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# Technology business incubators: how effective as technology transfer mechanisms?

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## Abstract

Technology business incubators provide a mechanism for technology transfer, promote the concept of growth through innovation and application of technology, support economic development strategies for small business development, and encourage growth from within local economies. This study provides a profile of technology business incubators in the United States, reviews previous research, and reports results of research on the technology transfer activities of technology business incubators. It is not surprising that universities and other research organizations are major developers of technology business incubator programs. The study found that technology business incubators have not had a high incidence of technology transfer despite the fact that many were established with that goal in mind. This finding implies the need to continue investigating the problems that hinder the technology transfer process, especially in light of the fact that most technology incubator programs state as their objective the transfer and commercialization of technology. © 2002 Elsevier Science Ltd. All rights reserved.

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## 1. The technology business incubator as an economic development tool

Technology business incubators merge the concept of fostering new business development with the concepts of commercialization and transfer of technology. Institutions and organizations that perform research and development (R&D) often

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seek mechanisms for diffusing technology, promoting entrepreneurial activity, and ways to collaborate on projects [1]. Since technology business incubators appear to respond to these desires by serving as a mechanism for commercializing R&D, it is no surprise that universities and other research organizations have been major developers of technology incubator programs. Past evidence indicates that technology business incubators associated with universities typically focus on commercializing university technology while also providing local economic development benefits [2,3]. Other reasons for the increase of technology business incubators as an approach to economic development may be due in part to a larger number of technology-based startup companies and the desire of state and local governments to encourage technology-based businesses in their respective regions [4]. In general, technology business incubators as a development approach appear to have emerged from two influences: (1) an increasing interest in fostering indigenous business development, particularly small business entrepreneurship, as an economic development strategy [5], and (2) the allure of high-technology business development [6,7].

What differentiates technology business incubators from other incubators? Most general business incubator programs hope to increase the rate the new business formation, expansion, and development, and to increase the chances of survival among client firms [8]—whether they are focused on technology-based businesses or not. Another difference is that general business incubators tend to focus on client firms that have or are developing proprietary advanced technology with marketable products or services. Such firms usually have a strong R&D component. Technology business incubators offer a slightly different array of services. Incubators associated with universities typically offer access to advanced technology laboratories, equipment, and other research and technical resources such as faculty, staff, students, and libraries. Many of the first incubators in the United States were sponsored by universities. Smilor and Gill found that the advantages of being near a university campus include access to library facilities, access to student labor, a creative environment, and exposure to state-of-the-art technical equipment and expertise. Companies within university-affiliated incubators were perceived to benefit from these advantages. The Smilor and Gill study further explained that incubator companies:

...may benefit from having the best available talent when they need it without having to carry that high-priced talent on their payroll. And these companies received the stimulations and catalytic effect associated with working alongside exceptional professionals from outside their organization [1, p. 20].

A third difference is that technology business incubators linked to universities or other research institutions have, as a major objective, the transfer or commercialization of technology. Technology transfer can be defined generally as the transfer of a technology, technique, or knowledge that has been developed in one organization and then transferred to another where it is adopted and used [9, p. 223]. Technology transfer is a major component of the innovation process. Mowery captured its importance in this way: “The economic impact of innovation, whether revealed in productivity growth, employment creation and destruction, or changes in wages and

profits, is realized only through the adoption of innovations” [10, p. 481]. In other words, technology business incubators have—theoretically—an inherent capacity for economic impact through facilitating technology transfer.

In many ways, technology business incubators are the epitome of technology-based economic development. They provide a mechanism for technology transfer, the common goal of many technology-based economic development programs. In addition, they support the concept of growth through innovation and application of technology, and economic development strategies that encourage small business development and growth from within a local economy [11].

## 2. Review of previous research

While there has been a significant volume of research conducted on business incubators, few studies have focused on technology business incubators and the aspects of technology transfer and commercialization—despite the fact that these aspects are often the objectives of such programs. The following summarizes the findings of the more relevant studies of technology business incubators.

Tomatzky et al. [4] provide descriptions of best practices in technology business incubator programs. Data were collected from 54 managers of technology business incubators where the most common service provided was facilitating access to university faculty, students, and technical facilities. The study did not offer details of the volume or incidence of technology transfer for the observed incubator programs.

In 1991, Mian [12] conducted an exploratory study of six university technology incubators through in-depth case studies, interviews with incubator experts, and surveys of incubator tenants and graduates. Not enough surveys were returned to generate adequate data for statistical analysis; therefore, the research methodology was exploratory and based on case study research [13].

Much of Mian’s research was descriptive in nature and explored such issues as how the incubators were organized, managed, and funded, and their target markets. Other research was more evaluative, examining contributions the incubators made to client firms, the strategic operating policies and to what extent those policies enhanced the effectiveness of operations, and the extent to which overall objectives of the incubators had been achieved. One of the major findings was that faculty members had little incentive to become involved with firms located in university incubators [14]. A recommendation was made to examine incentives that would encourage faculty members to become involved with firms located in university incubators [14]. Another recommendation was to examine the incentives that encouraged faculty members to become involved with product and firm development. The study proposed that incubator programs that sought and encouraged faculty involvement were more likely to develop successful firms based on university-developed technology. A later study confirmed this idea by finding that incubator firms with faculty involvement were more likely to prosper with successful technology transfer efforts [11].

An earlier exploratory study by Finholt and Kaiser [15] merits discussion as one

of the first studies to consider only technology incubators. A survey was conducted of 29 universities with planned or operating technology incubators. The incubators included an average of 14.6 firms that produced 222.4 new jobs from current and graduate companies. Another identified trend was the move toward developing technology incubators as part of a larger economic development scheme, such as a research park, or as a greater effort to encourage technology transfer from universities to the private sector.

A study by Roberts et al [16] assessed the State of Iowa's incubators on an individual basis in context of the area's business needs and the available services. This approach addressed the issue of overcoming the limitations of research conducted on a larger scope, such as at state or regional levels, when such findings may also be applicable to local-level analysis. The research methodology for this descriptive and exploratory study was multiple case study, with limited analysis of performance or process outcomes. Despite the promising research design, the study did not truly evaluate the effectiveness of Iowa's incubators, but instead provided an assessment of entrepreneurial services available through the incubator and other entities in each community. Levels of use and quality of service were not assessed. No evaluation was conducted of each incubator's operation nor was any determination made of the value of the incubator's services to participating firms [8].

### **3. Findings of this research**

The focus of my research is on the technology transfer aspects of technology business incubators, an area where more research is needed. In addition, information regarding the types and characteristics of technology business incubators is provided. For the purposes of this study, technology transfer is defined as the licensing of technology from a university to an incubator client firm. I begin by providing insight into the types of technology incubators found in the United States. Then a profile of technology business incubators is provided through new analysis of data previously collected via a mail survey. Finally, I examine university-sponsored technology incubators and present data collected from managers of technology incubators regarding technology transfer activities.

#### *3.1. Types of technology business incubators*

The National Business Incubation Association (NBIA) is a nonprofit association based in Athens, Ohio. Its annual membership directory provides information about all members' incubator programs as well as information on some nonmember incubator programs. The directory for 1993–94 was examined to determine the types and numbers of technology incubators in the United States. All states except Rhode Island had at least one incubator which served technology-intensive or R&D tenants [17]. However, not all of these incubators can be classified strictly as technology incubators because many of them accepted other types of tenants, such as service, manufacturing, distribution, or sales and marketing firms.

Further examination of the NBIA directory found there were 92 incubators serving R&D and high-tech clients in addition to other types of clients. Probably not all of these were technology incubators in the strictest sense even though they may have served some technology-intensive firms. Additional analysis revealed that 31 of the 92 incubators served *only* R&D and high-tech firms. The sponsors for the 31 technology incubators included universities and private entities, as well as a coalition of sponsors that include government, private, economic development, and other types of organizations. Incubators that are sponsored by a coalition of sponsors are termed “hybrid incubators” by the NBIA.

The remaining 61 incubators of the 92 that serve technology and other clients had a variety of sponsors. There were 31 university incubators, 28 hybrid incubators, and two private incubators. Of these 61 incubators, I noted that 27 offered services to high tech, R&D, and one other type of compatible firm activity, such as sales and marketing. Thus, for purposes of this research, I assumed that approximately 90 incubators, including one-third identified as concentrating solely on high tech and R&D, comprise the most certain sample of technology incubators in the United States. Table 1 lists the types of technology incubators by sponsor and the type of clients served.

### 3.1.1. Identifying technology business incubators

In 1991, 425 managers of incubators in the United States were surveyed by the NBIA. Completed surveys were returned by 150 incubator managers. I asked the NBIA to analyze the surveys to identify the technology business incubators in order to obtain data for this analysis. I formulated two criteria to identify technology incubators: (1) Was the primary sponsor of the incubator a university? (2) Did any of the primary objectives listed by the incubator include “transfer of technology” or “commercialization of research”? The NBIA Director then reviewed the selections to further confirm if the chosen incubators were technology business incubators. As a result of this process, 34 surveys were identified as coming from technology incubator managers.

Table 1  
Types of technology incubators in the USA (1993)

Sponsor types	Type of client served		Total
	High-tech/R&D only	High-tech/R&D and other types	
University	11	31	42
Private	7	2	9
Hybrid	13	28	41
Total	31	61	92

Source: National Business Incubation Association, 1993 [17].

### 3.2. *Characteristics of technology business incubators*

The majority of the incubators in this group were sponsored in full or part by universities and other educational institutions. Twenty-nine of the 34 incubators were organized as nonprofit entities and the remaining five were organized as for-profit entities. The mean age of the incubators was five years old, which was considered a midpoint in development. “Young” incubators were considered to be less than three years old. The oldest incubators were 13 years old; thus, five years old could be considered a midpoint.

The three most important objectives for the technology business incubators were:

1. economic development and local employment opportunities;
2. commercialization of research; and
3. transfer of technology.

These objectives were slightly different from the primary objectives listed for all incubators in the NBIA survey. There, the top three objectives for all 150 respondents were:

1. economic development and local employment opportunities;
2. diversification of the local economy; and
3. commercialization of research [18, p. 60].

A profile of the management of a typical technology business incubator identified a male with a mean age of 45 years, 2.67 years in the position, and 10.73 years of previous business and management experience. There were eight female managers among the 34 incubators. All managers had a college degree, with 82% possessing a Master’s degree or higher. The managers estimated that the majority of their time was spent in direct interactions with clients (counseling and related activities). Beyond that, their time went to non-incubator responsibilities, creating and maintaining external resources and networks, and incubator operations (leases, budgets, collecting rent, staff management, hosting tours, etc.). The mean number of full-time staff was four and the number of volunteers (full-time job equivalents) was two.

The incubators in the sample offered a wide range of services. The four most common services offered by incubator management to tenants through in-house services were:

1. access to labs, lab equipment, and sophisticated computer equipment;
2. help in obtaining equity financing;
3. clerical and receptionist services; and
4. office equipment and furniture.

The services most frequently offered by outside service providers, such as advisors in an incubator network, were:

1. legal and patent services;
2. accounting and tax assistance;
3. international trade assistance; and
4. government contract procurement assistance.

Infrequent services included bookkeeping or employment assistance.

Thirty-one of the incubators did not offer or administer group medical or dental insurance plans for tenants. Only eight maintained or administered a seed capital fund for tenants, and only 10 offered a revolving loan fund for tenants.

Ten of the 34 technology incubators were located in new buildings built explicitly for use as incubator facilities. The remaining incubators use existing buildings, primarily existing university or office buildings. The average gross square footage for all 34 technology incubators was 39,988 sq. ft. Nearly half the incubators reported that leaseable square footage had expanded in the previous year by an average of 9336 sq. ft.

The mean minimum rental charge per square foot on an annual basis was \$7.83 in 1991. The mean maximum rental charge per square foot on an annual basis was \$12.42 for the same year. This was estimated to be below the prevailing market rates for similar space in the incubators' areas as the mean market rate was calculated at \$14.00 per square foot on an annual basis for all incubators. In other words, incubators appear to offer lower rates to member firms—an advantage that members may not be able to otherwise obtain in the marketplace.

On average, technology incubators had 13.93 tenants, with 11.70 “non-anchor” tenants and 2.23 “anchor” tenants. Anchor tenants are those requiring a sizable amount of space or those whose presence might attract other tenants. Average number of employees for all non-anchor tenants was 49.83 and 21.25 employees for anchor tenants, for a total average incubator tenant employment of 54.4.

Tenants were recruited through an informal external network, referrals by affiliated agencies, and by tenant or graduate firm referrals. The top three tenant entrance screening criteria were:

1. compatibility of the business to the objectives of the incubator;
2. demonstrated business capability of the principals; and
3. projected growth potential.

Half of the technology incubators had a exit policy for tenants defined in years. The average normal maximum time limit tenants are allowed to stay in the incubator was three years. Sixty percent of the incubators escalated rental fees to encourage tenant firms to graduate. The average number of graduates (defined as businesses that grew while in the facility, then moved out more freestanding than when they moved in) in the previous year was 1.71 per incubator. The average number of graduates since incubator inception for the sample was 7.69 per incubator. The average number of full-time jobs of graduate firms in the previous year was 30.35 and 146.68 since incubator inception.

In 1990, 25 tenant firms discontinued operation while in incubators. On average,

this was less than one discontinuance per incubator, or a mean of 0.862. However, since the inception of all the technology incubators, the mean discontinuance of firms rose to 2.69 for a total of 78 discontinued or out-of-business firms for the entire sample. Twenty-one of the incubators reported that, in 1990, 37 firms left the incubators but did not graduate, for a mean of 1.15 firms for the sample. Since incubator inception, the mean number of firms exiting the incubator without graduating rose to 3.34.

It would be difficult to determine the exact survival rate of incubator tenant firms with the given data. However, it is important to attempt survival rate calculation so that comparisons can be made of the survival rates of firms in the general population. When differences in survival rates exist, it indicates the effect that the incubator is having on its member firms. In order to calculate an exact survival rate, additional information, such as the rates of survival *after* graduation and the number of firms that exited the incubator and later discontinued operations, would be needed. However, general “rates of performance” were calculated using the following information: in 1991, there were 400 tenants in all the incubators, 48 graduates for the previous year, 25 business failures, and 37 tenant firms that left the incubators without graduating. The performance rates for the sample in 1991 were: 12% graduated; 9% exited the incubator without graduating; and 6% discontinued operations while in the incubator.

Even though an exact survival rate would be difficult to calculate, a rudimentary survival rate for 1991 was calculated at 85%; that is, 15% of incubator tenants either failed or exited the program (it is not known if the firms discontinuing membership remained in business or not). The remainder were assumed to continue in the program and graduate at some point in the future. Information was not available to calculate a survival rate since inception. The only data available were that 223 incubator firms have graduated since inception of the incubators, 107 firms have exited the incubators without graduating, and 78 firms have discontinued operations since incubator inception.

Some of the respondents provided detailed information regarding their tenants and graduates. This information was used to calculate the following information. For 84 tenant cases, the mean tenant firm revenue for the last fiscal year before the survey was \$482,631. The mean number of full-time employees per firm was 4664 for 295 valid cases. The number of patents for 103 valid cases totaled 310 for a mean of 3.01 patents per incubator firm. For graduates, the last fiscal year revenues averaged \$1,036,350 (for 34 valid cases) and the mean number of full-time employees was 13.14 per firm for 132 valid cases. The average length of time the firms stayed in the incubator before graduating was 1.65 years.

Twenty of the survey respondents provided data regarding the finances of their incubators. From the analysis, average total operating revenue for the fiscal year prior to the survey was \$262,256 for the sample. Average total operating expenses were \$269,084, which implies that some of the incubators experienced a budget deficit. Further analysis indicated that seven of the 20 incubators operated at a deficit. For the remaining incubators, revenues either exceeded or equaled expenses. Surprisingly, the average age of the incubators with expenses exceeding revenues was 7

years, rather than young or new incubators which might be expected to experience budget deficits.

The majority (17 out of 20 respondents) reported receiving contributions, grants, or donations that were used for operating subsidies as part of operating revenues. Contributions and subsidies as a whole accounted for 56% of total operating revenue for the sample, ranging from a minimum of 6% to a maximum of 93%. The four largest sources for contributions, grants, or donations used as operating revenues were the federal government, state agencies, universities, and local governments. Thirteen of the 24 incubator respondents (54%) reported that they expected to receive a financial subsidy for operations.

In addition to financial subsidies, approximately half of the incubators in the sample received in-kind support which was received “off-budget”; that is, not reported as a contribution, grant, or donation as part of operating revenues. The most common in-kind services received by the incubators were accounting, tax and bookkeeping services, legal services, insurance, and utilities.

The largest expense item for the incubators was labor costs (wages, salaries, and benefits for incubators’ employees), accounting for 43% of operating expenses for the sample. The next major expense was debt service for the incubator buildings. A surprising finding was that only a small proportion (8%) of the total operating expenses were allocated to tenant programs and services.

### 3.3. *Comparison of technology incubators with other incubators*

Without a basis from which to compare the characteristics just described, it is difficult to draw conclusions about the performance of technology incubators. The most logical basis of comparison is to contrast the technology incubators to the entire group of incubators responding to the NBIA survey. Table 2 presents a summary of tenant, graduate, and financial performance indicators for these two groups. Table 3 provides a summary of various other characteristics of these two groups.

Technology incubators on average had a higher number of tenants, tenant employees, and tenant firm revenues than the NBIA group. They also had a higher number of graduate employees. As expected, technology incubator firms had a higher number of patent applications per firm than did the NBIA group as a whole. The average number of staff members for the technology incubators was higher and the operating expenses were higher. Net operating deficits (or net income deficits) were larger for technology incubators than for the NBIA incubators. Technology transfer information was not available in the NBIA data.

In 1994, the Maryland Department of Economic and Employment Development issued a study entitled *State Incubator Report*, which presented an assessment of the state’s incubator needs. As part of the report, performance indicators for incubators in the United States were compiled by the NBIA [18] and from works by Allen and Dougherty [19] and Campbell [20]. Table 4 presents the performance indicators used by the State of Maryland compared with the same measures for the NBIA group and the technology incubator group in this research. Other performance indicators

Table 2

Comparison of performance indicators for technology business incubators and all business incubators from the NBIA survey

Item	Technology incubators (mean/N) <sup>a</sup>	All incubators (mean/N) <sup>a</sup>
<i>Tenant and Graduate Indicators</i>		
Number of tenants per incubator	3.9/30	12/138
Number of tenant employees per incubator	71.1/29	54.4/132
Tenant revenues, 1990 (\$)	482,631/84	451,000/242
Number of patent applications per firm	3/301	2/84
Number of discontinued businesses, 1990	0.86/17	0.3/135
Since incubator inception	2.7/21	4.2/130
Number of tenants exiting, 1990	1.2/32	1.1/127
Since incubator inception	3.3/32	3.1/118
Number of graduates, 1990	1.7/28	3.3/89
Since incubator inception	7.7/29	10.0/91
Number of graduate employees per incubator	30.4/17	22.4/82
Since incubator inception	146.7/19	85.3/85
Number of years of graduate tenancy	1.6/154	2.2/491
Graduate revenues (\$)	1,036,350/34	1,100,000/62
<i>Financial Indicators</i>		
Tenant rental fees (\$)	100,485/22	181,356/22
Tenant service fees (\$)	25,027/18	40,779/13
Total operating revenues (\$)	262,256/17	216,472/78
Labor costs (\$)	115,820/20	83,007/70
Total operating expenses (\$)	269,084/24	219,225/78
Net income (\$)	(6,828)/24	(2,753)/78

Sources: National Business Incubation Association [18]; compiled from responses to the 1990 NBIA Incubator Survey.

<sup>a</sup> Total number of responses.

used are incubator costs per job and per firm. Table 5 provides a summary of costs for various incubators.

These figures are rather arbitrary, as the calculations do not include the full costs of funding but rather the annual amount of funding. The figures do not reflect the full costs over the time the tenants were incubated but are an indication of an annual cost only. It is not a true cost comparison because amounts of revenues received from the incubator tenants during the incubation period were not subtracted from the costs. To have a more realistic comparison, a benefit–cost analysis would be needed for each case.

The incubators in the Purdue study had the lowest costs per job created by incubator tenants at \$3000, compared with a much higher cost of \$11,353 for the Ohio group. The NBIA survey incubators had the lowest costs per tenant firm. However, the figures for the NBIA survey and the technology incubators were in 1991 dollars while the other figures were in 1994 dollars. A better measure would be to compare

Table 3  
Summary of characteristics of technology business incubators and all Incubators in the 1991 NBIA Survey

Item	Technology incubators	All incubators
1. Average number of incubator staff	4	3.1
2. Normal incubation period (in years)	3	2.2
3. Total number of incubator tenants (1991)	400	1100
4. Total number of incubator graduates (1991)	48	246
5. Since inception	223	687
6. Number of discontinued firms (1991)	25	150
7. Since inception	78	468
8. Number of exiting firms (1991)	37	103
9. Since inception	107	259

*Sources:* National Business Incubation Association [18], compiled from responses to the 1990 NBIA Incubator Survey. Note: The totals for items 3–9 for “all incubators” do not include the figures for the technology incubators in the NBIA sample.

Table 4  
Performance indicator comparisons for Maryland, NBIA incubators, and technology incubators

Item	Maryland	Incubator group NBIA	Technology incubators
Average incubator size (sq. ft)	24,000	24,375	38,988
Average number of tenants	12	12	13.9
Average number of tenant employees	4.5	4.5	5.1
Number of graduates per year	3	3.3	1.7
Tenant firm failure rate (%)	14	NA <sup>a</sup>	15
Average graduate employment	20	22.4	30.4
Firms remaining in community (%)	80	82.2	86

*Sources:* State of Maryland [21], NBIA [18]; and compiled from responses to the 1990 NBIA incubator survey.

<sup>a</sup> NA, data not available.

the costs per tenant firm and job over the time of incubation, less the revenues received from the tenants.

Fifty-four percent of revenues were received from tenants rents, royalties, and fees by the technology incubators. Fifty-three percent of revenues were received from tenants for the NBIA incubators. The average length of incubation was three years and 2.2 years for the technology and NBIA incubators, respectively. Using these data revealed a total cost per job of \$5223 and a total cost per tenant firm of \$26,656 for the technology incubators over the three-year incubation period. A total cost per job of \$5000 and a total cost per tenant firm of \$18,889 was found for all the NBIA incubators for an average incubation period of 2.2 years. This figure does not reflect

Table 5  
Costs per job and per firm for incubator programs

Incubator	Costs per job (\$)	Cost per firm (\$)
Technology incubator survey	3785	19,316
NBIA survey	4030	18,268
Thomas Edison Technology Incubators <sup>a</sup>	6609	29,640
Ohio Comparison Group <sup>b</sup>	11,353	29,519
Purdue University Survey <sup>c</sup>	3000	N/A
State of Iowa Incubators <sup>d</sup>	5516	N/A

<sup>a</sup> Four technology incubators sponsored by the State of Ohio were assessed by Human Resources Investments in *Thomas Edison Technology Incubators*, 1994 [15].

<sup>b</sup> As part of the Thomas Edison Technology Incubator study, four technology incubators not located in Ohio were surveyed to provide a basis of comparison to the four technology incubators sponsored by the State of Ohio.

<sup>c</sup> Three incubators were analyzed by researchers at Purdue University's Department of Agriculture and Applied Economics (Maryland Department of Economic and Employment Development, 1994 [21]).

<sup>d</sup> Prepared for the Iowa Department of Economic Development by Roberts et al. [16]. Information was provided for three of state's eight incubators on costs per job created. The figure was calculated by dividing the total operating deficit since incubation inception by one-half the number of jobs created (an assumption was made that approximately half of the jobs would not have existed without the incubators).

the startup costs of the incubators or grants and subsidies that would raise the total cost figures.

It is difficult to compare the costs per job of incubator programs with other economic development programs. The bases of comparison may be different in many cases. The benefits of one type of job may outweigh those of other types. Incubators typically generate income in the form of tenant revenues and fees whereas other economic development programs may not generate any direct program income. Nonetheless, it bears mentioning that the average cost per job for other economic development jobs in the State of Ohio was \$10,000 [21]. This figure has been used as a benchmark to compare costs of economic development programs. At an annual cost of \$6609 per job, the Thomas Edison Incubators met the State of Maryland's expenditure per job benchmark test, given the data available.

In summary, it appears that technology incubators perform on par with other incubators in terms of numbers of tenants and tenant employees. Costs per job are not significantly higher for technology incubators versus other incubators.

### 3.4. University-sponsored technology incubators

The NBIA survey data did not address issues of technology transfer and commercialization of research in incubators. Technology business incubators, particularly those sponsored by universities, often have these two elements as primary objectives. In the recent past, much emphasis has been placed on promoting transfer and commercialization of research from university laboratories and other publicly funded laboratories to the private sector. However, not much is known regarding the effec-

tiveness of technology business incubators as technology transfer and commercialization mechanisms.

Because the NBIA survey did not ask questions regarding these issues, efforts were made to gather primary data from university technology business incubator managers to assess technology transfer and commercialization activity of technology business incubators in the United States. As identified by examining the NBIA membership directory, there were 42 university-sponsored technology business incubators in the United States as of 1993. This group was used to develop a contact list for efforts to gather primary data. In January 1995, I contacted, via facsimile or mail, the managers of 32 university-sponsored technology incubators to gauge technology transfer and commercialization activities. Initial contact was followed by telephone calls to managers when appropriate. Ten useable responses were received; a few other managers responded that they did not have the requested data [11].

There were more university-sponsored incubators in the United States than the 42 identified in the NBIA directory, but the primary focus of these other incubators was not to serve technology-intensive firms. It should be noted that, of the 42 university incubators, 11 served *only* high-tech and R&D clients. Another nine served high-tech, R&D, and one other compatible type of client, such as sales and marketing or light manufacturing firms. The others served high-tech, R&D, and at least two other compatible types of clients. (Note: These distinctions for classifying incubators are somewhat arbitrary. I realize that many of the hybrid universities discussed in the previous section are sponsored by universities as well as other groups and may have represented a technology incubator more so than the university incubators identified in this section.)

Also, it should be noted that my intent in contacting these managers was to gather general data regarding technology transfer and commercialization activities. Few data existed in the literature at the time about these issues and the contacts with managers was designed to increase understanding of the level of technology transfer and commercialization activity. This was not an attempt to gather data regarding manufacturing technology transfer or extension services, because technology transfer from the university laboratory to startup technology incubator firms is different from technology extension services.

#### *3.4.1. University technology incubators: summary of findings*

Only four of the managers reported that direct technology transfer or commercialization of associated university research had occurred. Of the cases for which these data were provided, the majority of technology was independently derived rather than university-based. The remaining managers reported that no technology transfer or licensing activity had occurred and all tenant firms had independently derived technologies. Table 6 summarizes the technology transfer activity of the four cases.

While this initial data gathering provided some insight, additional research is needed to determine more precisely the level of technology transfer and commercialization activity at university incubators. If these data are an indication of the level of activity, then it appears that technology incubators have not focused on technology

Table 6  
Technology transfer/licensing activity of university incubators

Incubator	Number of incubator firms with:		
	University independent technology	Faculty technology	Involvement
ATI	16	4	All
OADI	NA <sup>b</sup>	Some	Some <sup>a</sup>
NET	38	6	Some <sup>a</sup>
TIC	7	7	All

Source: Phillips survey, 1995 [11]. Abbreviations: ATI, Arizona Technology Incubator; OADI, Office for the Advancement of Developing Industries (University of Alabama, Birmingham); NET, Benjamin Franklin Technology Center (Pennsylvania); TIC, Technology Innovation Center (Iowa).

<sup>a</sup> It was reported that there were some firms with university-related technology; however, specific numbers were not given.

<sup>b</sup> NA, data not available.

transfer and commercialization of university research. One reason for this may be the legal impediments to licensing university research for commercialization. A few managers reported that the existing legal structure at their universities impeded the ability to transfer or commercialize university-based research. One manager reported that conflict of interest considerations prohibited faculty members from having more than a minority interest in a company located in the incubator. Another reported that conflict of interest provisions forced faculty members to make decisions to either remain a full-time faculty member or leave the university job entirely to work in the startup firm. Few faculty members chose the latter option. A study by the Southern Technology Council further confirmed that conflict of interest policies and practices were troublesome or hindered the technology transfer process [22].

Another issue that appeared to impede technology transfer or commercialization efforts dealt with the amount of royalty to be retained by the university. If the percentage was thought to be too high by firms seeking to transfer technologies, then negotiations for technology transfer could stall or be cancelled altogether.

A couple of the four cases that transferred university-based technology to incubator firms reported that technology transfer or commercialization was not a problem. The manager for the Arizona Technology Incubator (ATI) stated that Arizona State University established a separate nonprofit entity to negotiate and administer all technology transfer cases. This entity also was responsible for holding the property rights and royalty for the university. In addition, a well-defined set of conditions apply to faculty regarding technology transfer and commercialization activities. Of the 206 applicants to ATI thus far, only nine involved technology transfer from Arizona State University. Of these nine, four were accepted versus 16 out of the remaining 197 applicants. Of the four firms involving technology transfer, all had a faculty member as a principal. Interestingly, all remained full-time faculty members, and their incubator client activities have been supported by the university administration.

ATI's situation may not represent the typical scenario for university technology

transfer to startup firms involving faculty members. The manager of the NET Ben Franklin Technology Center reported that six of the 44 incubator firms involved technology transfer deals. Limited success was reported for these six firms, all of which involved faculty members from LeHigh University. The university allowed one day per week for faculty to be involved with other types of activities, which included starting a company in the incubator. However, this was insufficient time for the faculty to dedicate to the firms and they were not willing to give up their positions at the university to work full-time with their firms. Some attempts were made to bring in graduate students as partners but these efforts were not viewed as successful.

One of the LeHigh University's responses to the problem of faculty unable to dedicate enough time to their startup firms was the creation of a corporation to perform *corporate partnering* activities. Corporate partnering is defined as identifying and matching potential executive personnel with startup firms in an incubator; for example, identifying a potential chief executive officer (CEO) who is willing to invest equity into an appropriate startup firm. In addition, the corporation also attempts to identify firms that would transfer specific technologies from the university.

While the Center for Business Innovation (CBI) at the University of Missouri Kansas City did not report any university technology transfer activities for their tenants, CBI has established a Technology Commercialization Task Force to encourage such activities. The goal of the Task Force is stated as identifying appropriate technologies at the university for (1) forming new startup companies around the identified technologies, (2) licensing the technologies to CBI clients, or (3) marketing the technologies to other companies for licensing [23, p. 12].

As part of efforts to identify appropriate technologies for transfer, the "Big Idea Contest" was initiated in 1994 by CBI. Teams consisting of at least one faculty member and one student submitted entries in a business plan format to the Task Force. The entries consisted of creative or innovative ideas that could be commercialized in 18 months or sooner. The first and second place winning entries received \$2000 and \$1000, respectively.

The State of Iowa appeared to have the most comprehensive program for encouraging university technology transfer to startup firms. State legislative action in 1989 established The Wallace Foundation, an independent nonprofit corporation directed to formulate a statewide technology transfer plan. Technology transfer is defined by The Wallace Foundation as, "...increas[ing] the wealth of Iowans through more effective use of their educational attainment and skill potential by improving the linkage between public resources, in both government and education, and business needs and opportunities" [24]. The major components of the plan are a Near-Term Program for Manufacturing Modernization to help existing firms adopt contemporary production processes and technologies that boost productivity and income, and a Long-Term Program for New Technology Opportunities. The latter was developed to support establishment of new businesses involved in commercializing technologies. As part of the Long-Term program, two technology incubators were founded: the Iowa State Innovation System (ISIS) and the University of Iowa Technology

Innovation Center (TIC). Because of the State of Iowa's emphasis on commercialization of university research, faculty members involved in startup incubator firms have received considerable support and flexibility. Thus far, half of the companies associated with TIC have formal technology transfer agreements with the University of Iowa.

Technology transfer and commercialization activities at university technology incubators have ranged across the spectrum—from half of the tenants in one incubator actively transferring university technology, to none in others. These disparate differences in the level of activity may be attributed to differences in the legal structure for technology transfer and commercialization at universities. Some differences may be due to the situation postulated by one manager: that many more firms with independently derived technologies exist than firms (or potential firms) based on university-based technologies; therefore, the incubator clients will primarily be firms with independently derived technologies, despite technology incubator program sponsorship by universities. It is apparent that additional research is needed to gauge more precisely the levels of technology transfer and commercialization activity at university incubators and to further identify factors and barriers that contribute to differences in levels of activity.

#### 4. Summary and conclusions

A review of the literature revealed few comprehensive studies regarding the effectiveness of technology incubators as technology transfer mechanisms. This study examined the number and types of technology business incubators, identified their characteristics, and offered insight into technology transfer activities in selected programs.

Through analysis of data collected in the 1992 National Business Incubation Association survey, it was found that technology incubators generally performed as well as other incubators when compared using a variety of measures. Technology incubators had a higher rate of tenant employment and tenant revenues, as well as a larger number of patent application per tenants firm. However, costs appeared higher for technology incubators, and the average operating deficit was higher for technology incubators than for other incubators.

There were approximately 42 technology incubators focused on technology transfer and R&D sponsored *primarily* by universities in the United States as of 1993. Data were collected from 10 managers from this group to gauge the level of technology transfer and commercial activity occurring in university incubators. It was found that considerable activity had occurred, ranging from half of the tenant activity involved in technology transfer to no tenants at all, although, in general, the level of technology transfer was lower than would be expected. Some of the differences in the level of technology transfer research may be attributed to varying legal structures, requirements, and conflict of interest policies. This implies a need to further investigate the barriers and problems hindering the technology transfer process, especially in light of the finding that most technology incubator programs state as their objective

the transfer and commercialization of technology. While additional research is needed to explore further the effectiveness of technology business incubators as technology transfer mechanisms, it appears that this approach holds potential, particularly those programs affiliated with universities, as a means of encouraging technology-based economic growth and development.

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