Creating The Technopolis: High-Technology Development In Austin, Texas

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Executive Summary

New institutional alliances, driven by the rapid increase in and diversity of new technologies, are altering the strategy and tactics of economic development. As a result, communities across the world are seeking to create modern technopoleis or city-states that interactively link technology commercialization with public and private sectors to spur economic growth and diversification through high-technology company development.

This paper develops the conceptual framework of a technopolis wheel from studying the dynamics of high-technology development and economic growth in Austin, Texas. It describes seven segments within the technopolis: the university, large technology companies, small technology companies, federal government, state government, local government and support groups.

Empirical data, based on surveys, interviews, and archival sources, are presented to assess the role and impact of each segment on the emerging Austin technopolis. Analysis of this data demonstrates the role of the research university on spin-out company formation, the direct and indirect impacts of federal, state, and local government, the evolution of high-technology companies over time with a focus on major company relocations or foundings, and the establishment of indigenous high-technology companies. A case study of Tracor, Inc., the only home-grown, Fortune 500 company headquartered in Austin, demonstrates some of the key factors at work in the technopolis wheel.

The paper points to new institutional relationships among the segments of the technopolis wheel. It emphasizes the role of influencers who provide leadership in each segment while networking the different segments to form new institutional alliances.

Key findings of the study include the pivotal role of the research university, the need for continuity in governmental policies, the catalytic role of large technology companies, the importance of indigenous company development, and the need for consensus for the sustained development of the technopolis.

Three important themes emerge in technopolis development, not only in the United States but also in Europe and Asia: the need for a coordinated approach to high-technology company development,

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the presence of a high-quality research university, and the importance of a network of influencers or "executive champions."

By focusing on the interaction among the seven segments of the technopolis wheel, we provide a conceptual framework for assessing the relative importance of government, academic, business, and public sectors in the high-technology economic development of a region.

TWO KEY ASSUMPTIONS ARE CENTRAL TO THIS ARTICLE. FIRST, WE ARE ON the threshold of a great technological era in the United States and throughout the world. Technology is dramatically altering the shape and direction of society and the way people think and act. The rapid increase in and diversity of new technologies are changing the nature of economic competition. How communities, regions, and nations anticipate and respond to this new competitive environment will largely determine the health and viability of their economics (Castello 1980; Olson 1982; Bolling and Bowles 1982; Reich 1983; Ouchi 1984).

Second, the nature of economic development has fundamentally and permanently changed. New institutional alliances are altering the strategy and tactics of economic development and diversification. New relationships between the public and private sectors- especially among business, government, and academia- are having far-reaching consequences on the way we think about and take action on economic development (Adams and Glickman 1980; Brooks, Liebman, and Schelling 1984; Ouchi 1984).

These assumptions are captured in the term technopolis. "Techno" reflects the emphasis on technology; "polis" is the Greek word for city-state and reflects the balance between the public and private sectors. The modern technopolis is one that interactively links technology commercialization with the public and private sectors to spur economic development and promote technology diversification. Linking technology and economic development in a new type of city-state is an emerging worldwide phenomenon (Gibb 1985; Tatsuno 1986; Glasmeier 19875; Smilor, Kozmetsky, and Gibson, 1988). Four factors are especially important in the development of a technopolis: the achievement of scientific preeminence, the development and maintenance of new technologies for emerging industries, the attraction of major technology companies, and the creation of home-grown technology companies.

Framework and Methodology

Using the case of Austin, Texas, this paper develops a conceptual framework, which we call the *technopolis wheel,* to describe the process of high-technology development and economic growth in a technopolis (Figure 1). The wheel reflects the interaction of seven major segments in the institutional make-up of a technopolis: the research university, large technology companies, small technology companies, state government, local government, federal government, and support groups. Finally and perhaps most importantly, are key individuals, or influencers, who link the seven segments of the wheel. We believe that the concept of the technopolis wheels has important implications

for understanding the development of other technopoleis in the United States and in other nations as well.

New institutional developments among business, government, and academia are beginning to promote economic development and technology diversification (Allen and Victor 1986; Ryans and Shanklin 1986; Sexton and Smilor 1986; Reynolds 1987; Merrifield 1987). A fascinating paradox has emerged - the paradox of competition and cooperation - on which Ouchi elaborates in his description of the M-Form society:

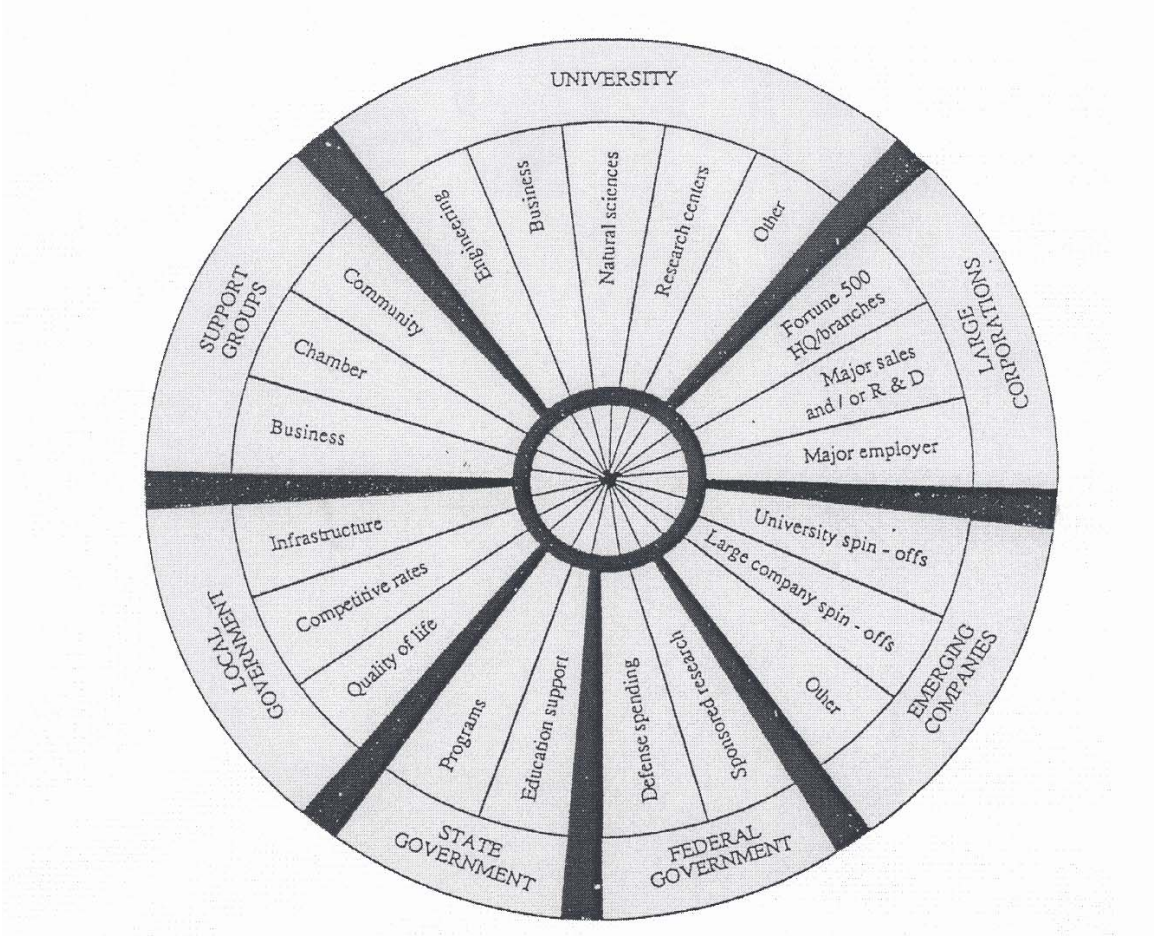


Figure 1 The Technopolis Wheel

> The Essence of an M-Form society is social integration. An M-Form society represents Balance, a balance between the need for government regulation and the need for inde-Pendent laissez-faire action. A balance between one special interest and another. (Ouchi 1984; 226)

On the one hand, a great deal of competition takes place among a state's universities, companies, and public- and private-sector entities. On the other hand, cooperation is essential for a technopolis to develop and survive over time. Segments of the technopolis wheel must find ways to cooperate while competing. Our research emphasizes the importance of networking across the seven segments of the technopolis wheel; that is, the ability to link public and private sector entities, some of which have been traditionally adversarial, to effect change.

The following graphic representations, as well as the conceptual design of the technopolis wheel, are based on interview, survey, and archival data collected in Austin, Texas during January-March, 1987. Interviews were conducted with respondents who either represented or were knowledgeable of the academic, business, community, and government interests of the region. A telephone survey was used to collect current information on start-up company spin-offs from the University of Texas at Austin and large Austin-based companies. Special attention was given to the case of Tracor, Inc., Austin's only home-grown *Fortune 500* company. Interview and survey data were checked against archival data whenever possible.

While further empirical research is needed to establish the generalizability of the theoretical concept of the technopolis wheel as well as the suggested policy implications and research conclusions, national and international implications are suggested. These implications are based primarily on emerging research on new, developing, and mature technopoleis (Smilor, Kozmetsky, and Gibson 1988).

The Case of Austin, Texas

The early 1980s were special years for Texans because of the state's approaching sesquicentennial in 1986 and centennial celebrations at the state's two flagship universities- the University of Texas at Austin and Texas A&M University. Momentum for the development of Austin as a technopolis reached a crescendo in 1983 when MCC (Microelectronics and Computer Technology Corporation) chose Austin as its headquarters after a major and public site selection process among some of the most visible high-tech centers in the United States (Gibson and Rogers 1988). Austin made headlines in the *New York Times,* the *Wall Street Journal,* and the world press as the next great "Silicon Valley." Nicknamed "Silicon Prairie," "Silicon Gulch," and "Silicon Hills," the area experienced an unprecedented wave of enthusiasm because of the perception that it had suddenly become a major technology center.

In 1984, the dramatic and unexpected plunge in oil prices coupled with declining farm and beef prices caused a general economic decline in Texas. A state that previously enjoyed a budget surplus and no corporate or personal income taxes now faced budget deficits. The development of Austin as a technopolis began to lose momentum. Between 1984 and 1987, Austin experienced a series of problems revolving around a general economic recession in the state, cutbacks in higher education funding, changes in local governmental attitudes, a speculative development cycle that ended in a plethora of foreclosures and bankruptcies, and a general loss of direction.

In 1987 the effects of an economic recession were still quite apparent in Texas and in Austin. However, the state had begun to reverse its past policy by increasing funding for higher education as well as providing other research support such as an Advanced Technology and Research Program (ATRP). The ATRP was funded to the amount of $60 million by the 70th Texas Legislature with the express purpose of supporting economic development in Texas by (1) attracting the best researchers and students to Texas and (2) expanding the state's existing technology base. In early 1988, after a national competition, the main players in the U.S. semiconductor industry chose to locate the industry's new research consortium of 13 member companies (Sematech) in Austin. Austin and Texas were outbid by several other contending cities and states in

terms of financial incentives. However, Sematech officials cited as a main reason for choosing Austin the synergy among business, academic, government, and community entities. The nature of this type of synergy and its application to high-technology development are the focus of this paper.

The University Segment

The nucleus in the development of the technopolis is the university segment. The research university plays a key role in the fostering of research and development activities; the attraction of key scholars and talented graduate students; the spin-offs of new companies; the attraction of major technology-based firms; as a magnet for federal and private sector funding; and as a general source of ideas, employees, and consultants for high-technology as well as infrastructure companies (Sexton and Smilor 1986; Doutriaux 1987). The University of Texas at Austin (UT) has played this key role in the development and perception of Austin as a technopolis.

For example, the total dollar amount of contracts and grants (both federal and non-federal) awarded to UT had increased steadily by year from 1977 (about $55 million) to 1986 (about $120 million). The university had established and organizes 18 major research units in the College of Engineering and 32 in the College of Natural Sciences (*Statistical Handbook* 1986-1987). Most importantly, many of these research units were in emerging, cutting-edge technological areas. Much of this increase could be attributed to the UT Endowed Centennial Program for chairs, professorships, and fellowships in 1983-1984. In other words, centennial endowments made a significant difference in attracting researchers who in turn attracted research funds and exceptional graduate students.

An important way to assess the impact of UT in the development of the Austin technopolis is to consider spin-out companies. Of 103 small and medium-size technology-based companies in existence in Austin in 1986, 53 (or 53%) indicated a direct or indirect tie regarding their origin to the University of Texas at Austin (see Figure 2). These companies' founders were UT students, graduates, faculty members, and other UT employees. Their tie to the university enabled many of the companies to start their businesses with a contract that originated while they were involved in university research activities. In addition, the ability to continue their relationship in some capacity with the university was an influential factor in their staying in the area. These firms demonstrate an important requirement for a technopolis - the ability to generate home-grown or indigenous technology-based companies which in turn have a direct impact on job creation and economic diversification.

The University of Texas (and Texas A&M University) have benefited tremendously from a Permanent University Fund (PUF) with a 1987 book value at $2.6 billion. This public endowment has been crucial to the development of the teaching and research excellence at UT and Texas A&M, as well as in permitting the acquisition of modern facilities and laboratories. The PUF alone, however, has proved to be insufficient in providing the resources necessary to the development of a world-class university. In Texas, as in the case in other regions in the United States, state government is responsible for the major portion of funding for the budges of public universities.

For example, in 1984, shortly after the MCC decided to locate in Austin and while oil prices were still about $30 a barrel and state revenues increased by $5.4 billion or 17% over the previous year, Texas decreased appropriations for higher education by 3%. Despite UT's phenomenal growth in endowed chairs, professorships, lectureships, and fellowships, despite the location of MCC in Austin, and despite national and international press claiming the University of Texas at Austin as a new center of excellence in education, the lack of sustained state support for higher education sent a mixed message to the best scholars and researchers whom the university was trying to attract (Gibson and Rogers 1988).

During 1984-1986, Texas' universities in general were not competitive with other U.S. universities in terms of faculty salary. As of 1987, the gap lessened, but UT faculty

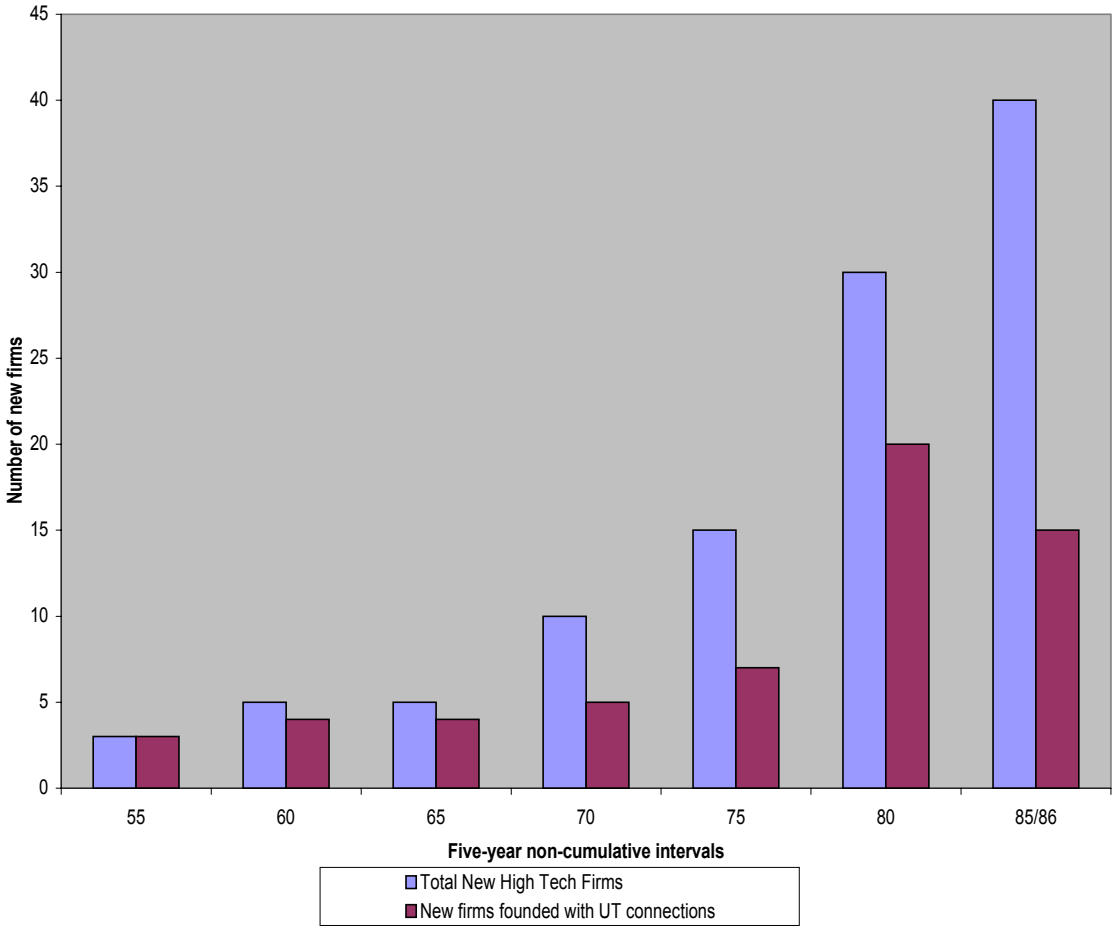


Figure 2 Small high-tech firms founded with UT connections.

salaries still trailed the averages offered in the 10 most populous states (*Statistical Handbook* 1986-1987). Also, during 1984-1986, the University of Texas lost some of the outstanding faculty it had previously acquired. As of 1987, many of the university chairs and professorships established in 1983 remained vacant. The few qualified candidates for these endowed positions had been attracted by more substantial offers from universities in other states.

In summary, as state allocations for higher education increased through the late 1970s and the early 1980s, the perception of the development of Austin as a technopolis outside the state increased proportionately as well. On the other hand, as the State of Texas began to cut back its funding to higher education in 1983, the perception of Austin as a developing technopolis declined and the perception of retrenchment in the university began to emerge (Gibson and Rogers 1988).

Government Segments

Federal, state, and local government play vital roles in the development of a technopolis. However, each level of government affects economic development differently.

The federal government has had an impact on Austin in two key ways – through the development and operation of Bergstrom Air Force Base and through federal funding for research and development activities at Balcones Research Park at the University of Texas at Austin. Bergstrom, established in 1942, has provided fundamental economic stimulation to the Austin region through the employment of 1,000 civilian and 6,000 military personnel with an annual payroll of about $167 million (U.S. government documents). An example of more direct government stimulation to the emerging Austin technopolis is Balcones Research Park, which was created in the early 1940s when the federal government ceded the land to the University of Texas and funded research in strategic resources to support the war effort.

While the state government's primary role has been in relation to setting the priorities for, and funding of, education, the local government's primary role in Austin has focused on quality of life, competitive rate structures for items such as utilities, and infrastructure requirements. "Quality of life" carries different meanings given one's perspective and the subjective attributes of the issues involved. In Austin, a high quality of life had remained relatively affordable (up until 1985) in comparison to other technology centers. Perhaps the most dramatic statement in support of this view is the fact that the MCC, which listed an affordable quality of life as one of its main site-selection criteria, decided to locate in Austin. An independently commissioned quality of life survey done at the time rated Austin as exceptional (when compared to San Diego, California; Atlanta, Georgia; and Raleigh-Durham, North Carolina) in terms of the quality of primary and secondary schools, quality of parks and playgrounds, outdoor recreational opportunities, community cleanliness, and as an affordable place to live (Gibson and Rogers, 1988).

Perceptions vary within any region undergoing rapid economic growth associated with a developing technopolis, and there is always the possibility that such growth will diminish the very qualities that caused the area to be so attractive to high-technology companies in the first place. This tension between a sustained quality of life and sustained economic development has been most visible throughout the development of Austin.

Over the history of the economic development of the Austin area, local government has tended to favor either the "developers" or the "environmentalists." When local government supports economic growth then the development of the technopolis is more likely to increase; that is, company relocation seems to be facilitated and obstacles to development seem to diminish. On the other hand, when local

government believes that the quality of life is diminishing, then the development of the technopolis is inhibited; that is, obstacles to development increase (such as high utility rates or slow permit procedures). The issues become quite complex because many developers are often local residents who also want to preserve the community's quality of life. On the other hand, many environmentalists also favor some economic development. Indeed, quality of life and economic development are two sides of the same coin – each has a vital impact on the other.

Although environmentalists and developers may disagree on what makes for sensible environmental/development policy, most agree that overall quality of life suffers when the people who inhabit the community are out of work and cannot afford to pay the costs associated with infrastructure development, housing, or factors such as expanded park land or recreational opportunities.

Support Groups Segment

Support groups can provide an important networking mechanism for the development of a technopolis. These groups may take a variety of organizational forms representing environmental concerns, labor issues, minority viewpoints, and other community interests. Business-based groups relate to the emergence of specific components for high-technology support in the practice of Big-8 accounting firms, law firms, major banks, and other companies. These components provide a source of expertise, even when embryonic, and a reference source for those founding and/or running technology-based enterprises.

The growth of venture capital (Wetzel 1986, 1987; Brophy 1986; Robinson 1987; Timmons and Bygrave 1986) provides a good example of the importance of business-based groups to the development of a technopolis. In 1980, Austin had virtually no venture capital money. However, by 1986, the city had approximately $80 million managed by five firms. The growth was due primarily to two factors – one external and the other internal (Kozmetsky, Gill, and Smilor 1986). Externally, changes in federal tax laws in 1979, 1981, and 1986 pertaining to capital gains encouraged investments in venture capital pools (Maier and Walker 1987). Internally, the perception of Austin as an emerging technology center encouraged the development of home-grown pools. The sources of the venture capital were a few individuals knowledgeable about the venture capital process as well as the major commercial banks in the area. Although funds in these pools increased, most venture capital investments continued to be made *outside* the state of Texas. Venture capitalists in Austin, while wanting a local window on technology and company development, did not see enough good deals, i.e. fast-growth company potentials, in the region (Kozmetsky, Gill, and Smilor 1986).

The Private Sector

One way to measure the growth of high-technology company development in a technopolis is to track employment and high-technology incorporations over time. Figure 3 shoes the incorporation of high-technology companies in Austin from 1945-1985. In 1984, the growth of these firms leveled off, probably as a result of the general economic recession. These are manufacturing-related technology firms and do not include service-related technology firms.

Two other means were used to track high-technology company development in Austin: one was the founding or relocation of major technology-based companies; the other was an evaluation of a selected list of emerging technology-based companies. The location and home-grown development of major technology-based companies began in 1955.[1] As shown in the timetable in Figure 4, Austin had 32 such major company relocations or foundings as of 1986.

Six of the companies are home-grown, and all have had direct or indirect ties to the University of Texas at Austin. The location of the other major firms in the area was dependent on two critical elements: the presence of the University of Texas at Austin and the perception of an affordable high quality of life – that is, a place with high quality of life factors where a company could also make a profit. Two four-year clusters are interesting to note: 1965-1969 and 1980-1984. Major events took place in each of these clusters: during the first, IBM located in Austin; during the second, MCC located in Austin.

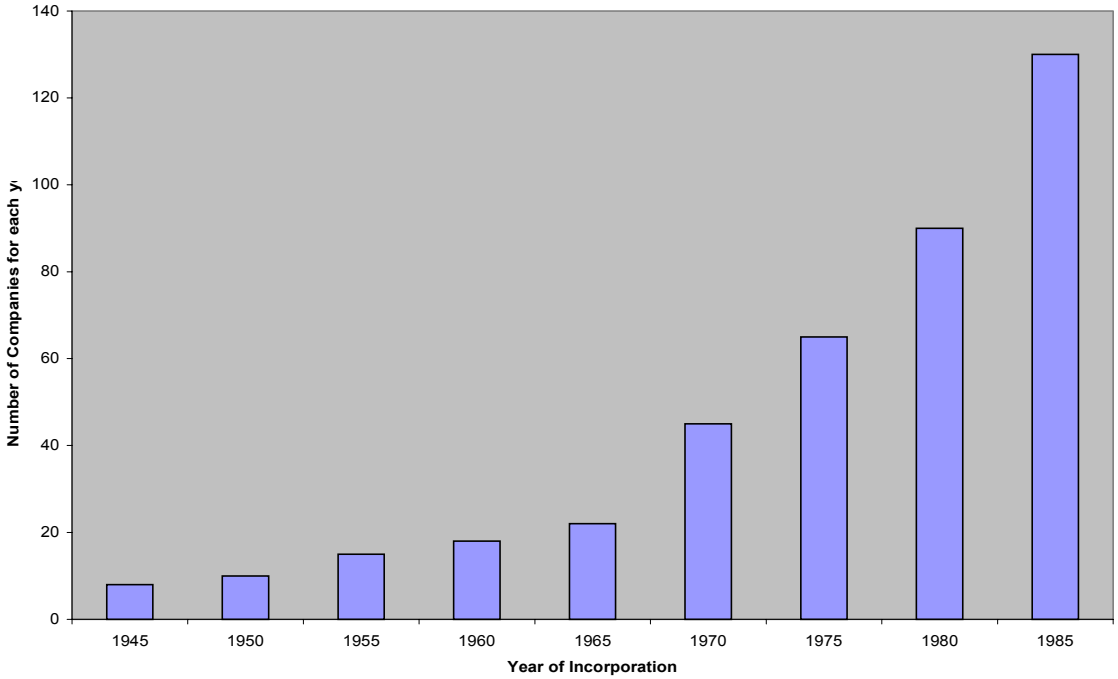


Figure 3 Cumulative total of high-technology manufacturing companies in Austin.

Source: 1986 Directory of Texas Manufacturers. Bureau of Business Research, Graduate School of Business. The University of Texas at Austin.

Note: These companies were defined by the following 3-digit SIC codes: 283, 357, 364-367, 369, 376, 379, 381-387. A number of studies have incorporated this definition of high technology products in analysis of high technology manufacturing. See Massachusetts Division of Employment Security, Job Market Research Division, *High Technology Employment: Massachusetts and Selected States* 1975-1979 (Boston: Massachusetts Division of Employment Security, March 1981); Peter Doeringer and Patricia Pannell, "Manpower Strategies for New England's High Technology Sector," paper presented at Conference on Manpower Policy Issues, sponsored by the Commission on Higher Education and the Economy of New England at the Harvard University Graduate School of Business Administration, May 15, 1981; and Joint Economic Committee, U.S. Congress, *Location of High Technology Firms and Regional Economic Development* (Washington, D.C.: Government Printing Office, June, 1981).

[1] By "major" technology-based companies, we mean headquarters and branches of *Fortune 500* companies, and/or those companies with annual revenues or annual R&D budgets of over $50 million, and/or those companies with over 450 employees in Austin.

In addition to these major firms, a second tier of small and emerging companies has been steadily increasing. In 1986, 218 large and small high-technology-related firms were in existence in Austin. Figure 5 shows the establishment of high-technology-related firms or branches in five-year intervals from 1945-1985. Figure 6 shows the establishment of small and emerging technology-related firms in existence in Austin in five-year intervals from 1945-1985.

The Tracor Case

The centrality of the research university to the development of a technopolis can be effectively demonstrated through a case study of Tracor, Inc., a home-grown company that is the only *Fortune 500* company headquartered in Austin. Tracor exemplifies what Kanter (1985) calls a high-innovation company and what Cooper (1985) calls an incubator organization.

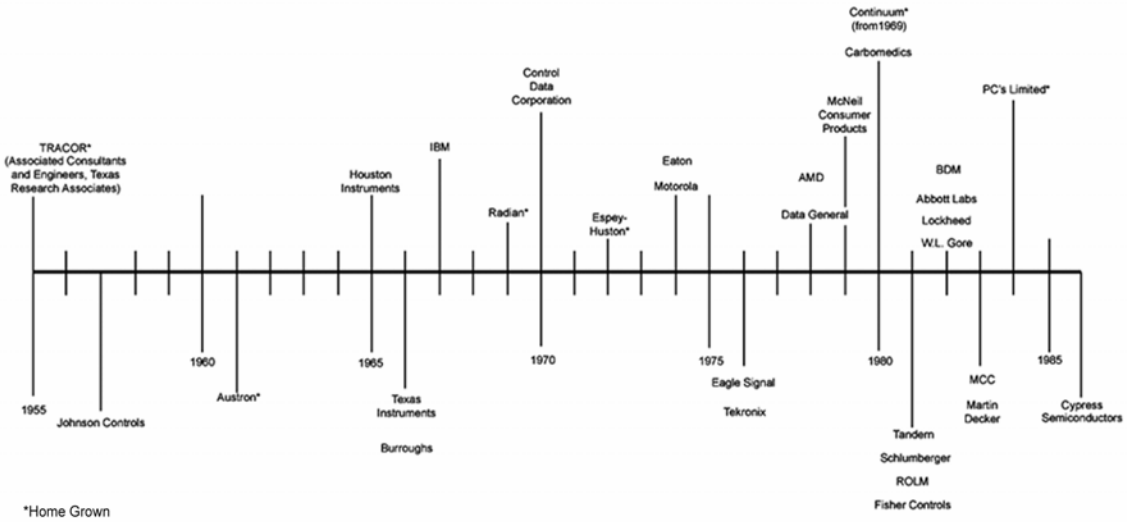


Figure 4 Major company relocations or founding in Austin, 1955-1986
Source: Thie timeline was developed by the authors on information from the Austin Chamber of Commerce and from survey and interview data.

Frank McBee, the founder of Tracor, earned both bachelor's (1947) and master's (1950) degrees in mechanical engineering at UT after serving as an Army Air Corps Engineer from 1943-1946. In the late 1940s, McBee became an instructor and then an assistant professor in the UT Department of Mechanical Engineering. In 1950, he became the supervisor of the mechanical engineering department of UT's Defense Research Laboratory (now called the Applied Research Laboratory) at UT's Balcones Research Park.

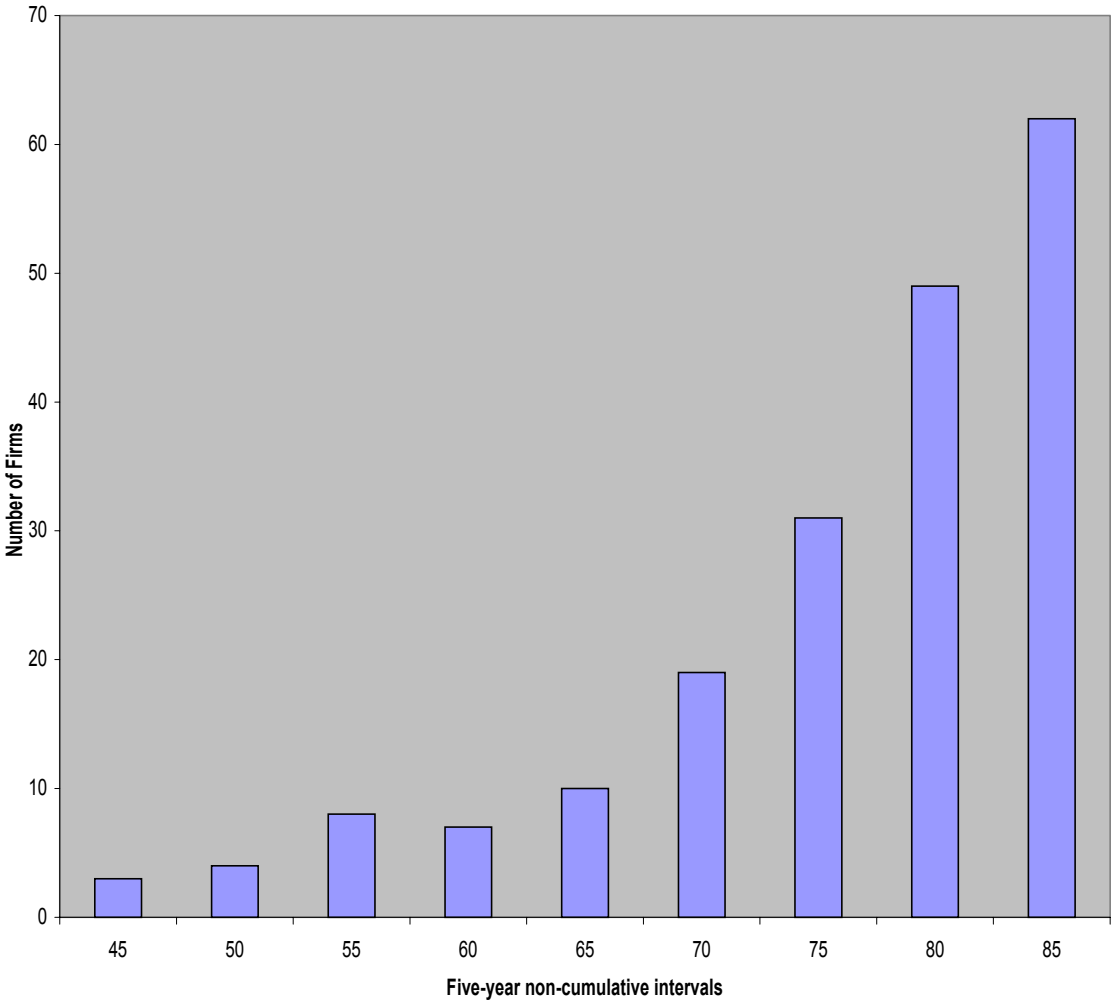


Figure 5 Establishment of high-technology related firms or branches, 1945-1985.
Source: Directory of Austin Area High Technology Firms, Austin Chamber of Commerce, 1986

In 1955, with funding of $10,000, McBee joined forces with three UT physicists to form Associated Consultants and Engineers, Inc., an engineering and consulting firm. Drawing on their UT training and work experience, the four scientists focused their efforts on acoustics research. They were awarded a $5,000 contract for an industrial noise reduction project. The company's name was changed to Texas Research Associates (TRA) in 1957. During the late 1950s, the four scientists taught and did research at UT while working on developing TRA. In 1962, the firm merged with a company called Textran and adopted its present name of Tracor, Inc. By this time, McBee had left the University of Texas to devote his time to building the company.

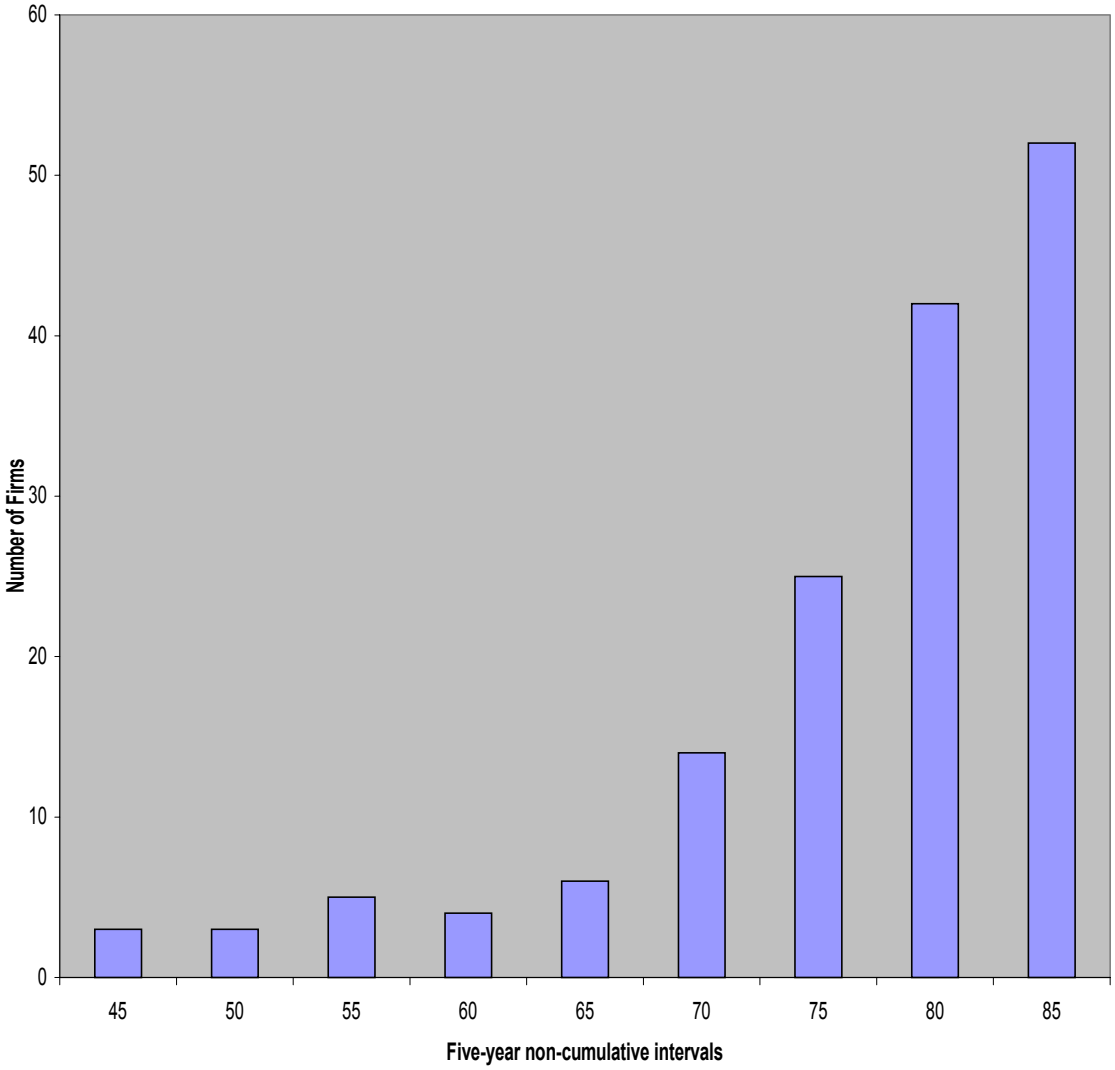


Figure 5 Establishment of high-technology-related firms or branches, 1945-1985.
Source: Directory of Austin Area High Technology Firms, Austin Chamber of Commerce, 1986

Figure 7 shows that from the College of Engineering and the Defense Research Laboratory at the University of Texas at Austin came the educated talent to form the entrepreneurial venture of Associated Consultants and Engineers in 1955, which led to the establishment of Tracor in 1962. However, even more impressive is the constant stream of entrepreneurial talent that came from Tracor itself. At least 16 companies have spun out of Tracor since 1962 and have located in Austin.

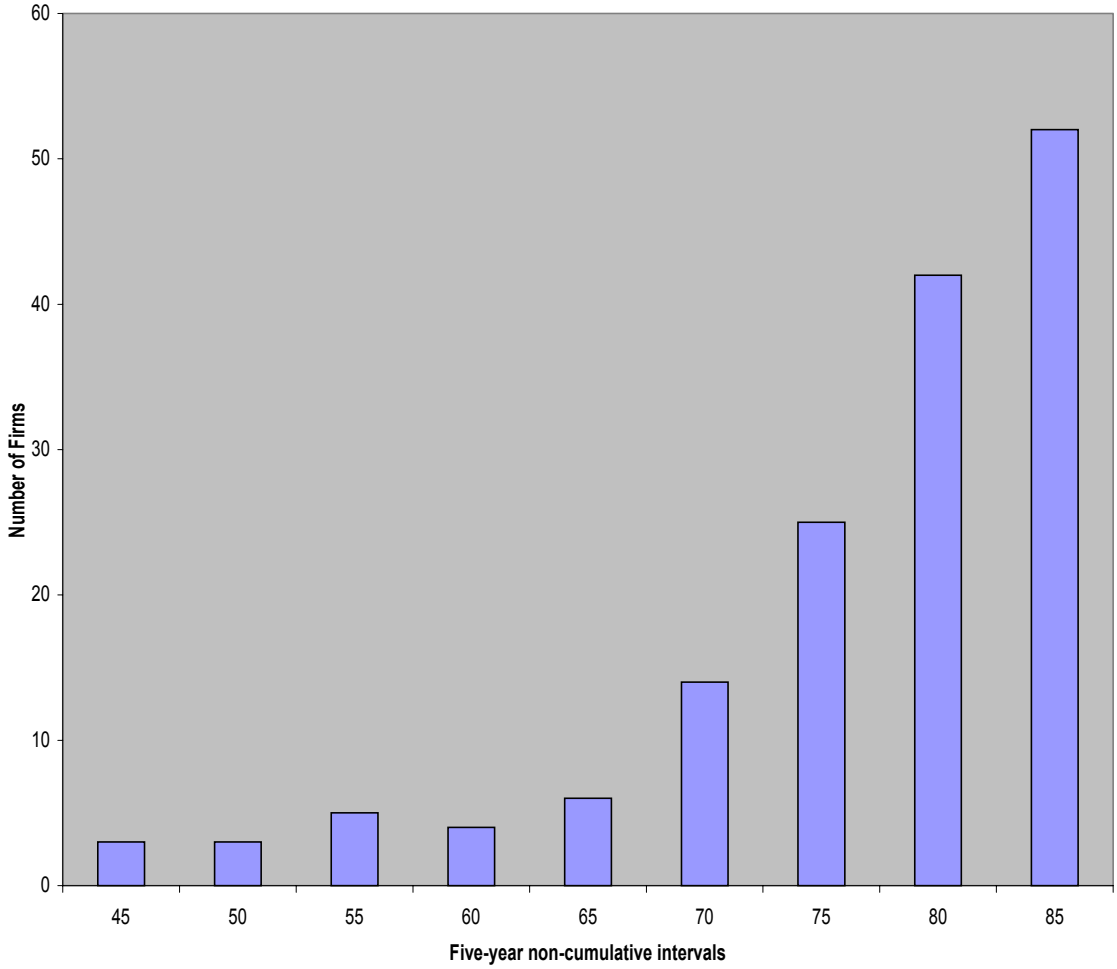


Figure 6 Foundings of small and medium-sized technology-related firms, 1945-1985
Source: Directory of Austin Area High Technology Firms, Austin Chamber of Commerce, 1986

Figure 8 dramatically shows the job creation impact of Tracor and its spin-outs on the Austin area. A total of 5,467 persons were employed in these companies as of 1985. These companies are also capable of creating spin-outs of their own. Radian Corporation, for example, has spun out four companies. Most importantly, neither Tracor, its spin-outs, nor the jobs they created would exist without the University of Texas at Austin.

In summary, the private sector associated with, and its effect on, the technopolis can be summarized as follows:

- Companies have spun out of the University of Texas at Austin.
- Major firms have been attracted and chose to locate in Austin for two primary reasons: access to university resources (particularly the talent pool) and desire to operate in an affordable quality of life environment.
- Employment has grown around technologically based companies.

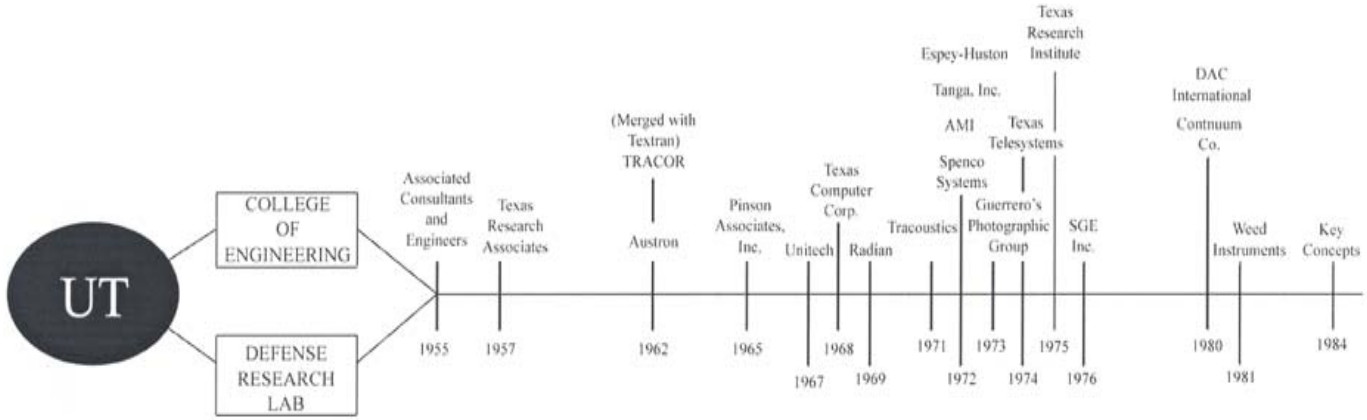
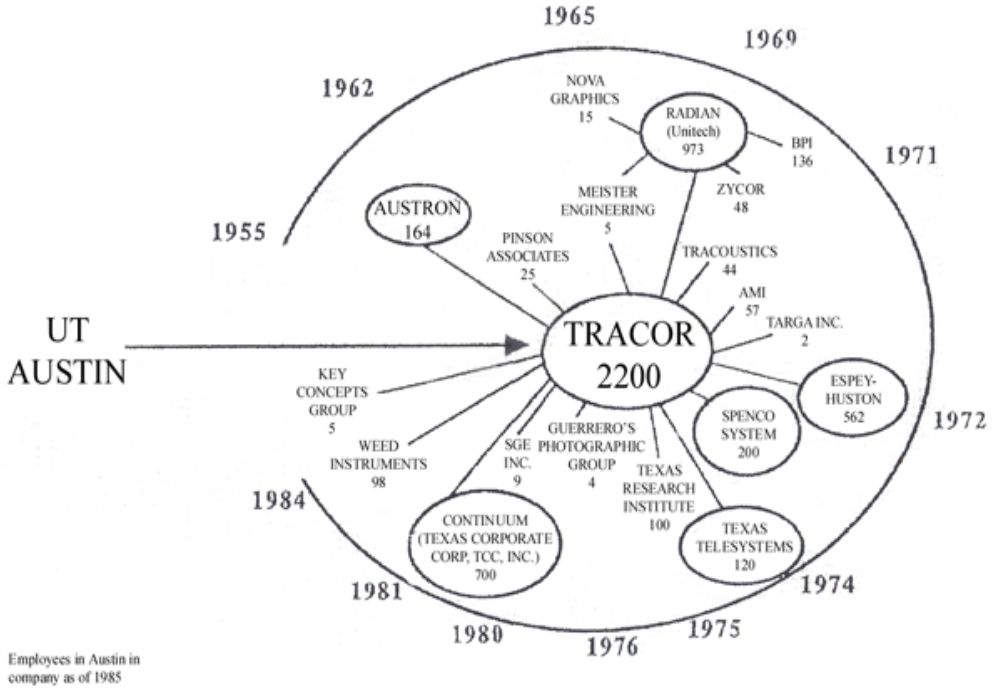


Figure 7 Development of Tracor and its spin-outs, 1945-1984

Source: This timeline was developed by the authors based on survey, interview, and archival data.

Figure 8 Job creation impact of Tracor and its Spin-offs

Source: This chart was developed by the authors based on survey, interview, and archival data.



Influencers

Although each of the institutional segments in the technopolis wheel is important to high-technology company development, the ability to link or network the segments is most critical (Birley 1985; Aldrich and Zimmer 1986). Indeed, unless the segments are linked in a synergistic way, then the development of the technopolis slows or stops. In Austin, these segments have been linked by first- and second-level influencers – key individuals who make things happen and who are able to network with other influencers in each of the other segments as well as within each segment.

- They provide leadership in their specific segment because of their recognized success in that segment.
- They maintain extensive personal and professional links to all or almost all the other segments.
- They are highly educated.
- They move in and out of the other segments with ease.

- They are perceived to have credibility by others in the other segments.

Cross-segment linkage is facilitated by second-level influencers who also represent business, academia, and government as well as local community interests. Within each segment, the second-level influencer interacts with and generally has the confidence of the first-level influencer. The role and scope of the second-level influencer is to act as a gatekeeper in terms of increasing or decreasing the flow of information to first-level influencers. Second-level influencers also have their own links to other second-level influencers in that the other second-level influencers initiate new organization arrangements to institutionalize the linkages among business, government, and academia.

Influencers seem to coalesce around key events or activities as described by Gibson and Rogers (1988) in their research on the interstate competition for the MCC. They play a crucial role in conception, initiation, implementation, and coordination of the events or activities. Once an event or action is successfully managed or achieved, they often help to institutionalize the process so that it can function effectively without them. Influencers play a particularly important networking role thorough support groups because these groups can provide convenient opportunities to interact across all segments of the wheel.

In short, an important characteristic of a technopolis is to be able to develop or attract and retain first-level influencers and nurture second-level influencers in all segments of the technopolis wheel. Based on the present research and the work of others (Rogers and Kincaid 1981; Ouchi 1984; Aldrich and Zimmer 1986) it can be argued that *the more extensive and the higher the level of networks across the different segments of the technopolis wheel, the more likely cooperative economic (and other) activities are to take place at community and state levels.*

Findings

A number of key points emerge regarding the development and maintenance of technopoleis from the study of Austin, Texas, and the framework of the technopolis wheel. They are as follows:

- The research university has played a pivotal role in the development of the Austin technopolis by 1) achieving scientific preeminence; 2) creating, developing, and maintaining new technologies for emerging industries; 3) educating and training the required workforce and professions for economic development through technology; 4) attracting large technology companies; 5) promoting the development of home-grown technologies; and 6) contributing to improved quality of life and culture.
- Local government has had a significant impact, both positively and negatively, on company formation and relocation, largely from what it has chosen to do or not to do in terms of quality of life, competitive rate structures, and infrastructure.

- State government has had a significant impact, both positively and negatively, on the development of the Austin technopolis through what it has chosen to do or not to do for education, especially in the areas of making and keeping long-term commitments to fund R&D, faculty salaries, student support, and related education development activities.
- The federal government has played an indirect but supportive role largely through its allocation of research and development moneys, on-site R&D programs, and defense-related activities.
- Continuity in local, state, and federal government policies has an important impact on maintaining the momentum in the growth of a technopolis.
- Large technology companies have played a catalytic role in the expansion of the Austin technopolis by 1) maintaining relationships with major research universities, 2) becoming a source of talent for the development of new companies, and 3) contributing to job creation and an economic base that can support an affordable quality of life.
- Small technology companies in Austin have helped in 1) commercializing technologies, 2) diversifying and broadening the economic base of the area, 3) contributing to job creation, 4) spinning companies out of the university and other research institutes, and 5) providing opportunities for venture capital investment.
- State and local influencers have provided vision, communication, and trust for developing a consensus for economic development and technology diversification, especially through their ability to network with other individuals and institutions in other segments of the technopolis wheel.
- Consensus among and between segments of the wheel is essential for the sustained growth of the technopolis.

The Austin example further emphasizes an interesting paradox: the very success of a developing technopolis can lead to greed and much community dissatisfaction. For example, at the local level an affordable quality of life, while subjective and hard to measure, can be a major source of friction between advocates and adversaries of growth. The result can be a shattering of the consensus that originally made the technopolis possible.

Implications for Other Technopoleis

The concept of the technopolis wheel provides some interesting and useful insights on the research and business venturing implications for other technopoleis in Europe (Cambridge, England, and Sophia Antipolis, France), Asia (Osaka and Tsukuba Science City, Japan, and Beijing, China), and the United States (Silicon Valley, California; Route 128, Massachusetts; Troy, New York; and Phoenix, Arizona). It is

striking to observe how much of the underlying concept of the technopolis wheel seems to apply to these case studies from across the United States and from other countries (Smilor, Kozmetsky, and Gibson 1988). Three consistent themes provide important implications concerning the generalizability of the concept of the technopolis wheel.

First, in the United States and Europe, short-sighted and fragmented policymaking among the community, government, business, and university components of the different technopoleis is being replaced with a more coordinated approach to high-technology development. In Europe, Sophia Antipolis is the most notable example of this observation. Since the passage of the "Technopolis Law" in 1983 and the enactment of 20-year development plans, Japan must be considered the most ambition nation in planning for high-tech cities of the future.

Second, the presence of high-quality research universities allows people engaged in basic research as well as professionally competent and managerially adept people to combine scientific research and invention with the practical applications of technology. The university is also an important source of liberal arts that underpin the quality of life factors necessary to sustain the technopolis and to provide a high degree of intellectual and cultural stimulation.

Third, a network of influencers or "executive champions" from the community, business, academic, and government sectors is essential to technopolis development. In Asia, Europe, and the United States, these influencers provide the vision and inspiration necessary for nurturing and maintaining a technopolis. It is the task of these influencers to make the technopolis wheel spin at the right speed and direction toward balanced growth and development.

In conclusion, our research suggests that the technopolis wheel provides a conceptual framework for assessing the relative importance of government, academic, business, and public sectors in the high technology economic development of a region. By focusing on the interaction among the seven segments of the wheel, the framework provides a practical perspective on the changing nature of economic development and the importance of new kinds of institutional relationships among the research university; large and emerging corporations; federal, state, and local government; support groups; and key influencers who network these segments in the modern city-state.

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