Do High Technology Policies Work? High Technology Industry Employment Growth in U.S. Metropolitan Areas, 1988-1998

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Abstract
Since the 1970s, federal, state and local governments have launched an array of new high technology development programs. Researchers and policy-makers disagree about the relative merits of these policies. We address the effects of seven of these policies on high tech industry employment growth in metropolitan statistical areas in the United States between 1988 and 1998. A conditional change score design shows that technology grant/loan programs and technology research parks have direct effects net of location and agglomeration factors. Five of seven programs positively interact with existing agglomeration advantages to create growth in high technology industry employment. Technology development programs compensate for deficits in agglomeration resources. Our results suggest that high-technology development can be planned by designing programs that magnify existing local growth advantages.

Since the early 1970s, state and local governments have launched a wide array of new economic development programs to promote high tech development. Popularly called "third wave," "new industrial" and "entrepreneurial" policies, these initiatives entail direct state intervention in the creation of new enterprises, products, markets and technologies. By helping to identify market opportunities, fostering local innovation capacities, and making public investments in new technology and private enterprises, these governmental programs have attempted to promote "risky but potentially productive undertaking(s) that would not have gone forward without governmental support." (Eisinger 1988:230) These initiatives involve direct governmental intervention in the creation of new technology, products, markets and enterprises. We focus on seven major

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programs: public venture capital programs, Small Business Innovation Research (or SBIR) programs, grant and loan programs to finance the development of new technology, university-affiliated technology development centers, technology deployment/transfer programs, technology business incubators, and technology research parks.

Our research addresses two questions about these programs. First, how effective are they at promoting high technology industry employment growth net of existing agglomeration and location factors? Second, do these programs magnify or compensate for agglomeration and location factors, including existing high technology industry?

We take a regional perspective by examining the growth of high technology industry employment in metropolitan areas (MSAs) in the United States between 1988 and 1998. Several large MSAs such as Chicago, Washington, D.C., Boston, and San Jose, started this decade with major high techn concentrations that continued to grow. Others such as Los Angeles, Detroit and Seattle, had large high technology sectors that declined. Other smaller MSAs such as Wichita, Kansas, Austin, Texas, Dayton-Springfield, Ohio, and Raleigh-Durham, N.C., began with small high tech sectors but grew rapidly. Our major concern is whether the high tech development policies adopted by state and local governments helped create this high tech industry employment growth.

Policymakers and the general public treat employment as the central yardstick for evaluating these programs. The primary rationale for these programs is that they create quality jobs. High tech also has significant spillover effects on the technology and growth of other industries (Hadlock, Hecker and Gannon 1991; Hecker 1999; Zachariadis 2002), and is critical to the economic competitiveness of specific regions and nations in an increasingly global economy (Atkinson and Gottlieb 2001; Devol, Koepp and Fogelbach 2002; Fujita, Krugman and Venables 1999; Harchaoui et al. 2002; *National Science Board* 1998:Ch. 6). As we show below, wages in high technology industries are typically 30 to 40 percent higher than in other industries. Labor productivity in high technology manufacturing increased between 1987 and 1999 by an average of 9.5 percent per year compared to 3.2 in the manufacturing sector as a whole (Kask and Sieber 2002). High tech employment was second only to human capital as a predictor of per capita income growth in U.S. states between 1995 and 2000 (De Vol et al. 2002). High tech development is critical to the prosperity and economic competitiveness of the states and communities that have invested in these new programs. But do these high tech programs work?

Differing Views on Location-specific Technology Policies

Some analysts argue that high tech development is a path-dependent process that cannot be influenced by public policies (Kenney and von Burg 2000). Others contend that conventional location factors, such as labor and housing costs, low taxes, regulatory environments and access to transportation and markets are of limited importance (Florida 2002). The major input factor in high tech production is scientific intelligence harnessed to technical problem-solving. In principle, high tech industry is location-free and cannot be influenced by traditional industrial recruitment incentives.

However, high tech industry is locality bound as it depends heavily on interpersonal networks and the social reinforcement of entrepreneurial activities (Florida 2002, Florida and Kenney 1990, Kenney and Von Burg 2000, Lee et al. 2000, Kolko 2002, Saxenian 1994, Thornton 1999). High tech entrepreneurs and workers need access to tacit and technical knowledge as well as social reinforcement for entrepreneurial activities that are important to industrial growth in general (e.g., Sorensen and Audia 2000) and especially to growth in high tech industries (Koepp 2002, Lee et al. 2000). High tech firms tend to cluster geographically because of the need for information exchange, the interpersonal transmission of tacit knowledge about business formation and product development, localized concentrations of skilled labor, lifestyle amenities, and research facilities associated with research universities, large corporations and federal research labs (Branscomb and Florida 1998; Cohen, Nelson and Walsh 1996; Goldstein and Renault 2004; Kenney and von Burg 2000; Kolko 2002; Luger and Goldstein 1997). Most new high tech firms are spin-offs of other high tech firms, typically located within the same immediate area as the parent enterprise. Markusen, Hall and Glasmeier (1986:154-56) found that agglomeration effects from *Fortune* 500 headquarters, business services and military R&D affected high technology manufacturing growth in MSAs between 1973 and 1977. Access to venture capital is critical for converting new ideas into commercial products (Florida 2002, Kenney and Florida 2000, Thornton 1999). State and local high tech programs may substitute by providing start-up capital (public venture capital, SBIR funding, and technology grants and loans), technical and management advice (business incubators, research parks), information networks (business incubators and research parks, networking programs) and, perhaps more importantly, operate as catalysts for magnifying the impact of existing location and agglomeration advantages.

Proponents of high tech policy have traditionally debated two general approaches: (1) a centrally-directed *infrastructure strategy* of investing in public research and specialized infrastructure to attract existing high technology industries to specific locations or "technopoles" (Castells and Hall 1994), and (2) a more decentralized *entrepreneurial strategy* of reinforcing local innovation capacities by investing in new enterprises and products, and promoting the development of local networks and partnerships (Clarke and Gaile 1989, 1998; Eisinger 1988; Osborne 1988). Federal, state and local governments have used both strategies, and the mix of these programs suggests that they are complementary parts of a general high-tech strategy. We want to know which of these policies promote tech employment growth.

We focus on decade-long change in high tech industry employment in MSAs between 1988 and 1998. MSAs constitute an ideal ecological unit for evaluating these policies as well as underlying location and agglomeration advantages. In 1990 an MSA was defined as an integrated labor market within a one-hour commute of a central city of 50,000 or more population. By mapping the location of federal, state and local high technology programs to these MSAs, we evaluate whether these programs had an impact net of existing location and agglomeration advantages and whether these programs magnify or compensate for these local growth factors. Several location and agglomeration factors, such as major air hubs and federal R&D expenditures, are likely to have benefits that operate on a larger ecological scale than cities or counties, pointing to the advantage of a focus on MSAs. Product development typically requires at least 5 to 10 years to move from an initial business proposal to actual production on a scale that would measurably affect employment.

We begin with a discussion of the nature of high tech industry and its distribution across MSAs.

High Tech Employment in Metropolitan Areas, 1988-1998

High tech industry is generally defined in terms of "the design, development, and introduction of new products and innovative manufacturing processes, or both, through the systematic application of scientific and technical knowledge." (U.S. Congress, Office of Technology Assessment, 1984:8-9) Such enterprises produce sophisticated products, use advanced or state-of-the-art techniques, have high expenditures on research and development, and employ a disproportionately large share of scientific, technical and engineering personnel.

What is High Tech Industry?

Analysts have taken two general approaches to measuring the growth of high tech industry. An *output approach* focuses on the technical sophistication of an industry's product or the extent to which products have undergone rapid change. The Bureau of the Census (National Science Board 1998:6.12-6.13), for example, used the expert judgment of industry analysts to identify leading-edge technologies in 10 product areas. Most popular accounts of high technology industry (e.g., Kotkin 2001) rely on similar criteria. However, there is little agreement on what constitutes a sophisticated product, and there is no clear way to link such products to employment change.

A second approach is to focus on *inputs* to industries by examining the proportion of workers in technology-oriented occupations or the business costs devoted to research and development. This approach provides objective criteria and has a direct link to employment data. Markusen et al. (1986) identify high tech manufacturing as industries that exceed the manufacturing mean in the percent of scientific, technical and engineering personnel in three-digit SIC industries. Hadlock et al. (1991) improve on Markusen et al. (1986) by using the Occupational Employment Statistics Survey (or OES) of private employers to identify the proportion of technology workers engaged in research and development.

We use Hecker's (1999) refinement of Riche, Hecker and Burgan's (1983) and Hadlock et al.'s (1991) approach that has three main advantages. First, it uses newer OES estimates of scientific and technical personnel. Second, it uses a more stringent input criterion of having at least twice the industrial mean in *both* employment in research *and* development and employment in all technology-oriented occupations. Third, it includes services as well as manufacturing, which is critical in view of the growing significance of high tech services. "High technology" is thus defined as all private sector industries where employment in *both* research and development *and* in all technology-oriented occupations is at least twice the national industrial mean. We use Hecker's estimates, which rely on the 1987 OES. The OES covers all industries except agriculture (but includes agricultural services), forestry, fishing, private households and the federal government. Hecker's definition provides a conservative objective basis for gauging industrial employment trends. At the MSA level, it also overlaps closely with the industry lists used earlier by Riche, Hecker and Hadlock (1983), Markusen et al. (1986) and Hadlock et al. (1991).[1]

We examine the first difference change in private sector employment at the MSA level in the 31 three-digit SIC industries identified by Hecker (1999). To measure this, we use the Current Employment Statistics Survey (or CES), compiled by the Bureau of Labor Statistics from Social Security establishment unit reports (also known as the ES-202 program). Four of our high tech industries are in services and 27 are in manufacturing. In 1988, there were 6.6 million high tech industry jobs inside of MSAs, representing 74.6 percent of the national total of 8.8 million high tech industry jobs. By 1998, high tech industry employment inside of MSAs grew to more than 6.9 million jobs, but reflecting the region diffusion of the high tech industry, this constituted only 67.6 percent of 9.8 million national high tech industry jobs. High tech's share of jobs in MSAs declined from 9.2 to 7.9 percent of total private sector MSA employment, reflecting more rapid employment growth in other industries. Nonetheless, high tech industry continued to be a source of "good jobs." In 1988 the mean wage for high tech industry jobs was $29,046 (in 1988 current U.S. dollars), which was 48 percent greater than the mean private sector wage of $19,628. In 1998, this high tech wage premium had declined slightly to be 36.3 percent greater than the mean private sector wage ($42,892 in current 1998 U.S. dollars for the high tech industry vs. $27,329 for all private sector jobs).

We analyze the 291 MSAs for which CEW employment data are available for both 1988 and 1998. Our 291 MSAs contain 97.04 percent of the 1990 U.S. Census estimate of the national metropolitan population and provide the most complete set of reliable estimates of change in MSA employment available.

Table 1 identifies the top 20 MSAs in terms of the growth of additional high tech industry employment between 1988 and 1998 and the top 20 MSAs in terms of the loss of high tech industry employment. In contrast with the conventional wisdom that advantaged high tech areas experienced greater growth in new jobs, the percent of employment linked to the high tech industry in 1988 is negatively correlated with the change in high tech industry employment between 1988 and 1998 ($r = -.144$, $p < .014$). This indicates the trend toward the dispersion of high tech industry employment and convergence among MSAs in terms of the presence of high tech industry (see also Kolko 2002). As noted earlier, some MSAs such as San Jose, California, and Washington, D.C., are high tech "meccas" that had major concentrations of high tech industry in 1988 and experienced further high tech industry employment growth during the 1990s. Others, including Los Angeles, Detroit and Seattle, had large high tech sectors but experienced significant loss in high tech industry jobs. Why?

Table 1: High Tech Industry Employment Change, 1988-1998

Top 20 High Tech Industry Job Gainers			
	# High Tech Jobs 1988	High Tech Jobs 1998	Change in Jobs 1988-98
MSA Name			
1. Chicago, IL	73,115	302,108	128,993
2. Washington, DC-MD-VA	191,979	288,469	96,490
3. Boston-Lawrence-Salem, MA	290,423	350,583	60,160
4. Houston, TX	83,822	139,978	56,156
5. Rochester, NY	19,976	75,063	55,087
6. Atlanta, GA	93,750	144,485	50,735
7. Portland, OR	40,295	83,865	43,570
8. Dallas, TX	151,510	192,682	41,172
9. New Haven-Waterbury-Meriden, CT	34,226	74,514	40,288
10. San Francisco, CA	56,315	95,674	39,359
11. San Jose, CA	267,542	302,176	34,634
12. Minneapolis-St. Paul, MN-WI	130,077	160,211	30,134
13. Oakland, CA	67,746	95,993	28,247
14. Newark, NJ	57,338	85,200	27,862
15. Austin, TX	35,568	62,679	27,111
16. Dayton-Springfield, OH	28,846	52,912	24,066
17. Raleigh-Durham, NC	36,191	59,426	23,235
18. Salt Lake City-Ogden, UT	29,535	52,679	23,144
19. Wichita, KS	6,399	28,422	22,023
20. Cleveland, OH	70,744	91,438	20,694
Top 20 High TechIndustry Job Losers			
	High Tech Jobs 1988	**High Tech Jobs 1998**	**Change in Jobs 1988-98**
MSA Name			
1. Los Angeles-Long Beach, CA	499,945	351,000	-148,945
2. Detroit, MI	258,553	121,456	-137,097
3. Seattle, WA	148,797	97,474	-51,323
4. Hartford-New Britain-Middletown, CT	79,946	39,580	-40,366
5. Nassau-Suffolk, NY	119,528	80,212	-39,316
6. Bergen-Passaic, NJ	82,559	55,008	-27,551
7. Baltimore, MD	66,927	46,312	-20,615
8. Flint, MI	34,953	15,879	-19,074
9. Fort Worth-Arlington, TX	65,762	47,703	-18,059
10. Lansing-East Lansing, MI	23,905	7,523	-16,382
11. St. Louis, MO-IL	112,196	95,883	-16,313
12. Allentown-Bethlehem-Easton, PA-NJ	25,464	9,819	-15,645
13. Saginaw-Bay City-Midland, MI	18,500	5,041	-13,459
14. Peoria, IL	16,364	3,106	-13,258
15. Buffalo-Niagara Falls, NY	35,614	23,262	-12,352
16. Binghamton, NY	15,501	4,178	-11,323
17. Ann Arbor, MI	28,096	17,289	-10,807
18. Syracuse, NY	23,618	13,430	-10,188
19. Richland-Kennewick-Pasco, WA	12,420	2,864	-9,556
20. Melbourne-Titusville-Palm Bay, FL	39,269	29,762	-9,507

Other Explanations for High Tech Employment Growth

Location Theory

While our major interest is the effect of high tech development programs, other explanations need to be included. Analysts of regional development have traditionally focused on *location advantages* and *agglomeration effects*. Location explanations suggest that lower input factor costs (such as wages or taxes) and central location advantages, such as access to transportation and markets, facilitate economic development. Irwin and Kasarda (1991) show that centrality in the airline industry hub system contributed to economic growth and, given the importance of rapid transit to high tech industry, we would expect airline access to facilitate high tech development. Similarly, central access to markets as gauged by greater population density and interstate highway access should boost high tech development. Markusen et al. (1986:155) found that a favorable climate, airline access and educational options in terms of the number of four-year higher education institutions contributed to high tech industry employment growth between 1973 and 1977. They also found that a greater percent black population discouraged high tech industry employment growth, which they interpreted as reflecting racial prejudice and human capital deficits. Other location factors, such as higher mean wages in high tech industry and recreational and arts amenities were not statistically significant.

Agglomeration Theory

Many argue that location factors are of little importance for high tech industry and that agglomeration processes are more important. Due to the labor-intensive nature of high tech production and the importance of tacit knowledge (Saxenian 1994), these firms are unlikely to achieve internal economies of scale, but may achieve external economies of scale by building business partnerships and extensive interpersonal networks among distinct firms to exchange technical and market information (Kenney and Von Burg 2000). Numerous case studies of particular high tech industries and regional high tech clusters indicate the importance of entrepreneurial resources (such as venture capital) and a pattern of corporate spin-offs, inter-firm personnel transfers and collaborative business partnerships (Cortright and Mayer 2002, Kenney and Florida 2000, Lee et al. 2000, Rogers and Larsen 1984, Saxenian 1994, Thornton 1999). Markusen et al. (1986) found that military R&D facilities contributed to high tech industry job growth along with concentrations of business service firms, such as accounting, legal and public relations firms. Although many note that high tech development has been greater outside the older more dense cities that were the urban centers for earlier industrial development, human ecologists argue that greater population density sustains high rates of social interaction and specialization, thereby promoting social and economic innovation (Hawley 1981). This innovation capacity should support high tech development. We therefore include population density as an agglomeration factor as well as a location advantage.

Technology Policy as a Multiplier?

Federal, state and local entrepreneurial programs are designed to compensate for or to reinforce agglomeration processes. Several studies have examined the effects of particular high tech policies but typically without comparing units with and without these policies. Luger and Goldstein (1991) found that more than half of the high tech parks founded between 1950 and 1989 failed in the early stages and, of those that survived, less than half generated significant total employment growth in their immediate region (mostly older parks affiliated with major research universities that had more comprehensive service programs). But they did not compare counties without parks to those with parks, leaving unclear the distinctive contribution of parks to employment growth. A more relevant outcome measure would have been high tech industry employment. Yet this study did point to the possible importance of proximity and ties to research universities as magnifying the effects of these parks. In a study of biotechnology patents, Cortright and Mayer (2002) found that university and federally funded biomedical R&D contributes to commercialized knowledge in MSAs that also have significant concentrations of private venture capital. In other words, it is the *combination* of biomedical R&D *with* private venture capital that leads to biomedical patents. Most university and federal research does not lead to patents but the existence of favorable university policies and local venture capital appear to be important contextual factors. Audretsch, Weigand and Weigand (2002) show that SBIR programs in Indiana provided small enterprise financing for a significant number of new high tech enterprises that otherwise were unlikely to have been created. All of these studies have the major limitation that they did not compare ecological units with and without programs, leaving unclear the distinctive impact of high tech policies. We examine seven programs that have been initiated by federal, state and local governments over the past three decades to promote regional high tech development.

1. *Public venture capital* programs provide start-up, intermediate and commercialization financing for new products and firms. While the specific financing terms vary widely, these programs put state government in the position of taking a royalty or ownership position in new products and enterprises. Some investments create equity shares in a private stock company or royalty claims against the sales of particular products. Others are convertible into long-term bonds. In the case of a business failure, some investments are converted into grants with no repayment obligation while others remain liabilities resolved in bankruptcy proceedings.

2. *Small Business Innovation Research* programs (or SBIRs) require federal agencies that make grants for technology innovation to set aside a specified portion for small business. Local SBIR programs chartered by state

governments administer these grant programs and, over the past two decades, have become a significant source of federal funding for new enterprise development (Audretsch et al. 2002, Wallsten 1998).

3. *Technology grant and loan programs* provide financing for the development of new products, typically through a competitive application process where would-be entrepreneurs provide business plans for the commercialization of specific products. We include in this category tax subsidized private venture capital firms, Business Investment Development Companies (BIDCOs) and commercialization programs that rely exclusively on grants and loans.

4. *Technology development programs*, typically associated with research universities and government-industry consortia (e.g. Sematech), focus on basic and applied research to develop new products and technology. Some are funded directly to operate research programs while others are funded by federal and state grants and contracts to develop new technologies and products.

5. *Technology deployment and transfer programs* focus on the utilization of "state of the art" technology. Taking land grant university rural extension programs as their historical model, these programs focus on the transfer and deployment of existing "state of the art" technology through consulting, customized labor training, technical reports, conferences and symposia. Some programs are administered as state agencies while others are organized as nonprofit corporations. Technology deployment and transfer programs typically deliver services through contracts and direct delivery.

6. *High technology business incubators* provide subsidized space for research and development and, in varying degrees, technical and business advice, including assistance in securing public and private financing. Some incubators are state or local governmental agencies; some are affiliated with research universities, two-year colleges and research parks, while others are independent nonprofit and for-profit corporations. Incubators often have multiple sponsors, including federal agencies and private corporations as well as state and local governments. We include only business

incubators with state and local government sponsors that have a declared high tech focus.

7. *Technology research parks* provide subsidized long-term space for high technology businesses along with varying degrees of business financing and managerial/technical assistance. Most are affiliated with research universities and typically operate as state-chartered non-profit corporations. Both business incubators and research parks typically specialize in particular technologies, attempting to foster local expertise, partnerships and networks.

While we view the distinction between infrastructure and entrepreneurial strategy as a continuum, business incubators, research parks and technology development programs are infrastructural because they subsidize research and development costs in specific locations. Public venture capital, SBIRs, technology grant/loans and technology deployment/transfer programs are entrepreneurial because they attempt to strengthen existing innovation capacities.

Capturing State and Local Technology Programs

Table 2 summarizes the counts of these state and local technology programs that were operating in metropolitan and non-metropolitan areas in 1990. We derived information on these programs from the comprehensive listing of state government technology programs compiled by the Carnegie Commission on Science, Technology and Government (Coburn and Berglund 1995), Luger and Goldstein's (1991) list of technology research parks in 1990, Eisinger's (1991) list of public venture capital programs in 1989-90, the 1990 membership list of the National Association of Business Incubators (1990), Clarke's (1986) inventory of state technology programs for the National Governor's Association, the inventory construction by the Minnesota Department of Trade and Economic Development (1988), the *Directory of Incentives for Business Investment and Development in the United States* published by the National Association of State Development Agencies (1986, 1991 and 1994), and a comprehensive review of the websites of all state technology development agencies (for an on-line directory, see: http://www.ncscienceandtechnology.com/ External_Programs.htm). In 1990, business incubators were the most numerous with 137 located inside of MSAs, followed by 99 research parks, 94 technology development programs and 77 technology deployment/ transfer programs. Roughly two-thirds of these programs were located inside metropolitan areas with the remainder in non-metropolitan areas. There were significantly fewer public venture capital, SBIR and technology grant and loan programs, reflecting the fact that state governments typically establish only one headquarters office in or near the state capital.

To gauge the effects of these programs, we use the sum of the total years' duration of each type of program for each MSA. As Wolman and Spitzley (1996) argue, it is important to move beyond measuring the simple presence of programs to capture policy scale. To gauge the scale of these programs, we

Table 2: High Tech Programs Inside and Outside of MSAs, 1990

Programs	In MSAs	Outside MSAs	Total
Public Venture Capital	20	2	22
SBIRs	17	9	26
Technology Grants & Loans	16	5	21
Technology Development	94	15	109
Technology Deployment/Transfer	77	23	100
Technology Incubators	137	41	178
Research Parks	99	18	117
Total	460	114	573

summed the total years of existence of each program type within each MSA as of 1990. If an MSA had multiple, e.g., technology incubators, then we summed the total years of existence for all such programs as of 1990. While it would be ideal to have measures of the cumulative funding for these programs and other program details, such data are not available and would be near impossible to collect reliably. A poorly-funded but long-term program might have little impact but, in general, programs with longer duration have likely succeeded in mobilizing more resources.

Table 3 identifies the top 10 MSAs in terms of their cumulative years of experience with each of these seven high technology programs as of 1990. Some MSAs, such as Boston and Albany, NY have longstanding public venture capital programs. Minneapolis leads in SBIR experience, Little Rock, AR and Boston in technology grant and loans, Raleigh-Durham, NC in technology development, Augusta, GA in technology deployment/transfer, and Philadelphia in technology business incubators and research parks.

Table 4 lists the top 20 MSAs in terms of the sum of all program years of experience. Raleigh-Durham, NC is the leader, with more than 152 cumulative years of high tech program experience, followed by Philadelphia (125 years), Augusta, GA (116 years) and Pittsburgh (81 years). The mix of these programs varies significantly, with Raleigh-Durham having more technology development and deployment/transfer programs and Philadelphia having more incubator and research park experience. More than 54 percent of the 291 MSAs have at least one year of program experience and 27 MSAs had five or more high technology programs operating in 1990. We now turn to our method for analyzing the effects of these programs and location/agglomeration advantages on the growth of high tech industry employment.

Methodology

Model

The main question facing policy makers is how to generate high tech industry employment net of existing employment levels. To address this, we use a conditional change design (Finkel 1995:6-9) where the dependent variable is the first difference change in the number of high tech industry jobs, which is regressed on the lagged endogenous variable (i.e., high tech industry

Table 3: Top 10 MSAs in Total Years of Experience with High Tech Programs, 1990

Public Venture Capital Programs	
Boston-Lawrence-Salem-Lowell, MA	19
Albany-SchenectadyTroy, NY	8
Hartford-New Britain-Middletown, CT	8
Madison, WI	7
Indianapolis, IN	7
Lansing-East Lansing, MI	7
Philadelphia, PA	6
Allentown-Bethlehem-Easton, PA-NJ	6
Portland, OR	5
Little Rock, AR	5
SBIR Programs	
Minneapolis-St. Paul, MN	18
Salt Lake City-Ogden, UT	7
Boise City, ID	7
Houston, TX	5
Columbus, OH	5
Charleston, WV	4
Billings, MT	4
Hartford-New Britain-Middletown, CT	3
Little Rock, AR	3
Baton Rouge, LA	2
Technology Grant & Loan Programs	
Little Rock, AR	14
Boston-Lawrence-Salem-Lowell, MA	14
Indianapolis, IN	9
Topeka, KS	9
Salt Lake City-Ogden, UT	7
Montgomery, AL	6
Washington, DC-MD-VA	5
Anchorage, AK	4
Austin, TX	4
Oklahoma City, OK	1
Technology Development Programs	
Raleigh-Durham, NC	48
Great Falls, MT	29
Detroit, MI	23
Lincoln, NE	21
Middlesex-Somerset, NJ	20
Ann Arbor, MI	19
Akron, OH	18
Salt Lake City-Ogden, UT	16
Orlando, FL	13
Dayton-Springfield, OH	12
Technology Deployment/Transfer Programs	
Augusta, GA-SC	116
Raleigh-Durham, NC	69
Macon-Warner Robins, GA	58
Charlotte-Gastonia-Rock Hill, NC-SC	43
Atlanta, GA	29
Columbus, GA-AL	29
Albany, GA	29
Athens, GA	29

Table 3 *(continued)*

Savannah, GA	29
Philadelphia, PA	27
High Tech Business Incubators	
Philadelphia, PA	43
Pittsburgh, PA	41
Buffalo-Niagara Falls, NY	25
Chicago, IL	22
Minneapolis-St. Paul, MN-WI	16
Boston-Lawrence-Salem-Lowell, MA	15
Syracuse, NY	15
Toledo, OH	12
Albany-Schenectady-Troy, NY	10
Dayton-Springfield, OH	10
High Tech Research Parks	
Philadelphia, PA	43
Oklahoma City, OK	40
San Jose, CA	39
Richland-Kennewick-Pasco, WA	36
Raleigh-Durham, NC	31
Washington, DC-MD-VA	30
Lafayette-West Lafayette, IN	29
Huntsville, AL	28
Champaign-Urbana, IL	27
Tampa-St. Petersburg-Clearwater, FL	26

employment in 1988) and additional independent variables. There are theoretical reasons for this design. The initial starting point of high tech industry employment is likely to affect subsequent change, either facilitating growth due to the location and agglomeration advantages associated with existing high tech industry or, alternatively, by capturing factors (diffusion, overbid wages) that geographically disperse high tech employment over time. Insofar as measurement errors are consistent across time, this design reduces problems with serially correlated measurement errors. We measure independent variables at the starting point or as near as possible with one exception – contemporaneous population change – which is introduced as an exogenous control variable.

Our model is as follows:

$$\left(Y_{t2} - Y_{t1}\right) = b_0 + b_1\left(Y_{t1}\right) + b_2\left(X_{t1}\right) + b_3\left(Z_{t2} - Z_{t1}\right) + \ldots + e$$

where Y_{t2} - Y_{t1} represents the first difference change in high tech employment, Yt1 is high tech employment in 1988, X_{t1} independent variables measured at or near 1988, Z_{t2} - Z_{t1} independent variables that change concurrently over the period in question (1988-1998), and e is an error term. To capture the contextual effects of policies in favorable agglomeration contexts, we also add to this equation interactions between policy measures and agglomeration variables net of the respective main effects of said policies and agglomeration variables.

We first control for location and agglomeration factors, then add the cumulative years for each type of high tech program. High tech programs need time to generate significant employment. We therefore use the total years of program experience for each policy type through 1990. We address two key questions about these policies: (1) Do high tech policies have a direct impact net of location and agglomeration factors? (2) Do these policies magnify local agglomeration processes? These programs often are presented as substituting for agglomeration factors by growing new industries and employment in areas that previously lacked them. This should be indicated by significant positive effects of policy scale net of controls for location and agglomeration factors. Programs are also seen as magnifying local innovation capacities. This should be evident from positive interactions between agglomeration contexts (including existing high tech industry employment) and policies.

Measurement

Our dependent measure is the first difference change score in the number of private sector high tech industry jobs between 1988 and 1998. The mean change in high tech industry jobs is 2,277.8. In our regression analysis, we control for the number of high tech industry jobs in 1988 (mean = 20,107). Both measures are moderately skewed, leading us to also test the natural log for all independent measures with a skewness of 3.0 or more. This identified the same set of statistically significant factors as the unlogged measures. We present the unlogged results because they provide interpretable partial slopes indicating the number of jobs created by specific independent variables as well as interpretable adjusted R2 statistics.

To capture location factors that may be attracting high tech industries, we use the following measures with means in parentheses: (1) the *1988 mean wages* of high tech industry jobs ($28,856); (2) *1988 median housing costs* ($86,400); (3) *climate quality* based on the number of sunny above freezing days per year (175.9); (4) *recreational amenities* based on the number of major recreational organizations (61.1 with a scale of 1-100); (5) *arts amenities* based on the number of art museums and attendance (65.5 with a scale of 1-100); (6) airport access based on the number of daily air flights(91.3); (7) *freeway access* based on the number of federal interstates highways in the metropolitan area (1.25); (8) market centrality based on *population density* in 1990 (404.6 persons per square mile); (9) *higher education options* based on the number of 4-year colleges and universities (2.77); and (10) the *percentage black population* (10.5 percent). Mean high tech industry wages were derived from the CES data, and population density and the percent black from the U.S. Bureau of the Census (1991). All other measures come from Boyer and Savageau (1989).

Agglomeration advantages are measured by: (1) *population density* in 1990; (2) the number of *Fortune 500 manufacturing corporate headquarters* (*Fortune* 1989 [1.45]); (3) the number of *private venture capital corporations* in 1987-88

Table 4: Top 20 MSAs with High Tech Programs, 1990

	Programs and Years of Operation							
	Public Venture Capital	SBIR	Tech Grant/ Loan	Tech Develop.	Tech Deploy./ Transfer	Tech Business Incubator	Tech Research Park	Sum of All Years
MSA Name								
1. Raleigh-Durham, NC	0	0	0	48	69	4	31	152
2. Philadelphia, PA	6	0	0	6	27	43	43	125
3. Augusta, GA-SC	0	0	0	0	116	0	0	116
4. Pittsburgh, PA	2	0	0	6	27	41	5	81
5. Charlotte-Gastonia-Rock Hill, NC-SC	0	0	0	0	43	4	22	69
6. Boston-Lawrence-Salem-Lowell, MA	19	0	14	0	8	15	8	64
7. Macon-Warner Robins, GA	0	0	0	0	58	4	0	62
8. Washington, DC-MD-VA	0	0	5	4	13	8	30	60
9. Minneapolis-St. Paul, MN-WI	0	18	0	0	1	16	16	51
10. Salt Lake City-Ogden, UT	0	7	7	16	0	0	20	50
11. Ann Arbor, MI	0	0	0	19	18	3	7	47
12. Allentown-Bethlehem-Easton, PA-NJ	6	0	0	6	27	7	0	46
13. Atlanta, GA	0	0	0	0	29	7	10	46
14. State College, PA	2	0	0	6	27	6	5	46
15. Detroit, MI	0	0	0	23	0	7	14	44
16. Oklahoma City, OK	0	1	1	1	0	1	40	44
17. Richland-Kennewick-Pasco, WA	0	0	0	0	0	7	36	43
18. San Jose, CA	0	0	0	0	0	3	39	42
19. Lafayette-West Lafayette, IN	0	0	0	4	4	0	29	37
20. Buffalo-Niagara Falls, NY	0	0	0	9	0	25	2	36

(Morris and Isenstein 1989 [8.368]); (4) university R&D expenditures for 1990 based on the earliest available data on the top 100 universities in terms of R&D expenditure in the National Science Foundation's (2002) WebCASPAR database: www.nsf.gov/sbs/srs ($50,503,000); and (5) *federal and military research facilities* as gauged by Hook's (2003) estimate of the mean of the 1980 and 1990 square meters of research space operated by the U.S. Defense Department, NASA, NIH and the nuclear arms labs (49.9 square meters). As noted earlier, we include population density in both location and agglomeration equations since it can be argued to tap both theories. To capture exogenous uncontrolled growth factors, we also introduce *percent population change* between 1990 and 1997 drawn from U.S. Bureau of the Census (2000) (8.1 percent). We use two-tailed tests of significance and inspected all equations for multicollinearity using variance inflation and tolerance statistics, finding no evidence of problems. We also tested for influential outliers (Bollen and Jackman 1985), and we removed Detroit from the regression results below as a result, making our regression sample 290 MSAs.[2] How do these factors affect high tech employment change?

Results

Our main regression results are presented in Table 5. The lagged endogenous control is not significant (Model 1), indicating little effect of the start point number of high tech industry jobs. The adjusted R^2 of .001 provides a baseline for comparing subsequent models.

In Model 2, the lagged endogenous term, mean high tech wages, a favorable climate and the number of daily air flights are significant predictors in the predicted direction. This suggests that wages encourage the dispersion of high tech industry. The number of four-year colleges and universities is significantly negative, the opposite found by Markusen et al. (1986:155). We suspect this reflects the fact that the majority of these schools are liberal arts colleges with little direct impact on high tech development. It may also reflect the post-1960s growth in higher education where four-year colleges are no longer critical amenities, especially relative to research universities. Later we introduce the more meaningful university R&D measure. Population density is not significant. Percent black is also not significant, suggesting that the industry avoidance of larger minority populations earlier found by Markusen et al. (1986:155) may have dissipated. Location factors contribute 18.7 percent to explained variance (adjusted $R^2 = .188$) over the baseline model.

Model 3 controls for agglomeration factors, showing that, in addition to a negative effect of the endogenous lag term, *Fortune* 500 headquarters, university R&D and military R&D positively affect change in high technology industry employment. These effects point to the importance of entrepreneurial resources and public sector R&D investments and resemble Markusen et al.'s (1986:154-56) findings that large manufacturing corporate headquarters and military spending contribute to high tech employment growth. Population density and private venture firms are not significant. In Model 4 we add population change, which is positive and significant but does not alter any of the other factors. This suggests that other factors associated with population growth do not alter the effects in

Model 3. The agglomeration factors in Model 3 add 17.9 percent in explained variance over the baseline model.

Model 5 examines the effects of our policy measures. In addition to the negative effect of the endogenous lag term, technology grants and loans, business incubators and research parks contribute to high tech industry job growth. Public venture capital, SBIRs, technology development and technology deployment/transfer programs are not statistically significant. Programs associated with both the infrastructure (business incubators, research parks) and entrepreneurial strategies (technology grants and loans) are effective at promoting high tech employment growth. At the same time, these results raise questions about the efficacy of the other four programs. Compared to the baseline model, high tech policies added 10 percent to explained variance.

Model 6 combines all the significant location and agglomeration variables with the seven policy measures to see whether high tech development policies affect high tech employment growth net of location and agglomeration factors. In addition to the location and agglomeration factors, technology grants and loans and research parks have positive independent effects on high tech industry job change. The partial slopes in this equation indicate that each additional grant and loan program year creates 2,666 high tech jobs and each additional year of research parks creates an additional 364 high tech jobs. Business incubators lose significance due to a moderate correlation with *Fortune* 500 headquarters ($r = .39$). When *Fortune* 500 headquarters are removed from this equation, the incubators effect is positive and significant ($b = 680.8$; $t = 2.688$), suggesting that their direct benefits are associated with the presence of Fortune headquarters.

In addition to the lagged endogenous terms, a favorable climate, air flights, Fortune 500 headquarters, university R&D and military R&D still contribute to high tech industry job growth. The strongest standardized coefficients in this equation are the endogenous lag term (-.76), Fortune 500 headquarters (.49), and air flights (.35) followed by technology grant and loan programs (.24), military R&D and climate (both .16), and research parks (.15), indicating that agglomeration factors are the dominant forces behind high tech growth. These factors add 36.3 percent in explained variance to the base model.

Do these programs magnify or compensate for the agglomeration factors? To examine this, we test interaction terms between our seven policy measures and our agglomeration factors. We also include interactions with daily air flights (for a facilitator of agglomeration, see Irwin and Kasarda [1991]), population density, and 1988 high technology employment along with the major agglomeration measures. Because population change is an exogenous control, it is not combined in interactions but is retained as a control in the models. If the interaction term is positive, policies are *magnifying* the agglomeration effect by creating greater positive change in high tech industry job growth. If the interaction is negative, policies are *compensating* for lower levels of agglomeration by generating high tech employment growth. In addition to significant interaction terms, the main effects may remain significant, indicating that a policy or agglomeration factor has a direct effect in addition to its contribution in a significant interaction term (see Jaccard, Turrisi and Wan 1990; Aiken and West 1991). If only the interaction term

Table 5: Effects of High Tech Employment Change, 1988-1998

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Constant	2448.75	15763.94	1723.27	-1157.83	622.40	2752.32	5319.51
High Technology Industry Employment 1988	-.001[a]	-.001**	-.18***	-.19***	-.081***	-.28***	-.29***
	-.03	*-.24*	*-.50*	*-.51*	*-.21*	*-.76*	*-.80*
	(.02)	(.03)	(.03)	(.03)	(.02)	(.03)	(.03)
High Technology Industry Wages per Worker	—	-.20**	—	—	—	—	—
		-.07					
		(.18)					
Median Housing Cost	—	20.01	—	—	—	—	—
		.04					
		(32.12)					
Climate Index	—	32.83**	—	—	—	25.78**	20.93*
		.21				*.16*	*.09*
		(9.36)				(7.95)	(8.14)
Recreation Index	—	2.14	—	—	—	—	—
		.01					
		(11.27)					
Arts Index	—	-18.80	—	—	—	—	—
		-.10					
		(15.34)					
# Daily Air Flights	—	40.50***	—	—	—	33.24***	41.53***
		.43				*.35*	*.44*
		(7.43)				(6.44)	(6.46)
# Interstates	—	1382.51	—	—	—	—	—
		.07					
		(1324.73)					
# 4 Year Higher Education Institutions	—	-832.11**	—	—	—	—	—
		-.08					
		(268.48)					
Percent Black	—	122.68	—	—	—	—	—
		.07					
		(95.14)					
Population Density	—	-.17	-2.65	-2.31	—	-1.58	-1.86
		-.01	*-.14*	*-.12*		*-.08*	*-.10*
		(1.19)	(1.42)	(1.40)		(1.11)	(1.25)
% Population Change 1990-1997	—	—	—	338.33**	—	200.84	251.04*
				.15		*.09*	*.11*

				(118.83)		(110.98)	(108.28)
# Fortune 500 Headquarters	—	—	1948.68***	1994.97***	—	1870.09***	1929.14***
			.51	*.52*		*.49*	*.50*
			(298.73)	(295.51)		(280.73)	(270.08)
# Private Venture Firms	—	—	28.12	30.54	—	—	17.61
			.05	*.05*			*.03*
			(40.66)	(40.17)			(36.98)
University R&D	—	—	.03*	.03*	—	.01	.003
			.16	*.16*		*.04*	*.02*
			(.01)	(.01)		(.01)	(.01)
Military R&D Space	—	—	72.77***	74.93***	—	55.45**	78.37***
			.21	*.22*		*.16*	*.23*
			(19.92)	(19.70)		(18.46)	(18.07)
Years – Public Venture Capital	—	—	—	—	-597.59	438.04	-292.87
					-.06	*.04*	*-.03*
					(746.18)	(659.43)	(702.52)
Years – SBIRs	—	—	—	—	732.48	178.42	—
					.06	*.01*	
					(744.89)	(642.47)	
Years – Technology Grants & Loans	—	—	—	—	2683.97***	2665.85***	—
					.24	*.24*	
					(776.60)	(660.11)	
Years – Technology Development	—	—	—	—	-164.21	-237.11	—
					-.04	*-.06*	
					(224.95)	(195.74)	
Years – Technology Deployment/Transfer	—	—	—	—	-18.06	7.18	—
					-.004	*.00*	
					(95.98)	(81.36)	
Years – Technology Incubators	—	—	—	—	712.30**	134.54	—
					.19	*.04*	
					(243.87)	(217.54)	
Years – Research Parks	—	—	—	—	483.76**	364.19**	—
					.20	*.15*	
					(153.22)	(133.03)	
Centered Interaction of Public Venture Capital * # Air Flights							11.21***
							.33
							(2.33)
Number of Cases	290	290	290	290	290	290	290
Adjusted R^2	.001	.19	.18	.20	.10	.36	.37

* $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$ (two-tailed tests)

[a] Standardized coefficients in italics, standard errors in parentheses

and neither of the main effects are significant, the policy benefits are limited to specific agglomeration contexts. We add each interaction term separately to the variables in Model 6 of Table 5 with the other policy measures removed and use centered measures to multicolinearity (see also Aiken and West 1991:32-35).

Model 7 in Table 5 shows the first of these 42 equations. To save space, Table 6 shows only the statistically significant interaction coefficients along with standard errors and t-statistics plus the adjusted R^2 (full results are available from the authors).

With the exception of SBIRs, which do not produce any statistically significant interactions, all of the high tech policies have contextual effects in at least two or more contexts. In several of these equations, the main effect for policy is not significant, indicating that the agglomeration context specifies the setting where these policies are more effective. In others, both the main effect and the interaction term is positive, indicating that the policy and the agglomeration context continue to have effects in addition to the combination of policy with the context.

Public venture capital programs had no statistically significant effects in our earlier equations but these programs contribute to high tech industry employment growth in all of our agglomeration contexts, including more densely populated MSAs. In MSAs with significant military R&D, these programs help compensate for agglomeration deficits. Four of these contexts – air flights, *Fortune* 500 headquarters, military R&D and existing high technology industry – are additively significant alongside the interaction effect.

High tech grant and loan programs interact positively with all the agglomeration contexts and, in five of these contexts, work additively in addition to interactively combining with agglomeration contexts to boost high tech industry employment. *Fortune* 500 headquarters and initial high tech industry employment also work additively in these equations. Overall, grant and loan programs appear to be one of the most consistently beneficial high tech policies.

Technology development programs interact negatively with several agglomeration contexts, indicating contexts in which these programs compensate for agglomeration deficits. Negative interactions with air flights, population density, *Fortune* 500 headquarters and initial high tech industry employment indicate that technology development programs are compensating for initial agglomeration deficits in these contexts. The main effects for air flights, *Fortune* 500 headquarters, university R&D and military R&D are positive in these equations, indicating that these factors still contribute to high tech industry employment growth.

Technology deployment and transfer programs are not statistically significant in the earlier equations but they do increase high tech industry employment in conjunction with private venture capital and initial high tech industry employment. Because these programs do not generate new technology but rather attempt to ensure that "state of the art" technology is being utilized, this suggests that these contexts maximize the employment benefits of technology deployment and transfer programs by accelerating the adoption of current technology. In both contexts, the main effect of the agglomeration context is also statistically significant.

The two strongest "technopole" factors – technology business incubators and research parks – contribute to high tech job growth in all agglomeration contexts except for military R&D centers for incubators. In the incubator equations with air flights and *Fortune* 500 headquarters, the main effect of incubators is negative and significant, suggesting that incubators do not stimulate high tech employment growth outside of MSAs with air hubs and *Fortune* 500 headquarters. Both "technopole" policies, the main effects of air flights, *Fortune* 500 headquarters and initial high techn industry employment also retain their statistical significance in these interaction equations.

Overall, these interactions indicate that both the infrastructural and entrepreneurial strategies are conditioned in their effects by the presence of agglomeration advantages. The critics of high tech policy are correct that high tech development is an organic process that cannot be planned from scratch. Existing agglomeration advantages are important to securing benefits from these policies. In a few contexts, policies compensate for agglomeration deficits. At the same time, the limits of these technology policies should not be overstated. Some of these policies – technology grants and loans, incubators, and research parks – have independent effects net of favorable agglomeration contexts and interactions among these. The best formula appears to be using both infrastructural and entrepreneurial policies by adapting them to complement existing local innovation capacities, thereby magnifying the effects of agglomeration advantages. Technology development programs are distinctive in compensating for agglomeration deficits. We find no evidence that the centralized or the decentralized approach is inherently superior. Multiple policies drawing on both approaches are effective, especially when they complement existing high tech resources or compensate for initial disadvantages.

Conclusions and Implications for Policy

Our results support the argument that federal, state and local high tech policies are contributing to high tech development and the creation of "good jobs." States and localities in partnership with federal programs have initiated a range of new programs to enhance local innovation capacity and to create new "technopoles" in specific locales.

Of these new high tech policies, technology grant and loan programs and research parks have been the most effective in promoting high tech industry employment growth. Technology grant and loan programs represent the core of a decentralized entrepreneurial approach, funding the development of new products and associated technologies proposed by existing enterprises and would-be entrepreneurs. Research parks represent the core of a centralized "technopole" approach that provides infrastructure for the creation of new high tech industry. By drawing on both approaches and recognizing the need for policy to complement existing agglomeration advantages, states and local governments have increased high tech industry employment.

Our results support the idea that high tech development is an organic, path-dependent process while showing that governmental planning can accelerate this process. The major driving forces behind high tech development are underlying location and agglomeration factors, especially *Fortune* 500 headquarters, air hub

Table 6: Effects of Policy/Agglomeration Interactions on High Tech Employment Change, 1988-98

Interaction Variable	Coefficient	S.E.	Main Effects	Coefficient	S. E.	Adj. R^2
Public Venture Capital						
Public Venture * Air Flights	11.21***	2.32	Public Venture	-292.86	702.52	.367
			Air Flights	41.53***	6.46	
Public Venture * Pop. Density	3.69***	.872	Public Venture	138.44	681.18	.356
			Pop. Density	-.660	1.304	
Public Venture * Fortune 500	408.36***	100.73	Public Venture	177.85	687.26	.352
			Fortune 500	1996.42***	275.25	
Public Venture* Private Venture	109.02***	19.89	Public Venture	420.53	597.38	.381
			Private Venture	52.46	37.11	
Public Venture * Univ. R&D	.009***	.002	Public Venture	-717.495	706.891	.383
			University R&D	.001	.010	
Public Venture * Military R&D	-24.84*	10.359	Public Venture	1920.266***	560.451	.328
			Military R&D	73.008**	18.565	
Public Venture * High Tech Employment	.019***	.004	Public Venture	-428.978	708.185	.370
			High Tech Employment	-.289***	.031	
Technology Grants/Loans						
Grants/Loans * Air Flights	17.481***	2.479	Grants/Loans	742.757	598.887	.448
			Air Flights	42.254***	5.993	
Grants/Loans * Pop. Density	5.875***	.940	Grants/Loans	1750.425**	555.282	.429
			Pop. Density	-.539	1.215	
Grants/Loans * Fortune 500	707.583***	112.116	Grants/Loans	1877.494***	547.973	.431
			Fortune 500	2297.069***	262.876	
Grants/Loans * Private Venture	135.438***	23.782	Grants/Loans	2202.682***	543.785	.417
			Private Venture	50.214	35.948	
Grants/Loans * Univ. R&D	.011***	.002	Grants/Loans	1228.457*	592.179	.426
			University R&D	-.003	.010	

Table 6 *(continued)*

Grants/Loans * Military R&D	36.485***	7.031	Grants/Loans	2550.785***	539.080	.407
			Military R&D	22.630	18.898	
Grants/Loans * High Tech Employment	.028***	.004	Grants/Loans	1011.784	599.825	.432
			High Tech Employment	-.304***	.029	
Technology Development						
Development * Air Flights	-3.148*	1.385	Development	-6.311	204.309	.302
			Air Flights	33.224***	6.613	
Development * Pop. Density	-2.949***	.473	Development	-103.945	185.515	.376
			Pop. Density	-5.680***	1.368	
Development * Fortune 500	-570.350***	73.569	Development	-491.480**	185.289	.415
			Fortune 500	2912.108***	300.355	
Development * High Tech Employment	-.024**	.008	Development	-4.046	198.407	.315
			High Tech Employment	-.254***	.032	
Technology Deployment/Transfer						
Deploy./Trans. * Private Venture	41.696*	16.841	Deployment/ Trans.	297.067*	147.942	.303
			Private Venture	127.555*	62.422	
Deploy./Trans. * High Tech Employment	.007**	.003	Deployment/ Trans.	2.461	81.823	.309
			High Tech Employment	-.225***	.031	
Technology Incubators						
Incubators * Air Flights	3.335***	.678	Incubators	-555.311*	264.739	.348
			Air Flights	23.818***	6.652	
Incubators * Pop. Density	1.320***	.240	Incubators	-324.054	229.873	.361
			Pop. Density	-2.317	1.257	
Incubators * Fortune 500	120.245***	23.260	Incubators	-589.137*	263.161	.354
			Fortune 500	1273.843***	284.530	

Table 6 *(continued)*

Incubators * Private Venture	46.615***	11.967	Incubators	61.525	214.956	.328
			Private Venture	65.971	40.623	
Incubators * Univ. R&D	.005***	.001	Incubators	-469.760	261.827	.341
			University R&D	.007	.011	
Incubators * High Tech Employment	.007**	.002	Incubators	-209.383	261.297	.315
			High Tech Employment	-.266***	.033	
Research Parks						
Parks * Air Flights	2.778***	.687	Parks	173.169	134.926	.342
			Air Flights	22.403***	6.876	
Parks * Pop. Density	1.357***	.263	Parks	234.880	128.240	.364
			Pop. Density	1.778	1.454	
Parks * Fortune 500	167.653***	25.233	Parks	75.701	129.276	.399
			Fortune 500	1322.359***	267.656	
Parks * Private Venture	21.845***	4.151	Parks	235.180	127.966	.366
			Private Venture	11.878	36.953	
Parks * University R&D	.002*	.001	Parks	238.215	140.087	.313
			University R&D	.006	.011	
Parks * Military R&D	5.811***	1.276	Parks	153.414	133.998	.352
			Military R&D	-7.726	22.732	
Parks * High Tech Employment	.010***	.002	Parks	-37.765	134.910	.401
			High Tech Employment	-.346***	.033	

Note: Centered Measures; N = 290).
*** ≤ .05 ** p ≤ .01 *** p ≤ .001 (two-tailed tests)**

centrality and university/military R&D. At the same time, several of these policies work independently and interactively with existing agglomeration advantages. In this sense, high tech development can be planned. This planning process needs to take into account existing location and agglomeration strengths and deficits. While we have not examined the details of this planning process, it is clear that high tech programs need to be adapted to the existing mix of high tech industry and other location and agglomeration resources. Processes that facilitate this policy adjustment, such as industry-government advisory boards, the use of nonprofit corporations and other policy tools, may contribute to policy effectiveness. High tech industry cannot be created entirely from scratch, but it can be aided by effective policy.

The conventional debate over infrastructural vs. entrepreneurial approaches to high tech development appears somewhat misguided. Some have argued for major infrastructural initiatives to create "technopoles" and new "Silicon Valleys." Critics correctly point out that this strategy is unlikely to work by itself and that the informal networks, entrepreneurial traditions, skilled labor and tacit knowledge bases that are critical to high tech development cannot be planned. However, government policies can nurture these local contexts where agglomeration processes are already in place. Hence a "technopole" strategy has to be adapted to fit the local strengths and weaknesses of existing high tech resources. At the same time, this approach needs to be balanced by more decentralized policies, such as public venture capital and technology grant and loan programs that depend on the initiative of existing enterprises and would-be entrepreneurs.

We also find support for existing arguments about the importance of location and agglomeration advantages. Numerous studies have discussed the importance of the R&D spillovers from large *Fortune* 500 companies, research universities and military research labs (Goldstein and Renault 2004, Hooks 2003, Kenney 2000, Lee et al. 2000, Markusen et al. 1986, Saxenian 1994). Others have pointed to the advantages of a good climate (Markusen et al. 1986) and centrality within the air transport system (Irwin and Kasarda 1991). Much of this literature has relied on case studies to demonstrate the plausible link between existing public and private sector R&D and the creation of new high tech firms, patents and regional industrial clusters. Little of this work has used systematic comparison and multivariate controls. Our contribution has been to use these techniques to gauge the relative contribution of these factors on high tech employment growth. Local agglomeration networks and institutions create local capacities for innovation that are central to high tech development. In this sense, high tech industry is locality based. It requires a local innovation capacity that sustains the continuous creation of new enterprises and technologies, including business restarts and the recycling of technology. At the same time, policies adapted to complement existing high technology strengths may magnify the benefits of these advantages and, for technology development policy, compensate for initial agglomeration deficits.

Do these policies break with traditional industrial recruitment policies? Many analysts have promoted the new technology policies as alternatives to traditional industrial recruitment, arguing that they allow states and localities to "grow their own" new industry (Osborne 1988; Eisinger 1988; Clarke and Gaile 1989, 1998). High tech programs differ from traditional industrial recruitment in requiring greater targeting and direct governmental participation in the development of new technology, products, markets and enterprises. Yet this distinction should not be overstated. The benefits of these policies depend on favorable agglomeration contexts. High tech policies help build on existing high tech industry and, for the most part, do not create new industries from scratch. In this sense, high tech policies may be seen as a more sophisticated form of industrial recruitment and retention, allowing areas with existing agglomeration and location advantages to capitalize on their assets. Future research should examine whether these policies reinforce or reduce existing regional disparities in high tech development.

Notes

1. We explored a variety of different measurement schemes, modelling strategies and variable measurement techniques. Details are available from the authors.

2. Detroit is an influential outlier because it lost high technology employment despite two longstanding programs – the Michigan Energy Research and Resource Association and the Metropolitan Center for High Technology. Apparently the two programs failed to halt this decline.

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