Sustaining The Technopolis: High-Technology Development in Austin, Texas 1988-2012

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Abstract:

Update and elaboration of the 1988 *Journal of Business Venturing* article "Creating the Technopolis: High-Technology Development in Austin, Texas" which emphasized the role of key influencers, institutions and networks that made possible Austin's extraordinary technology-based growth. Elaborates the "Technopolis Wheel" framework to better reflect challenges and opportunities as well as review lessons learned during the past 25 years. While new aspects have emerged an unchanging, fundamental reality is that the "magic" of the Austin Model continues to be based on 1st- and 2nd-level influencers — key leaders and visionaries from academia, business, and government networking and working together to achieve targeted objectives.

Keywords: Austin, Texas; technopolis; regional economic development; entrepreneurship; innovation; networking

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Sustaining The Technopolis: High-Technology Development in Austin, Texas

1988-2012[1]

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ABSTRACT

This paper is an update and elaboration of the 1988 Journal of Business Venturing article on "Creating the Technopolis: High-Technology Development in Austin, Texas" which emphasized the role of key influencers, institutions and networks that made possible Austin's extraordinary technology-based growth. We elaborate the "Technopolis Wheel" framework to better reflect challenges and opportunities as well as review lessons learned during the past 25 years. While new aspects have emerged an unchanging, fundamental reality is that the "magic" of the Austin Model continues to be based on 1st and 2nd level influencers—key leaders and visionaries from academia, business, and government networking and working together to achieve targeted objectives.

1. Introduction

The rapid and dynamic growth of the high-technology sector during the final decades of the twentieth century ushered in new approaches to regional economic development worldwide. One approach has been exemplified in the term "technopolis" in which economic development is stimulated by fostering R&D and technology commercialization through public-private collaboration (Tatsuno, 1988; Morita and Hiraoka, 1988; Onda, 1988).[2] Overtime greater emphasis has been placed on the importance of collaboration across business, academia, and government at the regional level (Smilor et.al. 1988a; Gibson et.al., 1992; Rogalev, 1998; Florida, 2002; Nishizawa and Fukushima, 2005;; Nishizawa, 2011) as more recently popularized in 'The Triple Helix' (Viale and Etzkowitz, 2010). In short, the modern technopolis interactively links public and private sectors for technology innovation and commercialization at the regional level to spur economic development and to promote economic diversification.

The present paper is informed by the conceptual framework of the Technopolis Wheel, first published in 1988, in modeling the interplay of high-technology development and regional economic growth in conjunction with seven key segments: The research university; large and start-up technology firms; federal, state, and local government; and support groups (e.g., chamber of commerce, venture and angel capital, IP lawyers and other business professionals).[3]

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[2] "Techno" emphasizes the importance of technology and "polis" is Greek for city-state and emphasizes the balance between the public and private sectors. In 1980 the Japanese Ministry of International Trade and Industry (MITI) announced the technopolis concept and in 1983 the Technopolis Law laid out 20-year development plans for the development of regional research centers in 28 Japanese cities. The long-term plan was to build a Japanese Technostate composed of research centers and technology-based regions throughout Japan. (S. Tatsuno, "Building a Japanese Technostate: MITI's Technopolis Program," in Creating The Technopolis, (Eds.) Smilor, Kozmetsky, and Gibson (1988c), pp 3-21). This ambitious national effort was motivated, in part, by the established success of California's Silicon Valley. However, Japan's Technopolis Strategy failed to produce the desired results (Nishizawa, 2011; Fukushima, 2011).

[3] "Creating The Technopolis: High Technology Development in Austin, Texas." Smilor, Gibson, Kozmetsky, Journal of Business Venturing, 4:49-67 (1988b).

On the one hand, key characteristics of the Technopolis Wheel have not changed for Austin, Texas over the past 25 years. On the other hand, new emphases and aspects need to be considered as we progress into the 21st Century, figure 1. In the end, we argue for the enduring value of the Technopolis Wheel as a useful conceptual framework for studying assets and challenges for accelerating regional technology-based development.

FIGURE 1. The Technopolis Wheel Framework Emphasizing the Importance of Influencers

1.2 Industry Clusters and Innovation Ecosystems

Research on the importance of technology-based industry clusters located in key geographic areas has been the subject of much scholarship including Castells 1985, 1991, 2001; Porter, 1990; Saxenian 1994; Folta, Cooper, and Baik, 2005; McCann and Folta, 2011, and Gilbert, McDougall and Audritsch, 2007. Along with the growth of high-technology regions came the debate about the future of cities (Kotkin 2000) including how the rise of information technology and the Internet would free workers from the constraints of space and time. However, the increasing importance of specific technology regions worldwide has largely debunked the notion of the imminent decline of regional importance (Castells 2001). Instead, specific geographic locations have become even more important to successful innovation and technology development (Kotkin 2000; Gibson and Rogers, 1994; Butler and Gibson, 2011).

The importance of better understanding the importance of Industry clusters can be traced to Alfred Marshall, who noted that industries tend to cluster in distinct geographic districts that tend to specialize in the production of narrowly related goods (Marshall, 1920). Marshall believed that knowledge spillovers are the cause (or result) of this clustering. Schumpeter (1934) continued down this theoretical path when he noted that innovative breakthroughs tend to distribute themselves irregularly over time in specialized clusters of activity. Michael Porter's The Competitive Advantage of Nations (1990) elaborated that the development of industry

clusters is key to a globally successful and competitive regional strategy (Moore, 1996). As noted by James Moore in 1993:

> To extend a systematic approach to strategy, I suggest that a company be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of businesses. In a business ecosystem, companies co-evolve capabilities around a new innovation, they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations (The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems, 1993:76).

In research on the interrelations of organizational structures the paradox of competition and cooperation comes to the fore with the belief that regionally-based public and private organizations can be simultaneously highly competitive and cooperative in networking across different community organizations and institutions (Ouchi 1984; Smilor 1988a). Smilor, Gibson, and Kozmetsky (1988b) introduced the framework of the Technopolis Wheel to emphasize the key role of first and second level influencers in networking across and leveraging assets of public and private sectors in the creation of jobs and wealth.

High-tech giant Silicon Valley was perhaps the first region to embody the cooperation-competition paradox in a flexible industrial system embedded in networks rather than single firms located in hierarchical, vertical institutional environments (Saxenian 1994). The premise being that a network of institutional alliances yields greater technological development and innovation, which accelerates regional development (Smilor and Wakelin 1990). Kozmetsky (1993) reinforced the concept of the region or community in the cluster discussion by focusing on the firm as one unit of analysis embedded in a regional ecosystem that includes public and private sectors. These organizational approaches emphasize networking and collaboration as important community or regional dynamics key to new venture creation. In "Breaking the Mold:

Reinventing Business Through Community Collaboration," a paper delivered at the MIT Enterprise Forum, Kozmetsky stated (1993):

> The solutions to many critical issues and problems now demand an integrated, holistic and flexible approach that blends technology, management, and scientific, socio-economic, cultural and political ramifications in an atmosphere of profound change and extreme time compression.

The organization of community and industry, rather than being a collection of fragments, takes on the structure of an industrial ecosystem comprised of local institutions and culture, industrial structure, and corporate organization (Saxenian 1994; Rosenberg, 2002; Nishizawa, 2011). Interplay between separate sectors changes the constitution of each and as emphasized by Gibson and Rogers (1994) the successful technopolis is best understood as a dynamic environment that is more than the sum of its parts. As observed by Richard Florida (2005), innovative ecosystems matter; there aren't many of them; and only a few dozen regions worldwide really compete at the cutting edge. Since the late 1990s, Florida as many other observers list Austin as a leading region in business development, creativity and innovation, entrepreneurship and business start-ups, and the creation of wealth and jobs.[4]

Up to the mid-1980s Austin was largely known as the Capitol of Texas and home of The University of Texas' flagship campus. UT Austin graduated students usually had to leave the region for Dallas, Houston, or the East and West coasts to find employment and to build careers.

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4 For context, Austin, the 14th largest city in the United States with a metro area of 4,2000 square miles, a population of 1.7 million, and a labor force of about 900,000. In 1998 Austin was ranked "The Best US City for Business," by Fortune; the "Top City for Entrepreneurship," by Forbes, May 2000; the 2nd most creative city in the US, by Richard Florida in 2002; the "Best Place for Business and Careers," Forbes 2003-2005; #1 for Economic Vitality, Wall Street Journal, 2007; #3 "Most inventive city due to patent activity," Wall Street Journal 2007; #2 Most Innovative City in the U.S., Forbes, 2010, Best US City for the Next Decade, Kiplinger's Magazine (June 2010); #2 Best Performing City in the US, Milken Institute (October 2010); Newsweek (November, 2010) described Austin as having the nation's strongest job growth, both in 2009 and over the last decade. "(Austin) enjoys good private-sector growth, both from an expanding roster of homegrown firms and outside companies, including an increasing array of multinationals such as Samsung, Nokia, Siemens and Fujitsu." Austin named the 'Best City for Finding Employment' (Forbes, 2011) and 'Among Top 10 U.S.' Brain Magnets,' Forbes, 2011. In May 2012 Austin's unemployment dropped to 5.5% after being at 6% since 2008.

In 1983 all this began to change with the City's winning a national competition for the nation's first for-profit R&D consortium, the Microelectronics and Computer Technology Corporation (MCC), followed by the recruitment of 3M research operations in 1984 and winning the national competition for a second major R&D consortium, Sematech in 1988. At the same time firms such as IBM, Motorola, AMD, and Applied Materials were expanding their Austin-based R&D operations. While under the radar of most Austinites, local entrepreneurs were launching ventures that would become global corporations based in Austin: In 1976, four professors left UT Austin's Applied Research Labs to form National Instruments; a UT undergraduate student and his girlfriend dropped out in 1978 to found SaferWay later known as Whole Foods; and in 1982 Michael Dell, an undergraduate pre-med major, launched PC Limited in his UT Austin dorm room.

1.3 Role of Key Influencers

The "momentum" for success within the Technopolis Framework comes from key influencers – visionaries and champions – in each sector or sub-sectors working together to connect and leverage otherwise unconnected and perhaps competing sectors for a common purpose. First level influencers are usually successful leaders in "their" sector, who also maintain extensive personal and professional network links to other sectors and who effectively cross sectors with credibility and influence. First level influencers also tend to mentor and at times "protect" second level influencers as they network across different public-private sectors to structure and implement action oriented activities that often challenge institutionalized rules, procedures, and established expectations of conduct.[5] Second level influencers act as communication bridges to

first level influencers while initiating boundary-spanning activities with their colleagues and trusted friends in other sectors whether business, academia, or government (Smilor, et. al., 1988b: p 63). The personal communication networks of such influencers tend to be outward looking as opposed to being closed and provincial and such "outward looking" networks tend to be multidisciplinary and open (Gibson and Rogers, 1994:179). "Collaborative Individualism" is the term given to individuals, with disparate organizational affiliations, who voluntarily come together to accomplish specific tasks of limited duration (Cunnington and Gibson, 1991).

2. The University Sector

A great deal of research over the past two decades has focused on the role of the research university in developing and sustaining regional technology-based growth (Rogers and Larsen, 1984; Smilor, et.al., 2008; Fetters, M and et.al, 2010). Going back to the Bay Dole Act of 1980, research universities have been considered a valuable resource of research and scholarship leading to technology commercialization. Increasingly universities are seen as key to a region's or state's economic development and competitiveness (Saxenian, 1994, p.8). This paper supports the view that the research university, functioning in concert with other segments of the technopolis, is the keystone for building and sustaining knowledge-based regional innovation ecosystems (Florida 2002; Smilor, et.al. 2007).

The Technopolis Framework identifies three key dimensions to define and measure a high-tech region: (1) The achievement of scientific preeminence, (2) the development of new

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5 Such a first level influencer was Dr. George Kozmetsky, co-founder of Teledyne who was recruited to Austin in 1966 as the Dean of UT's College of Business Administration. Dr. Kozmetsky is considered an early visionary of the Austin Technopolis. He founded and funded the IC² (Innovation Creativity Capital) Institute at UT Austin in 1977 and became an important influencer and champion for building regional academic-industry-government alliances. He was a key mentor to Austin-based entrepreneurs like Michael Dell; Jim Truchard of National Instruments; Jim McKay of Whole Foods; and 100s of entrepreneurs at home and abroad. Kozmetsky was a key catalyst in developing Austin's strategy for winning the MCC in 1983 and in championing such regional catalytic organizations such as The Austin Technology Incubator and The Capital Network in 1989, The Austin Software Council in 1991. In 1993, George Kozmetsky received the National Medal of Technology from President Clinton.

technologies for emerging industries, and (3) the attraction of major technology companies and the creation of home-grown technology companies (Smilor, Kozmetsky, and Gibson, 1988a, 1988c; Smilor, Gibson, and Kozmetsky, 198b; Gibson and Rogers, 1994). [6] This paper centers data collection and analyses based on these three dimensions. The data is presented to describe the evolution of key sectors of the Technopolis Wheel in the growth and sustainability of Austin as a technopolis.[7] Much of the data is longitudinal in nature, and is represented in charts and graphs to illustrate change over time to track the rise, setbacks, and continued development of the Austin Technopolis from the mid-1980's though 2012.

While this paper supports the view that a research university's most important deliverable for industry and society is to graduate well educated students, we emphasize three components of the University of Texas at Austin (UT) that impact quality research and education as well as the growth and sustainability of the Austin Technopolis: (1) endowed chairs in science and technology, (2) research and development (R&D) expenditures, and (3) technology licensing and spinoff activity. [8]

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[6] High-technology industry includes those based on the contributions of knowledge workers --- a highly educated labor force heavily concentrated in science and engineering including a culture of entrepreneurship and technological innovation, have a high ratio of research and development (R&D) to sales, and market their products globally (Larsen and Rogers 1988).

7 Data sources utilized in this paper include large technology company relocations, homegrown company establishments, research and development expenditures, technology licensing, and spin-out company formation. The data were gathered from archival sources including The University of Texas at Austin (UT), the Greater Austin Chamber of Commerce (GACC), and the City of Austin and we especially thank Jim Butler, Manager, Creative Industries, City of Austin; Beverly Kerr, VP Research, Austin Chamber of Commerce; Betsy Merrick, Associate Director, Marketing/Public Relations, Office of Technology Commercialization, UT Austin; and Susan Wyatt Sedwick, Associate Vice President for Research and Director, Office of Sponsored Projects, UT Austin.

[8] The University of Texas at Austin, established in 1863, is the flagship campus for the UT-System which is comprised of 9 universities and 6 health institutions. UT Austin enrolls about 50,000 students/year with 18 colleges and schools and 86 doctoral programs. The Cockrell School of Engineering's has 267 faculty and more than 7,800 students enrolled in nine undergraduate and 13 graduate degree programs. The College of Natural Sciences has 370 faculty and 10,800 students and 37 research units. With a 2011 enrollment of 38,437 undergraduate and 11,497 graduate students, UT Austin is a major supplier of educated talent for regional, as well as national and global, industry as well as the public sector. However, for technopolis growth and sustainability it is also important to emphasize the key role played by a range of types of regional educational institutions such as community colleges, and technical education and their contributions to the education and training and retraining of the managers and workers crucial to the growth and sustainability of a region's public and private sectors.

2.1 Endowed Chairs

Endowed chairs help attract top researchers who are key to world-class scholarship and research and to winning competitive federal, state, and other research grants that fund fellowships and attract superior graduate students. The result is a clustering of established and emerging talent in centers of research and education excellence and rising prestige for a university. At UT-Austin a dramatic rise in the number of endowed chairs in engineering and computer science in 1982 (32 Chairs) and in 1983 (41 Chairs) was directly linked to Austin's winning The Microelectronics and Computer Technology Corporation (MCC) in 1983.[9] This sharp rise in UT Endowed Chairs from under 50 pre-1982 to over 300 in 2012 resulted, in large part, from private donations that were enhanced by UT Austin's matching program.[10]

Graph 1 illustrates that, as of 2010, the vast majority of UT endowed chairs exist in the College of Engineering (19%); School of Law (16%); College of Natural Sciences (15%); College of Liberal Arts (12%); College of Business (11%); and Geosciences (4%). Endowed chairs help recruit and retain highly ranked "star" professors as well as the recruitment of top graduate students as competition is intense among research universities worldwide to recruit the best and the brightest. For example, after UT Austin's dramatic growth in endowed chairs in 1984, the Department of Computer Science in 1988 received three times as many graduate

[9] The Microelectronics Computer and Technology Consortium (MCC) located in Austin, Texas in 1983 after a major national promotion and competition. MCC was the 1st for-profit R&D consortium in the US and motivated the passage of the National Cooperative Research Act of 1983. MCC was a key and early catalyst for Austin's rise as a globally competitive technopolis.

[10] Winning the MCC provides an excellent example of public and private sector synergy at the regional level while strengthening UT Austin as a top research university. Peter O'Donnel, a successful Dallas businessman arranged with UT administrators to leverage his $8 million gift for endowed chairs with an additional $8 million from the private sector which was matched with $16 million from the University of Texas Permanent University Fund to create, in 1983, 32 million dollar chairs in computer science and engineering. The Permanent University Fund (PUF) is a Sovereign Wealth Fund with total assets of $12.8 Billion as of June 2011. The PUF was created by the State of Texas in 1876 to fund public higher education. A portion of the returns from the PUF are annually directed towards the Available University Fund (AUF).

student applications with substantially higher Graduate Record Exam (GRE) scores (Gibson and Rogers, 1999: 446-447).

GRAPH 1. UT Austin Endowed Chairs by Academic Unit (Total 317, as of 12/21/2010)

2.2 Research Funding

UT Austin research expenditures grew from $376 million dollars (FY02-03) to $589M (FY 10-11) significantly up from $120M in 1986.[11] During 2010-2011, federal government funding to UT Austin totaled $355.5M and the main funding agencies were DOD at $122M; NSF at $76.5M; HHS at $72M; DOE at $42.5M; and NASA at $13M. For the same time period, corporate funding to UT Austin was about $68M; state and local research funding totaled about $41M; non-profits about $31M; and institutional funding at about $88M. As of FY 2010-2011, research expenditures by academic unit have been $158M for the VP for Research[12], $146M for the College of Natural Sciences, $130M for the College of Engineering, $56M for Geology, and $30M for the College of Education, Graph 2. As of early 2012, UT Austin's Cockrell School of Engineering had 21 science and technology (S&T) research units with annual budgets greater than one million dollars followed by the College of Natural Sciences with 27 such research units; UT Austin's VP Research with eight units; and the Jackson School of Geology with four research units each with annual funding greater than one million.

GRAPH 2. Total Research Expenditure by Academic Unit and Year ($US Millions)

[11] The total dollar amount of contracts and grants awarded to UT Austin was about $55 Million in 1977 and increased to about $120 M in 1986. In 1989 Federal funding totaled almost $90 M or about 60% of UT Austin research funding as compared with 7.5% State grants and 7% industry funding (Austin Technology-Based Industry Report, 1991).

[12] VP for Research funding includes university activities and programs such as UT Austin's Applied Research Labs (APL), Center for Electromechanics, The Center for Computational Engineering and Sciences, The Texas Advanced Computing Center, and the IC² Institute.

2.3 Science and Technology Commercialization

University research is dedicated to basic science and making contributions to the field of inquiry and the scientific process greatly benefits students who learn how to perform world-class research, form research teams, and ask important questions, as well as how to write and publish research papers and grants, and work to solve problems that may change the world. In short, the research university is the keystone of Technopolis development and sustainability as it attracts and educates sufficient numbers of talented researchers and students crucial to achieving scientific preeminence and an educated populace. It is also important to remember that university research is generally up-stream and far from the marketplace.

University-industry partnerships and college advisory boards at UT's Colleges of Engineering and Natural Sciences help link world-class science and education with innovation for industry. Research by Zucker and Darby (1996) concentrated on scientific discovery, diffusion, and technology transfer and they offered two broad conclusions: (1) to understand the diffusion and commercialization of bioscience breakthroughs (and science in general) it is essential to focus on the scientific elite, the stars, and the forces shaping their behavior; and (2) research breakthroughs by star scientists create a demand for boundary spanning between universities and firms. As Zucker, Darby, and Armstrong (1998:65) continue, "Knowledge spillovers (positive externalities of scientific discoveries on the productivity of firms) …play a central role….as causes of both economic growth and geographic agglomeration." In short, the benefit of talented researchers and their students tends to spill over from basic science into research and development, industry consulting, and technology commercialization (Gilbert, McDougall, and Audretsch, 2007).

In the United States, since the passage of Bayh-Dole in 1980, there has been a seeming ever-increasing political and societal pressure for greater economic impact of university research by successfully transferring knowledge and technology to commercial applications (Shane, 2002 and Markman, et.al., 2005). For UT Austin this increased emphasis on S&T commercialization has been a difficult transition given the established norms and values of a Tier One Research University funded, in large part, by public money. UT Austin's Office of Technology Licensing (OTL) was launched in September 1991 and, reflecting university concerns of the time, the office was staffed by lawyers who emphasized the protection of The University's intellectual property (IP). In September 2003, the OTL was renamed The Office of Technology Commercialization (OTC) to institute a more market oriented approach to transferring UT Austin S&T to industry. UT Austin's OTC continually works to: improve programs and processes in evaluating, protecting, marketing, and licensing university inventions and software; assist in the formation of startups; promote collaboration with industry, investors and other stakeholders; and educate faculty in appropriate and current patent protection and commercialization processes.

Between FY 2003 and 2011 UT Austin issued 281 US and 256 foreign patents. In FY 2010-2011 34 patents were issued in the US and 28 in foreign countries with the most foreign patents being filed in Japan followed by Denmark, Sweden, Ireland, the UK, Switzerland, Germany, France, India, and Mexico.[13] Annual tallies of license agreements at UT Austin have ranged from the mid-twenties to a high of 58 in FY 2008 for a total of 303 license agreements over the past nine years. Licensing income has increased considerably from about $500,000 in 1992 to

[13] The large discrepancy in foreign patents is due to the fact that, in FY03, 04, 07, and 08, THECB reports did not ask for foreign patents issued. In the current chart counts from Inteum (OTC database) have been inserted for those years.

$4.3 million in FY 2003 and to over $25 million in FY 2011. As is common in most royalty streams to a university, a few patents provide the largest financial rewards.

One of OTC's responsibilities is to serve as a startup or spinoff catalyst for the University (Rogers, and Speakman, 1999 and Minshall and Wicksteed, 2005). Graph 3 shows the number of Texas and Non-Texas located startups per year, based on UT Austin technology. Largely confined to one or two firms in the 1990s, this number increased from 6 to 12 firms per year during the past decade.[14] However, this research paper takes the position that it is also very important to include non-IP spinoffs in any assessment of the economic development impact of a research university. For example, in Austin, it is important to include university connected companies such as DELL Corporation and National Instruments in the UT affiliated spinoff category, as it was UT Austin that "recruited" the founding entrepreneurs to Austin: University researchers launched National Instruments while working at UT's Applied Research Labs (ARL) in 1976 and Michael Dell launched his entrepreneurial effort as an undergraduate business student in 1983. It is also noteworthy that these entrepreneurs chose to grow their companies in Austin, in part, because of the critical importance of a continuing supply of qualified talent graduating from UT Austin and other regional education institutions and, in part, because of the region's quality-of-life which they and their colleagues, employees, and new recruits and their families enjoyed. Additionally, we argue that UT Austin deserves considerable credit for the founding of non-technology entrepreneurial enterprises and institutions such as the internationally prominent and successful Austin-based Whole Foods, Inc. and SXSW Interactive, Film, Music, and Internactive Festival as both were founded by former UT Austin students.

[14] An IP-based university spin-off is considered to be a company that licenses a technology from a university in order to function; that is, the company did not exist until the time the university technology was licensed. A company is considered a spin-off regardless of whether or not the company founders were involved in the creation of the licensed technology.

Graph 3: Number of University of Texas at Austin Spinoffs by Year

2.3.1 The Austin Technology Incubator

The Austin Technology Incubator (ATI) was launched by UT Austin in 1989 when the region was in a serious economic slump and "see through" buildings were prevalent.[15] Led by IC² Institute, the Austin Technology Incubator secured modest funding: $50,000/year for three years from the City of Austin and $25,000/year from The Greater Austin Chamber of Commerce and a onetime $70,000 donation from Travis County plus $50,000 from a private donor. ATI was launched, near the epicenter of emerging software technology companies, in 4,000 sq. ft. of "borrowed" office space with donated furniture from university storage and Austin-based merchants gifting some "difficult to sell" furniture.[16] University administration was not entirely comfortable with the idea of a state supported educational institution hosting a business incubator, even if it was not-for-profit, so the concept was "promoted" as a technology venturing laboratory for UT students and professors much like a chemistry or physics lab. Over the years, ATI has educated students and faculty in real-life technology entrepreneurship, attracted and mentored entrepreneurial talent, graduated technology-based ventures, and been a key catalyst in the development of Austin's entrepreneurial and innovation ecosystem.

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[15] In 1982 Austin had 16 million sq. ft. of office space and the occupancy rate was 95%. In part motivated by the economic development hype of winning the MCC headquarters, by 1986, 14 million sq. ft. of office space had been constructed and the occupancy rate had dropped to 70% and by mid-1987 an additional 6 million sq. ft. dropped the office occupancy to 60% (Gibson and Rogers, 1994). In 2012 Austin's vacancy rate is at 17% and leases are being signed at 32% over 2011 prices (Forbes Web, May, 2012).

[16] The implied agreement was that when a company graduated ATI it would purchase its new furniture from those merchants that had originally supported ATI with donations of "hard to sell" or damaged office furnishings. As one of the wealthiest Texans, Dr. George Kozmetsky could have simply underwritten the start-up expenses of ATI; however, he wanted to secure buy-in and commitment from key public and private stakeholders and he wanted to emphasize building an entrepreneurial start-up culture as being most important to the launch and sustained success in the management and operation of the Austin Technology Incubator. As an additional challenge to the launch of ATI, a previously launched and well-funded Austin-based technology incubator called Rubicon had closed its doors with no successful graduate companies and millions in lost investment.

In 1989 the lack of Venture or Angel Capital was a noted challenge for the successful operation of ATI and the growth of a regional entrepreneurial culture. Key civic entrepreneurs from Austin visited their colleagues in Leadership Texas, The Texas Lyceum, and Texas Woman's Alliance to elicit support and funding to launch the Texas Capital Network (TCN), as a non-profit Angel Fund that would match promising ventures to potential investors. TCN was launched with the participation of wealthy influencers who agreed to review business plans in certain technology sectors and, if they so desired, provide seed funding to a particular entrepreneurial venture. In brief, ATI and TCN helped build Austin's emerging innovation ecosystem by conducting training seminars on business plan development and deal structuring; managing the investment process; and organizing venture competitions. Within a few years, TCN, which was based at ATI, was renamed The Capital Network and grew to be the largest Angel Fund in the Southwest facilitating more than $150M in total investments with 2000 registered entrepreneurs. TCN's annual Venture Capital Conference regularly attracted upwards of 300-500 investors and entrepreneurs from across the United States who came to hear venture pitches from Texas start-ups. TCN terminated operations in 2001 as Austin's reputation as a entrepreneurial "Hot Spot" grew and VC representatives from the East and West Coast started to locate offices in Austin as did Business Angels.

Since its inception ATI has had the dual purpose of service (1) to the University as an education and research laboratory for entrepreneurship and technology venturing, and (2) as a regional catalyst for economic development. Over the years, as Austin's regional innovation and entrepreneurial support systems have grown and matured, so has ATI (Phan, Siegel, and Wright, 2005). Austin's current extensive entrepreneurial ecosystem includes a broad range of private and public structures and associations supportive to technology venturing while ATI incubation

efforts increasingly focus on providing high value mentoring in the select technology verticals of IT, clean energy, wireless, and biosciences, figure 2. ATI brings its portfolio of companies, in each of these industry sectors, deep domain management expertise and investor network access, as well as important research and education links (formal and informal) to UT Austin and network ties to city and chamber of commerce economic development objectives and influencers.

Figure 2: ATI Evolved as did Austin Technology Venturing Ecosystem

3. Industry Sector: Large and Start-Up Firms

Successfully recruiting, retaining and growing, and creating firms in one or more globally competitive industry sectors or clusters is perhaps the most important indicator of a successful technopolis. The following discussion focuses on company relocations, retention and expansions, and indigenous firm growth in building the Austin Technopolis.

3.1 The Rise of the Austin Technopolis

Graph 4 illustrates the founding's and relocations of firms and branches of firms that were established in Austin from 1955 to 2000 and shows the takeoff and success of Austin as a globally competitive Technopolis by the increasing number of technology-based firm establishments over time. Austin's first Fortune 500 technology company, Tracor Inc., was spun out of UT Austin's Applied Research Laboratories in 1955 by four engineering professors with $5,000 seed funding and an acoustical system research contract.[17] However, the takeoff of the Austin Technopolis came in 1983 with the successful recruitment of MCC (The Microelectronics

[17] The Tracor case is celebrated in the "Creating the Austin Technopolis" (1988b) article and notes that through the next 2.5 decades the company gave birth to over 30 spin-off technology companies in Greater Austin. The company was taken over by Westmark, Inc. in 1987 and filed for Chapter 11 in early 1991. Tracor emerged from bankruptcy in late 1991 and grew with several acquisitions in 1999 became part of BAE Systems. In April 2012, BAE Systems dedicated a state-of-the-art manufacturing center in Austin to produce technologies for global defense, aerospace, and security

and Computer Technology Corporation) after an intense and public national competition including 57 cities and 27 states. Austin's bid for MCC was a carefully crafted collaboration of influencers primarily from the Governor's office, UT Austin, and local business leaders (Gibson and Rogers, 1994). The competition was intense, national, and public. And, as requested by MCC's first CEO, the competition stressed the key importance of partnering with a local research university to build a high quality "pipeline of talent" as being more important than traditional economic development criteria of low taxes, low cost of living, and transportation for shipping products.[18] Winning MCC was Austin's first large-scale recruitment success involving key government, business and academic influencers and it set the strategy for Austin's future economic development endeavors.[19] Indeed, Austin's winning MCC recruitment strategy formed the basis for the development of the Austin Model and it also spurred a reevaluation of economic development strategies of the other three finalist cities for the MCC (Raleigh-Durham, San Diego, and Atlanta) and many of the other 56 "losing" cities throughout the United States.

GRAPH 4. Austin Technology Company Timeline: 1955-2000

In 1984, the public-private collaboration effort led by the "MCC location Team" of government, business and academic influencers successfully recruited 3M corporate R&D operations from Minnesota to Austin and four years later led the successful bid for Sematech, the nation's preeminent semiconductor R&D consortium, followed by Applied Materials in 1992,

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[18] High-tech industries are built on a highly educated labor force concentrated in science and engineering, rapid technological innovation, a high ratio of R&D to sales, and global markets (Larsen and Rogers 1988) and not on shipping products but in the MCC competition several competing cities did not appreciate this distinction..

[19] The MCC was designed to help keep Japan from surpassing US companies in supercomputer development and the founding of the consortium legitimized R&D consortia as a new and acceptable US organizational form with the passage of the National Cooperative Research Act of 1984 (Gibson and Rogers, 1994). Even though MCC was formerly dissolved in late 2004 and the building was renamed the West Pickle Campus (WPC), winning the consortium had a tremendous positive impact on Austin, in part, through the national recruitment of over 450 highly skilled software and IT engineers and key administrative staff. Many of these employees chose to remain in Austin after their MCC-days and work in existing Austin public and private firms and as civic, social, and technology entrepreneurs.

and Samsung in 2005. Austin's development unfolded over time as large and small software, semiconductor, and PC companies located in Austin in what may best be described as a snowball effect—as more companies located in the Capitol City more were attracted to the region.

3.2 *Austin We Have A Problem:* Sustaining the Austin Technopolis

While many IT companies and about 13,000 Austin jobs were lost during the dot-com industry economic meltdown of 2000-2001, a more serious challenge to Central Texas' economic sustainability as a growing technopolis was a downturn in the region's semiconductor manufacturing that began in 2007 (Powers, 2007). For about 20 years, with thousands of employees and an average salary of $64,500/year semiconductor manufacturing was a key employer and the largest exporting industry in Central Texas. However, the $8.7 Billion industry declined by about $1.8 Billion year-by-year in a downward trend in which Central Texas lost 27,800 semiconductor manufacturing jobs resulting in a 30% decline in manufacturing employment. In addition 50% of Central Texas' remaining fabs were more than 10 years old. Major components of Sematech, Austin's highly valued semiconductor R&D Consortium, were being successfully recruited to New York through a public-private research effort led by NY State Government and Albany University.[20] Furthermore it was clear that without significant restructuring, Austin's PC Industry (i.e. DELL Corporation) was not likely to be the main accelerator for job and wealth creation that it had been in past decades.

The regional challenge was to leverage Central Texas' considerable assets in fabrication facilities and talent and trained workers to the benefit of emerging industry sectors such as

[20] Spurred by $300 Million investment from New York State in 2007, Sematech agreed to a major expansion of its R&D operations at the Center of Excellence in Nanoelectronics and Nanotechnology at The University of Albany. In 2010 Sematech further expanded its NY operations with the College of Nanoscale Science and Engineering (CNSE). Sematech significantly downsized the R&D operations that remain at the Austin facility and the building is largely unoccupied.

nanotechnology, bio-medicine, and clean technology. Accordingly, The City and the Greater Austin Chamber of Commerce targeted the following industries for recruitment and entrepreneurial support: Automotive and Aerospace research and components manufacturing; convergent technology; data centers; life sciences; wireless; clean energy; and creative industries and multimedia, figure 3. It is important to note that each of these industry sectors had an established and growing Austin presence including relevant research, education, and training programs at The University of Texas and other regional universities and colleges.

FIGURE 3. Austin's Assets Supporting High Tech Industries & Targeted Start-ups

3.4 Austin's Continued Technology Industry Growth

In addition to firm relocation and technology venturing, firm retention and growth has been important to Austin's economic development and sustainability. Initially attracted by Texas' lack of corporate and personal income tax, cheap land, and a relatively low cost of living, IBM came to Austin in 1966 to manufacture the Selectric Typewriter. More importantly, IBM elected to stay in Austin and transition into a major research center. From the creation of the world's fastest UNIX servers and the groundbreaking Cell Processor, IBM Austin has evolved as a critical component of IBM's globally integrated enterprise and is recognized as one of IBM's eight main research laboratories worldwide. IBM's Austin research facility was launched in 1995 to explore the usage and expansion of microprocessor research through the growing technology market of high-speed microprocessors with an emphasis on very fast circuits and computer-aided design tools to support complex, high performance microarchitectures. More recently IBM Austin research includes software and hardware systems, high-speed communication chips, formal verification, distributed systems software, innovative cooling technologies, low power microprocessors, systems management, and performance evaluation. Over the years, IBM and UT Austin have partnered to build substantial education and research

programs while working with the City and The Greater Austin Chamber of Commerce to help shape the region's technology landscape.[21] With more than 6,239 employees and an annual payroll of about $600 million, IBM Austin is the largest corporate R&D operation in Texas. In 2008, IBM received 4,186 U.S. patents, the most of any U.S. company. IBM-Austin contributed 825 patents to the total, more than any other IBM location worldwide.[22] As commented by Ben Streetman, Former Dean of UT Austin's Cockrell School of Engineering,

> Through the sharing of technology, resources, and talent, IBM and The University of Texas have enjoyed mutually beneficial relationship that goes back many years. IBM is a top hirer of UT engineering graduates year after year. We consider IBM and invaluable partner. (IBM Press Release, October 3, 2007).

Graph 5 lists select Austin technology company foundings from 2001 to May 2012 as well as total number of company foundings and number of employees across Austin's established and emerging technology sectors.

GRAPH 5. Austin Technology Company Timeline: 2001-2012

Graph 6 indicates the number of jobs created in Austin by new company formations and company expansions between 1994 and 2011. The drop-off of technology company expansions and new company formations is evident during the dot.com bust of 2001-2002 as well as in the economic downturn beginning in 2008. Over this 17 year period, Hi Tech company growth created the most jobs in Austin (56,101 or 49%) followed by the growth of Non-Hi Tech companies (26,470 or 23%), followed by new Hi Tech company formations (17,775 or 16%)

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[21] Forbes in their first ever ranking dubbed "The Silicon Hills" of Austin as America's 2nd most innovative city after Silicon Valley, CA. The ranking was based on the 100 largest metropolitan statistical areas in the US using data from the US Patent and Trademark Office combined with venture capital investment per capita along with ratios of high-tech science and "creative" jobs. Greenburg, Andy, "Americas Most Innovative Cities," Forbes.com, April 24, 2010.

[22] About 3,050 patents were issued to Austin area inventors per year in 2010 and in 2011 (US Patent and Trademark Office).

followed by new Non-Hi Tech companies (13,775 or 12%).[23] Clearly, while start-up and entrepreneurial ventures are important, the retention and expansion of existing firms is a key regional job and wealth creation strategy.

GRAPH 6. Jobs Created by New Company Creation & Company Expansion, 1994-2011

As of 2011 Austin's technology company employment totals about 101,000 in the following industry sectors: High tech information and other IT 32,000; high tech manufacturing 28,000; creative media 26,000 (employed in 2,160 firms); computers and electronics 24,000; engineering, R&D and labs/testing 19,000; and semiconductors 12,000. Dell with 14,000 employees tops the list of Austin's largest technology company employer followed by IBM with 6,239; Freescale Semiconductor 4,336; AT&T 3,450; Advanced Micro Devices 2,933; National Instruments 2,500, Apple 2,500; Applied Materials 2,500; Flextronics 2,113; and Samsung Semiconductor 2,000, table 1.[24]

TABLE 1. Austin Region Technology Companies: Selected Major Employers, 2011

4. Government Sectors

The government segment of the Technopolis Wheel is divided into three sectors: federal, state, and local or city government. Each of these sectors can contribute to or frustrate regional strategies for technology-based growth.

4.1 Federal Government

The influence of the federal government on Austin, as well as other technology-based regions in the US, has largely manifested in policy initiatives such as the Bayh Dole Act of 1980 and

[23] Data were extrapolated from longitudinal datasets provided by The Greater Austin Chamber of Commerce. High technology companies were selected according to the following parameters: R&D and manufacturing in IT, software, and semiconductors; precision parts and applications (i.e. semi-conductors and medical devices); clean energy companies (but not fossil fuel energy companies); business-to-business high tech products and services; b2b and b2c internet or technology infrastructure services. Default, and therefore error margin, falls toward the non-technical or "other" categories.

[24] Data from Greater Austin Chamber of Commerce, 2012 and the Texas Workforce Commission, 2011.

funding for university-based research. However Federal Government policies have also had major indirect impact on regional development of Central Texas as with the transition of a WW II magnesium plant in North Austin to a research park to be owned and managed by UT Austin. In 1949, with the assistance of then-Congressman Lyndon B. Johnson, UT-Austin purchased the site for an off-campus research center that in 1953 became the University's Balcones Research Center and home to Applied Research Laboratories. In 1994 the center was renamed The JJ Pickle Research Campus (PRC) in fond memory and recognition of U.S. Congressman and UT alumnus, J.J. Pickle. The PRC is a collaborative effort of government, industry, and academia in science and engineering research and development and is home to 19 UT Austin affiliated research centers including Applied Research Laboratories, Bureau of Economic Geology, Center for Energy and Environmental Resources, Microelectronics Research Center, Robotics Research Group, Texas Advanced Computing Center (TACC), and the Institute for Geophysics and all these research centers have benefitted significantly from federal and state funding.

4.2 State Government

Over the years, Texas State Government policy has also had important consequences for Texas technology-based growth and the sustainability of the Austin Technopolis in many direct and indirect ways. Texas Governors appoint the representatives who serve on UT-System's Board of Regents, and the influence of the Governor and the Regents on the UT-System in general and UT Austin in particular is significant. Funding for higher education is one key area of influence that has been somewhat contentious in recent years as state funding for UT Austin has steadily decreased from 52% in 1981, to 45% in 1983; 31% in 2008, to about 14% by 2011. As Austin businessman, John Watson observed in 1987, "The state revenue shortfalls were so monumental (in 1984, 1985, 1986, and 1987)….within the legislative process there has not been

a learning curve of the true appreciation for what higher education can do for economic development….there are lots of house representatives that just don't understand"[25] (Gibson and Rogers, 1994:448). In 2011, The Texas State legislature cut UT Austin's appropriation by $92M and as a result the University cut academic programs and activities while freezing salaries for staff and faculty.

As the Legislative funding cuts took effect, the University appealed to the State Legislature and Board of Regents for the ability to raise tuition. In 2004, tuition-setting authority shifted from the State Legislature to UT System Regents. Average annual tuition increases for resident undergraduates grew by $1,300 in the past 8 years from an annual tuition of $3,500 in 2004 to $4,896 in 2011. In December 2011, the President of The University of Texas at Austin asked the Regents for tuition increases for the next two years of 2.6% for in-state undergraduate and 3.6 % for out-of-state undergraduates – the largest increases allowed by law. In May 2012 The UT-System Regents denied UT Austin's tuition increase request.[26]

4.2.1 Texas Policy Initiatives for Technology-Based Development

In 1987, during a period in which waning oil revenues were adversely affecting the state economy, the 70th Texas Legislature created the Advanced Research Program (ARP) and the Advanced Technology Program (ATP) to fund scientific and engineering-related research conducted by faculty at Texas institutes of higher education. In 1993 the Advanced Technology Development and Transfer (TD&T) Department was created as an extension of the ATP, to contribute funds to develop and commercialize technologies created under ARP and ATP grants.

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[25] John Watson was the Chair of the Governor's Task Force and Austin Task Force for the MCC in 1982-1983.

[26] UT-Austin's operating budget for 2011 was $2.25 Billion: 31% comes from research, gifts, and endowments; 25% comes from tuition; 16% self-supporting activities like athletics, food and housing; and 14% from state appropriations. Tuition, state funding, and PUF funds are used for the University's Academic Core or education.

Both of these programs were created to diversify and strengthen the state's economy. Both these initiatives yielded mixed results.[27]

The 78th Legislature of 2003, enacted an economic development plan that included taking $390 million from the state's Economic Stabilization fund (also known as the Rainy Day Account) to create a Texas Enterprise Fund (TEF), to help attract industry to Texas and to create jobs. TEF projects must be approved by the governor, lieutenant governor and speaker of the House. The TEF was re-appropriated funding in 2005, 2007, 2009 and 2011. It is generally agreed that Austin's growth as a major technology center has been enhanced with the use of TEF funds as exemplified in the recruitment of such high profile company expansions as Facebook in 2010, e-Bay in 2011 and Apple in 2012 as well as retaining companies that are in danger of being recruited away from Austin as was Heliovolt in 2007.

As a companion to the TEF, the Emerging Technology Fund (ETF) was created by the 2005 Texas Legislature to provide funding for research, development, and commercialization of emerging technologies. ETF grants have been awarded in the following three areas:

1. Commercialization Awards to help companies take ideas from concept to market
2. Matching Awards to create public-private partnerships leveraging the strengths of universities, federal government grant programs, and industry
3. Research Superiority Acquisition Awards for Texas higher education institutions to recruit the best research talent in the world

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[27] ATP and TD&T no longer receive funding. ARP was significantly reduced in scope, and funding is now a small fraction of earlier amounts. For an analysis of the effectiveness of these programs J. Jarrett, Impact Assessment of the Advanced Technology Program, Bureau of Business Research, McCombs School of Business, University of Texas at Austin, 2005 and J. Jarrett, Impact Assessment of the Advanced Research Program, Bureau of Business Research, McCombs School of Business, University of Texas at Austin, 2006. Both available at: http://www.ic2.utexas.edu/bbr/back-issues/other-bbr-publications/2.html.

By 2012 the ETF had invested $192 Million in 133 companies which made it the largest seed investor in the State of Texas. Outside investors put three times this amount in the startups which attracted almost $1.3 Billion in investment. Under the ETF the State also awarded $178 Million in research grants and other assistance to Texas universities including assistance in the recruitment of 52 "world-class" researchers and their colleagues. (L. Copelin, "Tech fund deals touted," in AAS, B1-2). As shown in Graph 7 in Central Texas (the Austin region), the TEF has invested $34,993,000 in 25 companies across 11 technology sectors. As required by the TEF, each of these companies has an affiliation with a Texas University. The University of Texas at Austin has research collaborations with 23 ETF funded companies.

GRAPH 7. Central Texas: Texas Emerging Technology Fund Commercialization Investments by Industry Cluster

4.3 City Government

Austin's government is comprised of an elected mayor and six council members as well as a City Manager who is appointed by the City Council. A key ongoing challenge in Austin's sustainability as a growing technology region, has been striking a balance between fostering economic development verses controlling or managing smart growth, a rising cost of living, and in protecting the regions natural and cultural assets so prized in Austin. Ongoing grievances for tenured Austinite's and new arrivals include the need for affordable housing, escalating property taxes and utility rate hikes, and increasing traffic congestion. Austin's growth has outstripped the capacity of existing roads and public transport and the citizens are conflicted over options such as light rail to arguably improve the situation.[28]

[28] "Austin America's Fastest Growing City" (Forbes, web May 2012). Austin's MSA population grew 37% from 2000 to 2010 as the population growth for Texas was 20.5% and for the US 8.7% (US Bureau of the Census). As of 2012 Austin is the 2nd fastest

Austin's City Government has continually worked to maintain the region's attractive, diverse, and accessible quality of life for new arrivals as well as established residents but it has been a continuing challenge. Over the years, mayors and council members have championed actions and policy that impact Austin in different and important ways. For example, in 1999, Austin mayor Kirk Watson led a successful effort to attract Computer Sciences Corporation (CSC) to locate its offices within downtown Austin, citing benefits of downtown area revitalization, enlargement of "tax rolls" and contributions to the high-technology sector within city limits. However, to make room for CSC's new downtown offices, the City terminated the lease on city-owned property held by the highly popular live music venue Liberty Lunch Music Club. The closure of Liberty Lunch, considered by many to be an Austin landmark if not Austin icon, brought to the surface concerns of residents that economic prosperity was threatening the very things that made Austin unique and so attractive to many of the city's citizens.[29]

4.3.1 Austin's Growing Economic and Educational Divide

On the one hand, despite Austin's enviable reputation as a top U.S. location for entrepreneurs, business start-ups, wealth creation, and low unemployment (under 6% in mid-2012 and under 5% in early 2013) a growing economic and educational divide is an increasingly important challenge for the Capitol City in particular and for Texas in general. After a ten-year longitudinal study of the digital divide in Austin, Straubhaar and his co-authors suggest in Inequity in the Technopolis: Race, Class, Gender, and the Digital Divide in Austin, Texas, that

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growing US metro area (at 3.9%) between April 2010 and July 2011. Austin Metro area's population is at 1.8 million. Austin's projected growth rate is 2.8%/year almost triple the national rate and is projected to be 2 million by 2015 and to double every 20 years.

[29] An interesting point of discussion is the importance of community icons to a regions brand and quality of life. It is generally agreed by most Austinite's that key regional icons include Barton Springs (the nation's oldest and largest spring fed outdoor pool); such music venues as the Continental Club, Antone's Blues Club, Threadgills, Saxon Pub, The Broken Spoke, and UT Austin's Cactus Cafe and depending on your taste a broad range of long-established restaurants. When one of these assets or establishments is threatened by new development segments of the populace rise in vocal protest.

Austin's technology boom has left behind the region's poorer residents, many of them African-American or Latino. The authors also examine city efforts to enhance digital inclusion including establishing education and training programs with public libraries and nonprofits.

In "High-Tech Growth and Community Well-Being: Lessons Learned from Austin, Texas," a 2006 report by the Nonprofit Executive Roundtable also concluded that the economic boom was not all that positive for Texas' low income African Americans and Hispanics and other low wage workers (Saidel and Bordenave, 2006). Compounding the challenge of how to diminish the digital or economic divide in Austin are considerable education and training challenges including the high dropout rate of high school students. It's estimated that in the Austin-Round Rock Metropolitan Statistical Area, over 6,000 students dropped out of the class of 2010. According to The Alliance for Excellent Education, the region (with 45 schools) is one of the lowest performing in the nation, with 28 percent of high school students failing to graduate on time and with a diploma. In short the educated Austin (that leads the nation in job growth and wealth creation) is clearly in contrast with a sizable population that does not achieve the education needed to sustain this growth. Concerned with these challenges, the City, The Greater Austin Chamber of Commerce, and regional businesses are working to improve education, training, and graduation rates for the region's disadvantaged.

On the other hand, Austin's rising tide of entrepreneurial successes and resulting job and wealth creation has "floated a lot of boats." When DELL had its IPO in June 1988 at $8.50/share hundreds of employees became instant millionaires or "Dellionaires" as they are called in Austin. This wealth, and the wealth generated by Austin's other entrepreneurial successes, has "given back" to the region in terms of financial gifts to UT Austin and other regional educational institutions, providing angel funding for new waves of entrepreneurs in emerging industries, and

other charity and philanthropic contributions.[30] In addition, discretionary income from well-paid technology jobs supports consumer and retail spending, housing construction, and auto dealerships, as well as a growing numbers of restaurants, bars, and entertainment venues, and an enlarging community of creative artists. In "High-Tech Growth and Community Well-Being: Lessons Learned from Austin, Texas," (2006) it was concluded that new wealth generated from Austin's tech boom provided new philanthropic opportunities as well as new expectations. Indeed, major giving increased significantly from the typical pre-boom level of $1,000 to about $20,000 (Saidel and Bordenave, 2006).

4.3.2 The High Importance of Austin's Creative Industry

Much has been written in recent years about the importance of quality of life and creative enterprise in regional development. Richard Florida's *The Rise of the Creative Class* documents the environments favored by workers who create ideas, technologies, and content in a variety of fields ranging from science and engineering to arts and music. Such creative environments foster regional climates that value diversity, economic opportunity, abundant natural amenities, and a thriving urban culture. Given Austin's education assets, rolling green hills, abundant lakes, thriving music scene, and openness to diversity the region exemplifies the quality of life characteristics desired by Florida's "creative class."

Gibson and Rogers (1994) credit Austin's historic music venues as exemplified by Threadgills, Armadillo World Headquarters, and Liberty Lunch as cultural icons for inspiring the

[30] For example The Michael and Susan Dell Foundation has donated or pledged $150 Million for Austin health related initiatives: $50M for the new University of Texas Dell Medical School; 38 M UT's Dell Pediatric Research Institute; $32M Dell's Children Medical Center of Central Texas; $10M community health initiatives; $9M community clinics; $6M for the Dell Center for Healthy Living; $4M for electronic medical records mobile health, Seton Breast Cancer Center; and $1M for prevention and treatment of childhood obesity. Other former Dell executives have also donated to philanthropic causes such as The Topfer Foundation and the Meredith Foundation giving millions to the Long Center for the Performing arts and the Zachery Scott Theater.

free and creative spirit and "Keep Austin Weird" culture which has continued with ever prominent Austin music and other artistic events, performers, and celebrities. Austin's music scene had its beginnings in the 1950s, but gained significant momentum in the 1970's as live music artists and venues began to multiply.[31] The 1976 launch of Austin City Limits at UT Austin's College of Communication TV studio was a seminal event in the city's branding as "Live Music Capital of the World." After the pilot episode featuring Willie Nelson set fundraising records for Public Broadcasting (PBS), the show was launched by showcasing Texas blues, western swing, progressive country and Tejano music and overtime has included a diverse array of genres including jazz, alternative rock, folk music, and jam bands. ACL continues as the longest running music show in the history of American television and in early 2011 began its 37th season with the first live performance in the new Moody Theater and studio located in Austin's new W Hotel next to Willie Nelson Blvd. and the Willie Nelson statue in downtown Austin. In addition, nationally and internationally recognized Austin events, such as the annual South by South West (SXSW) film, music, and interactive festival, bring thousands of performers and creative support and related business representatives to the Capitol City.

5. Support Groups Sector

While considerably less developed in the mid-1980s than in 2012, the Support Groups sector (e.g., venture and angel capital, chamber of commerce, business professionals and associations) has been critically important to the launch, growth, and sustainability of Austin's entrepreneurial

[31] Threadgill's garage of 1950-60's, in addition to gas and an oil change, also served beer and music while welcoming local and emerging guest artists such as Janis Joplin and a wide sampling of local musicians. Armadillo World Headquarters (1970 – 1980) located in an old National Guard Armory was the iconic venue for established and yet to be established music talent as well as an occasional ballet, poetry reading, and other performing artists. The "dress as you want and come as you are," audience included university professors, students, bikers, cowboys and hippies all sharing the music, Shiner and Lonestar, quacamole and marijuana.

and innovation ecosystem. Over the years such Support Groups have matured and multiplied in numbers and variety and have become increasingly important in building Austin's regional innovation ecosystem. As stated by Saxenian (1994), "Support groups are a segment of regional institutions that set the tone for social interaction, and both influence and are influenced by the culture of a region."

Business-based support groups include professional services such as law, finance, accounting and related professional associations are an important source of expertise and services for supporting Austin's entrepreneurs, new ventures. A key contribution of these groups is providing the business know-how for Austin-based ventures to scale to large firms that are nationally and internationally competitive. Such groups proliferated as Austin grew and welcomed new residents. For example, in addition to the formal and informal entrepreneurial support activities resident at UT Austin and other regional colleges, the City of Austin, and the Greater Austin Chamber of Commerce, a 2010 survey found 24 community-based organizations and associations focused on supporting entrepreneurs with four of these focused on women entrepreneurs and three representing minority groups; 16 groups (not including Austin's established VC and Angel organizations) provide venture funding advice including bootstrapping; 12 community-based education groups and 12 regularly scheduled entrepreneurial events; six incubators in addition to The Austin Technology Incubator; and six blogs focused on fostering regional entrepreneurship.

5.1 Greater Austin Chamber of Commerce

The Greater Austin Chamber of Commerce (GACC) has evolved as Austin has evolved as a national and international technology center. In the mid-1980s when Austin won the MCC competition, the Chamber was a rather small operation that focused on company recruitment. As

of 2012 the GACC has a Board of Directors and Executive Committee representing major sectors of Austin's business community and seven Senior Vice Presidents heading such areas as Global Technology Strategies, Talent and Workforce Development, and Government Relations and Regional Infrastructure. The Chamber has programs to foster the growth of technology firms in targeted industry sectors as well as to facilitate the retention and expansion of established firms. The GACC's Greater Austin Technology Partnership includes participation of regional business, academic, and government officials and is focused on support of both mature companies and entrepreneurial ventures in technology manufacturing, clean technology, life sciences and healthcare, mobile and gaming technologies, advertising technology, and software.

5.2 Venture and Angel Capital

Austin Ventures (AV) began operations in 1984 and as of 2013 remains the largest VC in Central Texas with $3.9 Billion in funds under management. AV focuses its investments in Texas on business services and supply chain, financial services, new media, Internet, and information services companies. In early 2003, AV initiated the CEO-in-Residence program, where AV partners with experienced CEOs pursue value-creation opportunities in segments of mutual interest. In September 2008, the firm announced the closing of Austin Ventures X with $900 million of investor commitments to fund emerging companies and growth capital for expansion rounds and recapitalizations. As of 2011, Austin was ninth among U.S. metros for VC funding with more than 70 Austin firms receiving VC funding from 2006 to 2010. Table 2 shows VC investment in Austin from 2007 to 2011 by industry sector indicating investment was largest for Software ($526 M) followed by semiconductors ($349 M), industrial/energy ($301 M), IT services ($203 M), and medical devices and equipment at $200 M investment over the past 5 years (PricewaterhouseCoopers).

As the Austin Technopolis has developed, there has been an increase in the pool of high-net-worth individuals with technology and business experience who are attracted to investment opportunities and who want to mentor and be involved with entrepreneurial ventures. The Central Texas Angel Network (CTAN) was founded in 2006, as a non-profit organization, by a group of local investors and community leaders who believed that early-stage investing can provide a meaningful return for investors while also contributing to local economic growth. CTAN members are selected based on their business experience and skill in their respective fields or industries. CTAN provides a forum for its members to cooperatively source and vet deal flow and early-stage investment opportunities while assisting Central Texas entrepreneurs and early-stage growth companies. CTAN works with local industry, universities and colleges, The Greater Austin Chamber of Commerce, and other non-profit organizations to provide Central Texas entrepreneurs with access to information, networking opportunities, and educational resources. In 2011 CTAN reviewed about 100 ventures and invested $6 million in about 20 start-up ventures in a range of technology and non-technology based business sectors.

TABLE 2. Austin's Capital Venture Investments 2007 – 2010 with Overall %, Rank

6. Conclusion

While specific characteristics and dominant features of each sector of the Technopolis Wheel Framework have changed with time, all seven sectors have continued to be important to technology-based growth and sustainability in Austin into 2013 as they were in the mid-1980s. Indeed, taken together the evolution of all seven sectors has defined and elaborated the growth of Austin's regionally-based innovation ecosystem. There are many regions in the United States with excellent research universities, proactive city governments and chambers of commerce, and a highly-recommended quality of life that have not been very successful in leveraging these

assets for accelerated technology-based regional development. It is clear that institutional excellence in each sector is not sufficient. The power of the Austin Model resides in the effectiveness of the formal and informal collaboration, coordination, cooperation and at times synergy among influencers networking across public and private sectors during key targets of opportunity.

In 1983 when key influencers in Austin crafted the public-private strategy to win MCC followed by 3M corporate R&D and Sematech general public awareness and involvement in the pros and cons of rapid technology-based growth was considerably less than in the following years. Overtime with the rise of the Austin Technopolis, the number of stakeholder and interest groups has proliferated in the Capitol City. In an era of tight if not shrinking federal, state, and local budgets and the increased visibility and demands of specific interest groups it is a daunting task to build consensus on a regional vision or even specific strategies. Numerous and overlapping and conflicting interest and community groups often delay and frustrate the timely development of specific action strategies.

We conclude that a key dimension of a sustainable technopolis strategy is the ability to grow and attract 1st level influencers and to nurture 2nd level influences that foster an environment of creative cooperation. Key influencers can come from the academic, business, or government sectors depending on a particular regional vision or challenge and depending who, at the time, occupies key positions of authority in each sector. It is also important to stress that regional academic, business, government collaborations are based on relationship building and trust and not on enhanced internet access or high volumes of Tweets. Over twenty-five years of public-private successful and not-so-successful collaborations and experience in Austin has confirmed the 1988 observation that "the more extensive and the higher level and deeper the networks

across the different sectors of the Technopolis Wheel, the more likely cooperative economic and other activities can and will take place.

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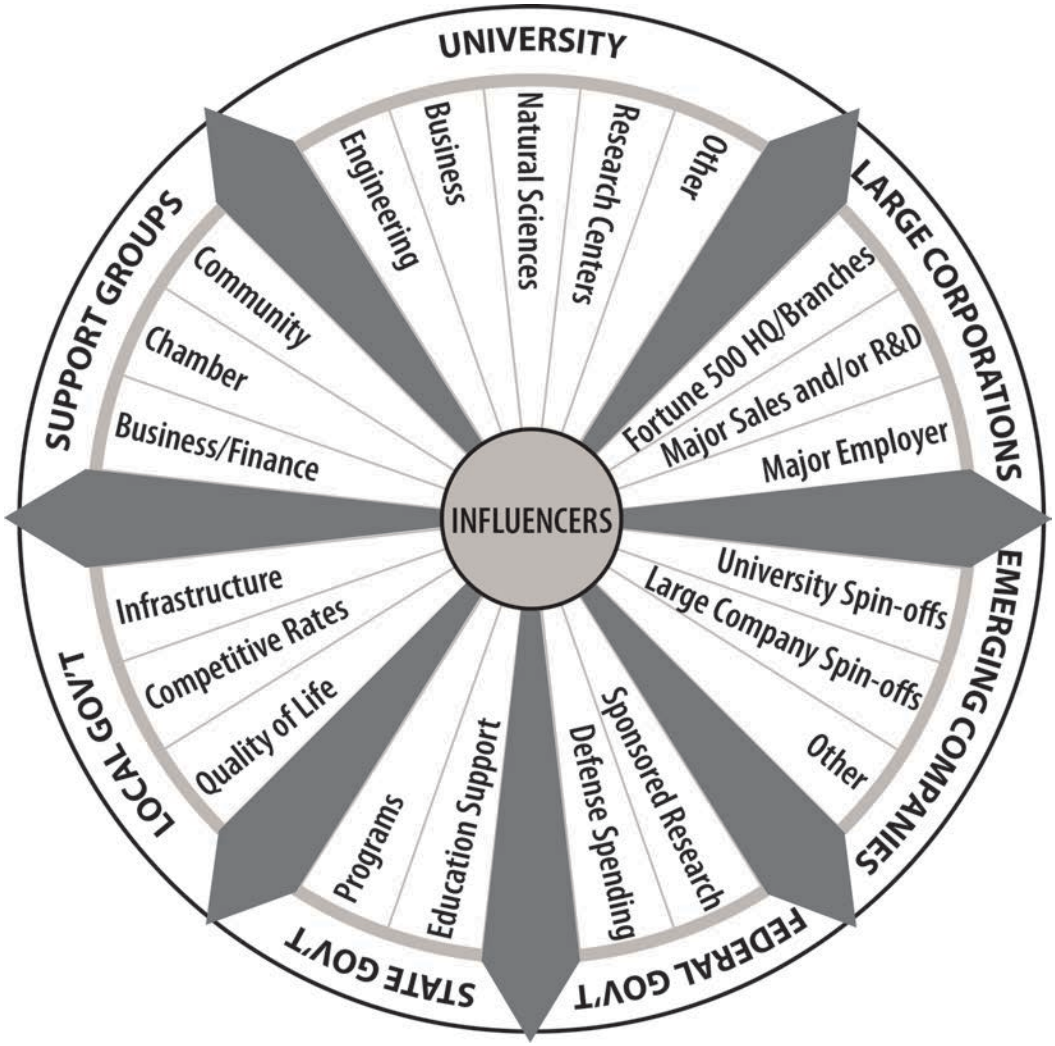
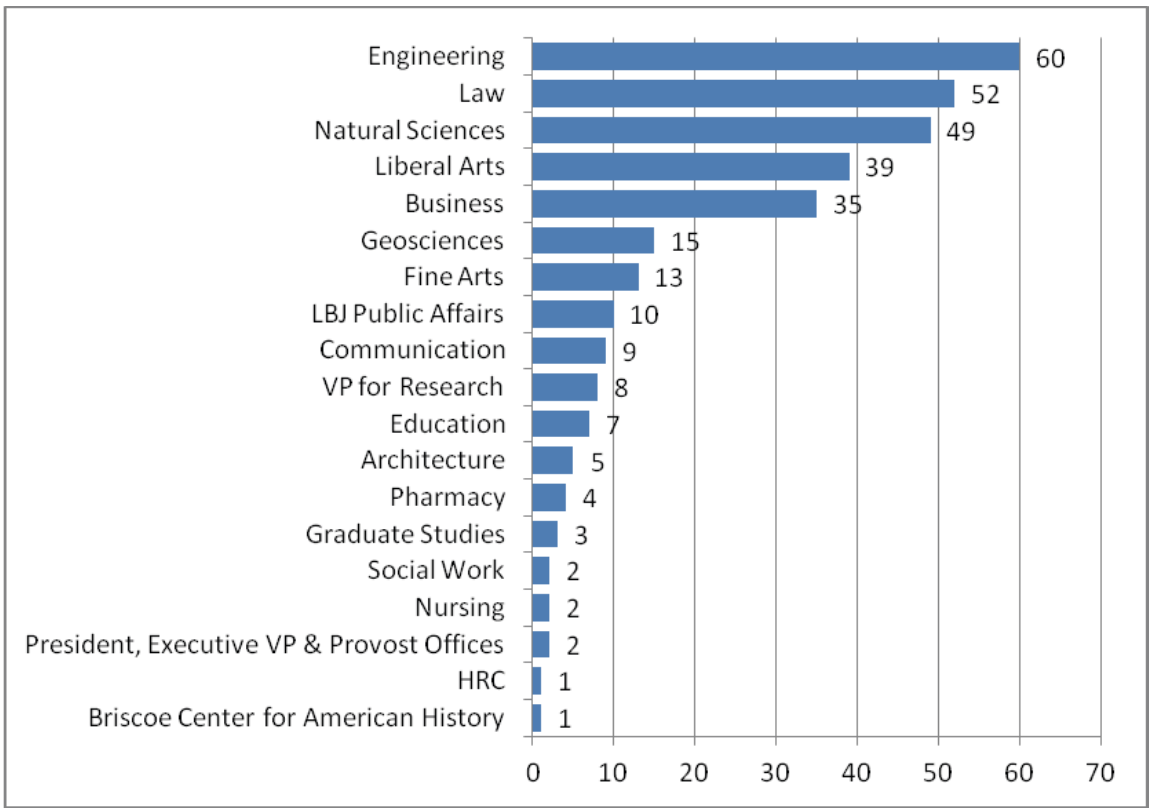
FIGURE 1. The Technopolis Wheel Framework Emphasizing the Importance of Regional Influencers



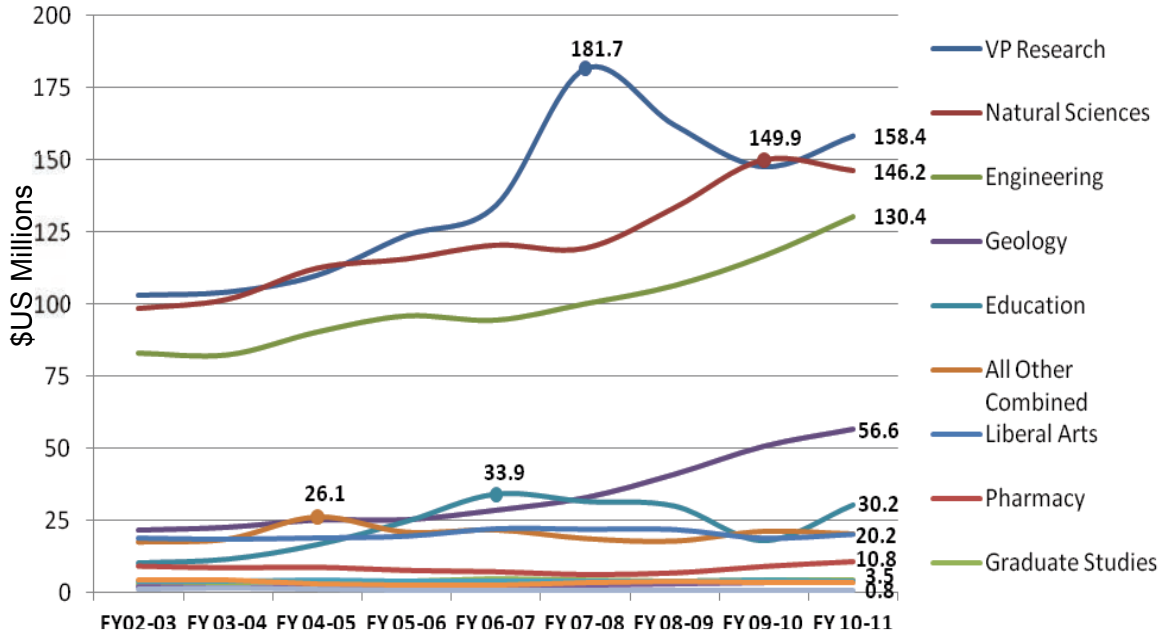
Source: IC² Institute, The University of Texas at Austin

GRAPH 1. UT Austin Endowed Chairs by Academic Unit (Total 317, as of 12/21/2010)



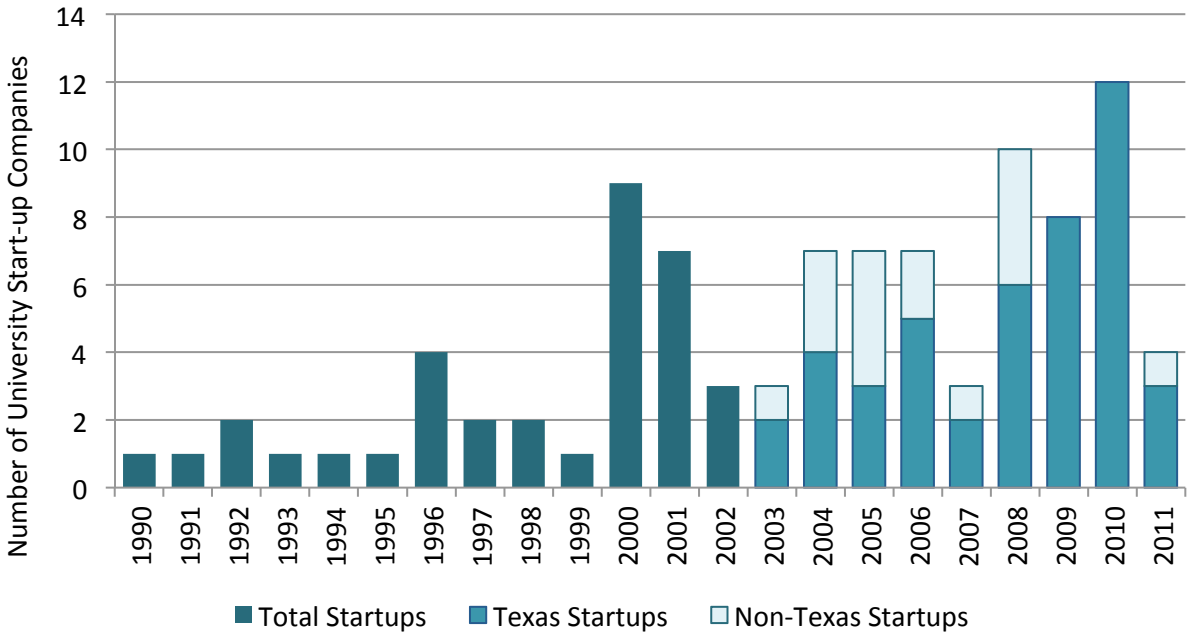
Source: The University of Texas at Austin

GRAPH 2. Total Research Expenditure by Academic Unit and Year ($US Millions)



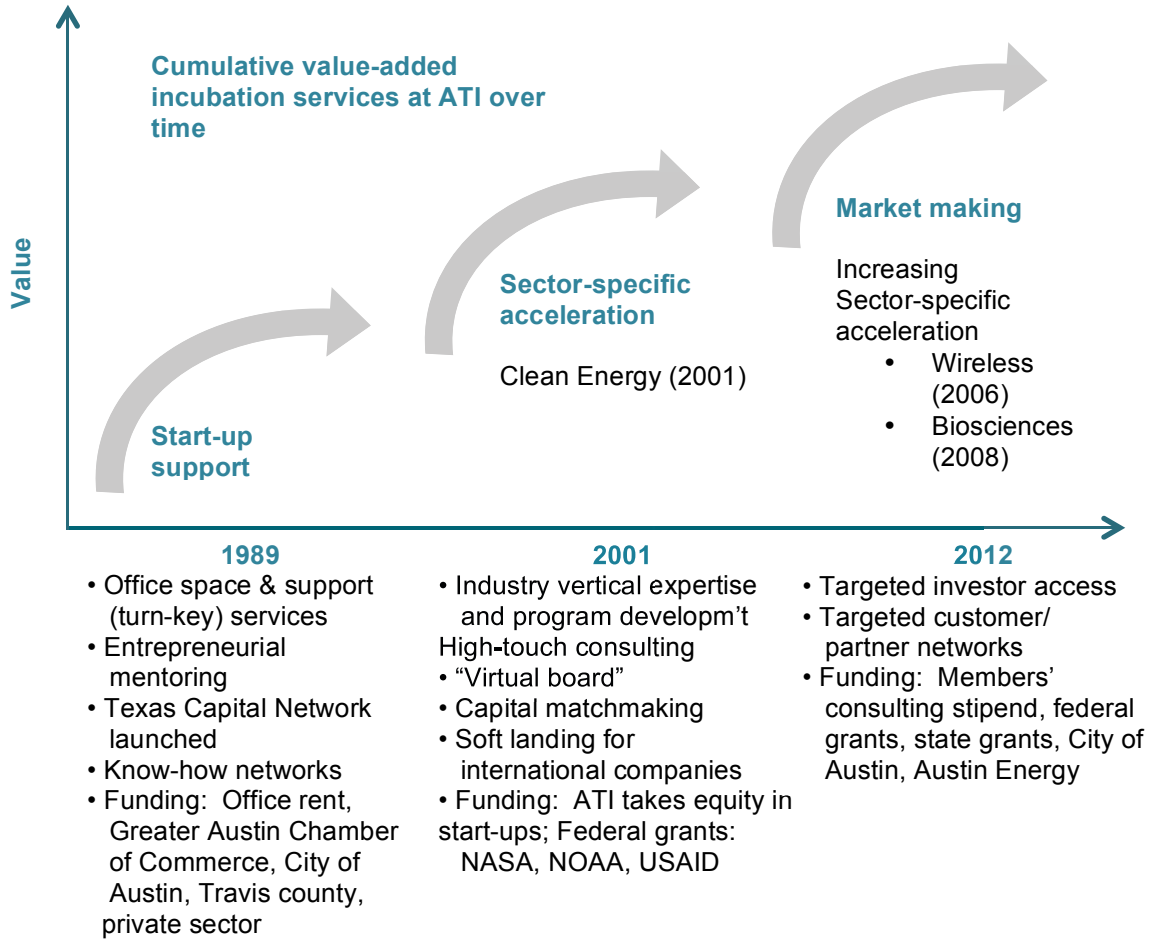
Source: The University of Texas at Austin

GRAPH 3. Number of University of Texas at Austin IP-Based Spinoffs by Year



ource: Texas Higher Education Coordinating Boards, 2005 through 2010; OTC 2003-04 and 2011

FIGURE 2. ATI Evolved as Did Austin's Technology Venturing Ecosystem



Source: Austin Technology Incubator, IC² Institute, The University of Texas at Austin