The goal of the board is to gauge the level of community interest and support, identify potential partners, and determine if a feasibility study should be conducted. It is also common that members of this team become advisory board members.

Empowerment Incubator: An incubator focused on fostering the growth of business located in areas that face economic challenges, such as high unemployment or distressed neighborhoods. They may focus on welfare-to-work clients, women-owned businesses, or minority-owned enterprises.

Entrance Criteria: Depending in part on the sponsor of the incubator, entrance criteria for a client's admission into an incubator range from the ability to pay the rent to other benchmarks such as local ownership, potential for job creation, type of industry, and having a written business plan. Other criteria may include an evaluation of entrepreneurs' commitment to the new enterprise as well as an evaluation of their entrepreneurial skills.

Exit Policies *see* Graduation Policies.

Feasibility Study: An objective, systematic analysis to determine whether an incubator program should be established in the host community.

Graduate Firm: A client (tenant or affiliate) firm that has exited an incubator program having completed a set of benchmarked goals. Though exit criteria may also apply to affiliate forms, most often these goals are part of the lease agreement for tenant firms in an incubator.

Graduation/Exit Policies: Graduation policies have a rational hierarchy of both real estate and business-development criteria. Firms may exit the incubator as a result of not meeting the real estate criteria (such as noncompliance with the lease agreement or having reached the predesigned maximum length of tenancy), although in these cases the former client probably did not meet the other benchmarked business-development criteria and would not be considered a graduate. One business-development criterion is escalating rent over time to cushion the firm's early-stage cash flow while preparing it to pay market-rate rent over time and inducing relocation as rent approaches or surpasses the market rate. Having a flexible and explicit time limit on the length of tenancy is another best practice. One of the most important goals is firm growth. In the case of technology incubation benchmarked criteria may include prototyping, scale production, and full-scale production. The explicit length of tenancy is usually longer for technology incubators as a result of the length of time it takes to develop and commercialize new technology products and services.

Incubator without Walls: An incubator program that provides some or all of the complementary business services and entrepreneurial training programs but has no physical facility to house tenant firms. Often these services are delivered via the Internet.

Internet/E-Commerce Incubator: An incubator that fosters the development of new enterprises engaged in establishing e-commerce businesses.

Management Board *see* Advisory Board.

Manager: The executive who directs the operation of an incubator program. A manager develops and coordinates business assistance programs and usually provides one-on-one counseling and referral services to incubator clients. Other tasks include marketing the incubator program, fund raising, client screening, collection of rents and fees for service, and managing other incubator personnel.

Manufacturing Incubator: An incubator designed to assist new enterprises engaged in the manufacturing sector. Because of the needs of their clients for manufacturing space in addition to office space they tend to require more square footage than other segments of the incubator industry.

Mixed-Use Incubator: An incubator that does not focus on a particular type of firm and services clients from a variety of different industries.

Service Incubator: An incubator that fosters the development of entrepreneurial firms in the service industry. Firms range from professional services to household services and may be targeted at selected segments of the service industry.

Targeted Incubator: Incubators that focus on assisting startup companies from a specific industry.

Technology Generator: An institution—such as a university, national laboratory, or private research and development laboratory—that ensures a sufficient concentration of human capital and engages in an adequate amount of R&D to produce numerous opportunities for new commercialization ventures.

Technology Incubator: An incubator that fosters the growth of new technology ventures by helping to close the gaps in the innovation process and correct for market failures. Generally, if 50% of the client base are "technology firms" then an incubator is considered a technology incubator. There is no standard definition of a technology firm. See Appendix C for a review of the literature on defining a technology industry/firm.

Tenant Firm: A client firm that is housed at an incubator facility, receives the menu of business services, and participates in the entrepreneurial training provided by the incubator program.

Value-Added: In the incubator industry, the concept of value-added refers to the manner in which incubator programs enhance the ability of their tenants to survive and grow in the market place. The value-added components of an incubation program generally include business management and marketing training, affordable rent, shared office services, networking opportunities, financial assistance, and, in the case of technology incubators, access to host institutions' facilities and experts. For example, a university-hosted technology incubator will generally provide access to its library, laboratories, and faculty at no or reduced cost.

Venture Capital: Source of funds for earlier stage enterprises that are on the verge of product/service introduction and need an infusion of capital to ramp up to full production. These funds may also be used for research and development, testing, or prototyping. In technology ventures, generally the firm has a developed proto type. Typical funding ranges from $5 million to $15 million, the average investment growing steadily from $2.3 million in 1987 to $5.6 million in 1995 (ACE-Net). These institutional funds often include union pensions as well as individual investors' capital.

Note: Sources of the above definitions include Molnar et al. (1997), Meeder (1993), DiGiovanna and Lewis (1998), Allen and McClusky (1990), Wolfe et al. (2000), the NBIA web site at <http://www.nbia.org>, the Texas Angel Investors web site at <http://www.thecapitalnetwork.com/Txangels/TAICoApp.html>, and SBA report on ACE-Net: The Process and Analysis Behind ACE-Net (Access to Capital Electronic Network) found at <http://www.ace-net.sr.unn.edu/pub/wet/rpt-es.htm>.

APPENDIX B:
TYPOLOGY OF STATE AND LOCAL-LEVEL ECONOMIC DEVELOPMENT POLICIES

Typology of State and Local-Level Economic Development Policies

Laissez-Faire	Recruitment	Entrepreneurial
Relaxation Environmental Regulations	Direct State Loans and Loan Guarantees	Direct State Loans and Loan Guarantees
Right to Work Laws	Financing for existing plant expansion	Public Venture Capital Funds
Absence of State Minimum Wage	Financing for plant relocation	Small Business Incubation
Reduction of Workmen's Compensation Taxes	Revenue Bond Financing	Small Business Development Centers
Minimal Enforcement Agencies	Tax Abatements for Land and Capital	Technology Assistance Centers
	Accelerated Depreciation Credits	R&D Tax Credits for High-Tech Industries
	Sales Tax Exemptions on Equipment	Technology Grants
	Sales Tax Exemptions on Raw Materials	Technology Transfer Programs
	Job Creation Tax Credits	Customized Labor Training Programs for High-Tech Industries
	Tax Incentives for Industrial Investments	Export Promotion Programs
	General R&D Tax Credits	Science Parks
	Private Development Corporations	Advanced Technology Centers
	Industrial Parks	Increased Promotion of Advanced Degrees in Science,
	Enterprise Zones	Engineering and Math

Sources: Eisinger, 1988; Leicht and Jenkins, 1994; Atkinson, 1991; and Schmendt and Wilson, 1988

Note: Increasing the workforce's overall skill level via education is an example of a policy that clearly cuts across all three categories.

APPENDIX C: DEFINING HIGH-TECHNOLOGY INDUSTRIES AND FIRMS

It is imperative to operationalize a high-tech variable for the purpose of identifying high-tech firms, incubators, and regions. Past attempts have indicated that this is a complex and difficult problem. Initially, attempts were made to define high-tech without a theoretical understanding of high-tech. This led to completely subjective interpretations. Second, high-tech is a moving target—what is considered cutting-edge innovation today may well be a mature and diffusing product or process tomorrow.[i] The third problem relates to the availability of data and the classification methods of the North American Industry Classification System (NIACS) and its predecessor, the Standard Industry Classification (SIC) code, which generally lacks categories for emerging technological industries. In the case of environmental technologies, the various different entities working in this field were placed in SIC codes such as chemicals or, worse yet, in the not-yet-classified category. The problem is compounded when the code is updated to meet its limitations, by which time tracking a new industry becomes nearly impossible.

Early research on the importance of high-tech industries to regional economic growth and expansion applied a very simplistic definition, which is still used today although more rigorous research has moved beyond it. Essentially, this definition of high tech—"you will know it when you see it"—was the view of some economic development officials and technology incubator managers. In other words, it is the degree of perceived sophistication that determines whether an industry, firm, or product is high-tech.[ii] While the intuitive nature of this method is appealing there are obvious problems including: 1) it is subjective, 2) there are no working criteria to sort the industries of interest (Markusen et al. 1986, 11), and 3) one cannot determine which part of an industry or firm at the establishment level is performing the defined high-tech activity, limiting the usefulness of the data in regional analysis. The problem of capturing the type of activity occurring within an establishment is common to the majority of data sets. This is an increasingly acute problem as firms vertically disintegrate and the spatial division of labor grows. For example, an establishment within a defined region of analysis might be reported in a SIC code determined to be high-tech, but the activity within this establishment may be an unsophisticated component of the production process, such as wholesale distribution.

High growth rate in employment has also been used as a means of distinguishing high-tech from low-tech industries (Technical Marketing Associates 1979). The theoretical underpinnings of this definition are that industries in the innovation stage of development will see rapid expansion in employment, thus faster growing industries are innovating and technology-oriented. Again some obvious problems with this methodology are present. The most glaring is a tautological error: Because we anticipate that high-tech industries will grow rapidly, they can be defined by this criterion. This translates into two problems. The first is that industries can experience rapid growth for many reasons. Trade policies, increased demand as a complementary good to some other product, increased demand as a substitute good for some other product, a structural shift in the economy, and inflation are just some exogenous factors that may explain rapid employment expansion in a non–technologically oriented industry. Second, the period of study may skew the growth rate, so that an industry in its earliest stages of infancy may not be included in the mix.[iii] A high-tech industry may not experience high growth for a variety of factors such as lack of demand for its output. This method has often overlooked services as potential high-tech industries. Additionally, some sectors not apparently producing

high-tech products are included, such as furniture, textiles, and apparel (Markusen et al. 1986). A combination of the preceding two methods, product sophistication and growth rate, has also been utilized (Weiss 1985). This technique for operationalizing high-tech industries is only a slight improvement and is subject to the same criticisms as each in their independent form.

Other studies have used R&D as a measure of an industry's level of technological orientation. Within this methodology, two different formulas have been frequently offered as well as the combination of the two (Technical Marketing Associates 1979; Stenberg 1998). The first is the ratio of R&D expenditures to the total sales of an industry. The second is the percentage of R&D employment to total employment of the industry. Conceptually, it is important to distinguish between the 'R' and the 'D' in R&D when discussing industrial research and development. The 'R' represents basic and applied research, which is the significantly smaller portion of industrial R&D, as well as the less expensive (Markusen et al. 1986, 15). The larger portion—and more expensive and risky aspect of R&D—is the 'D,' development stage (ibid.). Conceptually, this technique is a decent quantifiable proxy of an industry's technological sophistication.

There are some conceptual problems in using a proportional measure of R&D as the exclusive means of defining high-tech. The aggregation of quite different functions (occupational or by expenditures) presents the problem of mature industries that have large sales—and therefore a large network of distribution, marketing, and sales workforce—being lost as the denominator dominates the ratio, skewing the analysis. The petroleum industry is an example of a high-tech industry that is not included in this definition because its multibillion dollar sales dominate the ratio (Markusen et al. 1986). Also, this method, by design, has difficulty in identifying service sector industries as high-tech (Glasmeier 1991). The strength of the method lies in its capacity to be quantified and its ability to identify earlier stage industries.

The most sophisticated method I have identified to date is the occupational structure criteria method developed by Markusen et al. (1986). This technique utilizes the occupational structure of an industry as the quantifiable measure of its technological sophistication by taking the percentage of specified occupations[iv] of the total employment in an industry and comparing it to the national average for all industries. Industries that exceed the national average are considered high-tech (Markusen et. al. 1986, 17). While this method provides a finer-grain analysis and a quantifiable objective measure, it still needs refinement and suffers from problems related to the availability of data and changing definitions within published data. The most important oversight of the authors was the exclusion of service sector firms, including private R&D laboratories and software companies. Glasmeier (1991) does include some service sector industries, though her theoretical conception of what industries to include is somewhat unclear**.** Lyons and Luker (1997) outline a similar list of methodologies and argue that a structural shift of high-tech employment from manufacturing to services has occurred. I concur with Lyons and Luker and believe there is a need to include more service-oriented industries in the definition.

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[i] See Vernon (1966, 1979) product cycle theory, Marshall (1987) and Booth (1987) regional long wave theories, and Markusen (1987) profit cycle theory.

[ii] The Massachusetts Division of Employment Security used this definition in the late 1970s, and selected 20 industries (Vinson and Harrington 1972, 12).

[iii] Bio-tech was overlooked in most studies of the late 1970s through the mid-1980s.

[iv] See Markusen et al. (1986, 17) for occupations considered as high-tech by these authors.