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HIGH-TECHNOLOGY INDUSTRIES IN THE MID-1970S: The Distribution of Industries and Employment

*Amy Glasmeier**

I. Introduction

The continued decline of basic industries in the manufacturing belt and the rise of new industries in other regions, has led many observers to conclude that a shift is occurring in the location of industrial innovation (Rees, 1979; Norton and Rees, 1979). Factors thought to produce this shift include an uncompetitive industrial structure in the manufacturing belt (Chinitz, 1960), the cumulative impact of product cycle phases (Rees, 1979), government spending for military procurement and troop placement (Markusen, 1984), and quality of life considerations (Hall, 1982).

This apparent shift has intensified competition between states for new high-tech jobs and investment. Southern and Western states actively recruit firms from the Northeast and Midwest by offering them financial incentives and a better "business climate" (Harris, 1983). Northeast and Midwest states have responded with similar programs in a effort to remain competitive (Office of Technology Assessment, 1983; Peltz and Weiss, 1984; National Governor's Conference, 1983). The race to offer a better business climate has resulted in the proliferation of state and local high-tech programs, but to date no systematic evaluation of their effectiveness has been undertaken.

Few empirical studies of high technology industry location have focused on a state or regional level (exceptions include Armington, Harris, and Odle, 1983;

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Brown, 1983; Glasmeier, Hall, and Markusen, 1983c). This is due largely to the lack of suitable data sources to enable a detailed state level industry analysis.

Using a well-known but infrequently analyzed data source, the 1972 and 1977 Census of Manufactures Plant location files and industry employment estimates, this paper presents a state-level analysis of the location and growth of high-technology industries in the mid 1970s.¹ The data base provides actual counts of manufacturing plants at a 4-digit industrial classification level for every county in the country. Employment estimates were constructed based on the plant level data. The two have been merged and aggregated to metropolitan and state levels allowing detailed analysis of high-tech plant and employment location in the U.S (Glasmeier, Markusen, and Hall, 1983b). The paper begins with a brief review of high-tech definitions, and then presents preliminary and partial findings of state level high-technology industry employment.

II. Defining High-Technology Industries

There is considerable debate about what constitutes a high-technology industry. Although the computer and microelectronics industries are generally considered to be "high-tech", the inclusion of other technology-intensive industries such as chemicals and machinery is controversial. A number of measures have been used to define high tech, all of which lack precision and comparability (Massachusetts Department of Manpower Development, 1979; TMA Associates, 1979). Specifically, the measures are either too aggregate or fail to treat all industries in the same manner. For the purpose of this paper, a working definition is based on the human capital component of the labor process. That is, industries are considered high-tech on the basis of the proportion of

¹ More recent data would add considerably to this analysis but unfortunately the results of the 1982 Census of Manufactures are still unavailable.

technical occupations in the total industry labor force (Glasmeier, Markusen, Hall, 1983a).

Any definition of high-tech industry must take account of the constantly changing nature of technology. This suggests that there can be no temporally static list of high-tech industries. Given that new technologies are always being incorporated into most industries, the technical component of the overall labor force is rising (Baran, 1984). Using a definition based on occupations controls for this effect, but necessitates a revision of the criterion used to select particular industries.

Most lists of high-tech industries are based on the Standard Industrial Classification (SIC) system and include parts of industry groups such as chemicals, electrical machinery, transportation equipment, communications equipment, and engineering and scientific instruments.² As part of our initial analysis, two definitions of high-tech were applied. The more restrictive definition uses the national durable manufacturing industry average for scientists, engineers and technicians (Green Harrington, and Vinson, 1983); the broader one uses the overall manufacturing average for engineers, engineering technicians, computer scientists, mathematicians and life scientists including geologists, physicists, and chemists (Glasmeier, Markusen, Hall, 1983a). The consistency of the results using both definitions was similar and therefore only the results of the broader definition are presented here. Table 1 lists the industries identified using the two cutoff points, showing the similarities and differences between the two groups.

² The SIC code is a numerical scheme that classifies industries into groups, industries and products; the larger the "digit" the more industry detail presented.

Table 1:

Employment in High Technology Industries

Definition I

<i>SIC Code</i>	<i>Industry Name</i>	<i>Estimated Employment</i>
2812	Alkalies and Chlorine	11832
2813	Industrial Gases	7397
2816	Inorganic Pigments	12000
2819	Ind. Inorganic Chem. Nec.	78203
2821	Plastic Materials, Syn. Resins	57106
2822	Synthetic Rubber	11545
2823	Cellulosic Man-Made Fibres	16229
2824	Syn.Org. Fibres, Ex Cellul	74064
2831	Biological Products	18468
2833	Med. Chem. Botanical Products	15725
2834	Pharmaceutical Preparations	126399
2861	Gum, Wood Chem.	4720
2865	Cyclic Crudes, Intermediates, Dyes	35513
2869	Ind. Organic Chem. Nec.	112400
2891	Adhesives, Sealants	16671
2892	Explosives	11549
2893	Printing Ink	10100
2895	Carbon Black	2600
2899	Chem, Chem. Prep., Nec.	35298
2911	Petroleum Refining	102399
3482	Small Arms Ammunition	12187
3483	Ammunition, Ex Small Arms, Nec.	20581
3484	Small Arms	17499
3489	Ordnance, Accessories, Nec.	19037
3511	Steam, Gas, Hydraulic Turbines	40964
3519	Internal Combustion Engines, Nec.	88799
3531	Construction Mach. Equip.	155198
3532	Mining Mach., Equip.	31298
3533	Oil Field Mach., Equip.	58499
3534	Elevators, Moving Stairways	10201
3535	Conveyors, Conveying Equip.	32926
3536	Hoists, Ind. Cranes, Monorail System	15799
3537	Ind. Trucks, Tractors, Trailers, Stackers	28385
3561	Pumps, Pumping Equip.	63055
3562	Ball, Roller Bearings	50288
3563	Air, Gas Compressors	31900
3664	Blowers, Exhaust, Ventil. Fans	28430
3565	Ind. Patterns	9398
3566	Speed Chgrs, Ind. High Drives, Gears	24546
3567	Ind. Process Furnaces, Ovens	16263
3568	Mech. Power Transmission Equip. Nec.	32558
3569	Gen. Ind. Mach. Equip. Nec.	58554
3573	Electronic Computer Equip.	192513

(Table 1 continued . . .)

3574	Calc.Acc.Mach.Ex Elec.Computer Equip.	15459
3576	Scales, Balances, Ex. Lab.	6712
3579	Office Mach., Nec.	42412
3621	Motors, Generators	96970
3622	Industrial Controls	56428
3623	Welding Apparatus, Electric	17399
3624	Carbon, Graphite Products	12082
3629	Elec. Ind. Apparatus, Nec.	16474
3661	Telephone, Telegraph Apparatus	124309
3662	Radio TV Transmit,Signal,Detect. Equip.	332923
3671	Cathode Ray Tubes, Nec.	36799
3674	Semiconductors, Related Devices	114000
3675	Electronic Capacitors	28643
3676	Resistors for Electronic App.	24922
3677	Resistors, Electric Apparatus	22425
3678	Connectors, Electronic Appls.	26013
3679	Electronic Components, Nec.	125965
3721	Aircraft	222799
3724	Aircraft Engines, Parts	106200
3728	Aircraft Parts, Auxiliary Equip. Nec.	101934
3761	Guided Miss., Space Veh.	93928
3764	Guided Miss., Space Veh. Propul. Units	17013
3769	Guided Miss., Space Veh. Parts Nec.	10193
3811	Eng,Lab,Scientific Research Inst.	42197
3822	Auto,Controls Reg.Resid,Comm.Env.Appl	39099
3823	Ind. Instr. Measure, Display	46499
3824	Fluid Meters, Counting Devices	16018
3825	Instr.Measuring,Testing Elec.Sigs.	66600
3829	Measuring, Controlling Devices, Nec.	32200
3832	Optical Instruments, Lenses	29905
3861	Photographic Equip., Supplies	111556
<i>Definition I:</i> Total Employment		3835211

(continued . . .)

(Table 1 continued . . .)

A Broader Definition Includes:

Definition II		
<i>SIC Code</i>	<i>Industry Name</i>	<i>Estimated Employment</i>
2851	Paints, Varnishes, Lacquers, Enamels	61297
2844	Perfumes, Cosmetics, Toilet Prep.	50799
2843	Surface Active Finishing Agents	6838
2842	Spec. Cleaning, Polishing Prep.	22919
2841	Soap, Other Detergents	32641
3561	Pumps, Pumping Equipment	63055
3549	Metalworking Mach., Nec.	19141
3547	Rolling Mill Mach., Equip.	8530
3546	Power Driven Hand Tools	27676
3545	Mach. Tool Access., Measuring Devices	54257
3544	Spec. Dyes, Die Sets, Jigs Fix., Ind. Molds	106107
3542	Mach. Tools, Metal Forming Types	23145
3541	Mach. Tools, Metal Cutting Types	59463
3652	Phono Records, Prerecorded MagTapes	23102
3651	Radio, TV Receiv. Sets, Ex Comm. Types	74600
3743	Railroad Equipment	56399
3843	Dental Equip., Supplies	16636
3842	Orthopedic, Prosthetic, Surgical Appl.	53990
3841	Surgical, Medical Instr. Apparatus	43225
<i>Definition II: Estimated Employment Total</i>		4760506

Source: Both definitions are based on the Occupational Employment Statistics Survey, 1980, Department of Labor.

Definition I: Robert Vinson, Richard L. Green, Paul Harrington, "High Technology Industries: Identifying and Tracking an Emerging Source of Employment Strength," Center for Labor Market Studies, Northeastern University, 1983.

Definition II: Amy Glasmeier, Ann Markusen, and Peter Hall, "Defining High Technology Industries," Institute of Urban and Regional Development, Working Paper No. 407, University of California, Berkeley, 1983.

III. The Location of High-Technology Industries and Employment

The intense interest in high-technology industries overstates their actual contribution to total employment. In 1977, high-tech employment accounted for approximately five percent of all employment or 24 percent of manufacturing jobs. In comparison to growth in non-manufacturing sectors, high tech industries have added relatively few jobs (Brown, 1983) and high-tech employment, though increasing rapidly relative to other sectors, is expected to contribute only ten percent of all new jobs created over the next ten years (Richie, Hecker, and Burgan 1983).

In addition, because most of the evidence about high technology industry location has been anecdotal, it is now the common wisdom that the South and the West have a disproportionate share of high-tech industries and therefore high-tech employment. On the basis of two measures at least, the location of high-tech plants and the absolute concentration of employment, the empirical evidence contradicts this popular imagery.

In fact, high-tech *plants* are found in 80 percent of the states; for example, plants in the Communications Equipment industry (SIC 3662), the largest single industry in terms of employment, are found in all 50 states. No doubt this reflects the general diversity found in this particular 4-digit product group. But the widespread distribution of these industries further suggests that many are market-oriented and produce highly differentiated products with considerable linkages to other high-tech sectors. Another explanation for this dispersion is the spatial consequences of different phases of individual industry product cycles. Thus, for example, while new product development of semiconductors is concentrated in states like California, Arizona, and New York, assembly operations occur in these and other states and also in other countries (Saxenian, 1980).

On the other hand, although high-tech industries are found in many states, employment is highly concentrated. First, as many as 100 industries make up the high-tech group, nevertheless, the great majority of all high-tech manufacturing employment is concentrated in only a few industries. Just 13 contribute approximately 1.9 million jobs to the economy and represent approximately 50% of all high-tech employment (Table 2).

Second, less than seventeen states are responsible for a majority of high-tech jobs in the largest industries. The regional distribution of this employment includes states in the Middle Atlantic, the Great Lakes, the Northeast, the Southwest, and the Pacific regions. Despite widespread growth of high-tech employment since 1977, (the year corresponding to the data base analyzed here), recent analysis of state-level employment confirms that the majority of jobs are still concentrated in a few states (see for example Department of Commerce, U.S. Industry Outlook for details). (Table 3)

States in the Northeast, Middle Atlantic and Great Lakes regions account for ten of the top thirteen states in terms of total high-tech plants and employment, (see Table 4). These thirteen were collectively responsible for 71 percent of total high-tech employment.

The prominence of Northeast and Midwest states within this group, although notable, is not surprising given their share of overall manufacturing employment. The concentration of high-tech employment in Northeastern and Midwestern states also correlates with research findings on the location of corporate research and development activities. Even when controlling for size, Malecki found that a significant relationship exists between manufacturing employment and the concentration of research and development employment and activities (Malecki, 1979).

Table 2:
The 13 Largest High Technology Sectors, 1977
 (all numbers are absolute)

Industry Name (SIC Code)	1977 Estimated Employees	# of States with the Industry '72	# of States with the Industry '77
Radio TV Transmit, Signal, Detect. Equipt. (3662)	332923	48	50
Aircraft (3721)	222799	33	34
Construction Mach. Equipt. (3531)	155198	46	47
Electronic Comput. Equipt. (3573)	192513	40	45
Pharmaceutical Preparations (2834)	126399	41	43
Electronic Components, NEC (3679)	125965	44	48
Telephone, Telegraph Apparatus (3661)	124309	37	40
Semiconductors, Related Devices (3674)	114000	37	42
Ind. Organic Chem. NEC. (2869)	112400	41	41
Photographic Equipt., Supplies (3861)	111556	42	41
Aircraft Engines, Parts (3724)	106200	28	33
Petroleum Refining (2911)	102399	41	39
Aircraft Parts, Auxiliary Equipt., NEC. (3728)	101934	40	43
Totals:	1,928,595		

NEC = Not Elsewhere Classified

Source: Glasmeier, Amy, "Spatial Differentiation of High Technology Industries:
 Implications for Planning," Dissertation, University of California. Berkeley, 1985.

Table 3:
The 13 Largest 4-digit High Technology Industries, 1977

State	Standard Industrial Classification Code of 13 Industries												
	3662	3721	3531	3573	2834	3679*	3661	3674	2869	3661	3724	2911	3728
Indiv. Employ. Acc'd for by Ind. States	83%	90%	89%	85.8%	84%	82.9%	82%	97.5%	85%	92%	75%	72.5%	86.3%
AR	2.0			4.3			3.4						
AZ	2.0							8.2			4.9		
CA	23.0	27.0	4.0	29.0	7.0	23.0	8.0	31.0	3.0	4.0	3.0	15.0	36.0
CN	2.2	6.0			1.0	4.0	1.0	4.0	1.0				31.0
CO	2.0			1.6			3.0			10.0			1.0
FL	7.6	6.1		4.0		4.0		4.0		4.0	1.0	1.0	5.7
GA		5.9	1.0										
IA	1.0		14.0										
IL	3.9		21.0		8.2	10.9	20.6		1.7				7.0
IN	2.0		3.0		7.0	1.0	5.0		1.0	1.0	10.0	3.0	4.0
KS	1.0	12.0	1.0										
LA						2.9			15.1				8.5
MA	6.0			12.4	1.0	7.0	4.0	4.0	1.0	15.0	10.0		
MI	1.0		6.0		5.0	1.0			3.7	1.0	1.0	2.2	
MN	2.0		4.0	9.5		6.5						9.7	
MO	1.1	3.1	1.0		2.1	3.2				2.4			
MS							2.8						
NC					6.2		4.0			4.9			
NJ	6.8			4.0	18.0	6.0	3.0	4.0	7.0	8.0	1.0	5.0	2.0
NM							2.9						
NY	11.7	6.0	2.0	6.3	1.5			12.5	4.0	30.0	6.0		3.0
OH	2.0		11.0		2.7	2.3	2.9	4.0	2.6		11.8	3.0	8.1
OK			3.0	2.5			3.4					3.8	7.0
PA	2.8	5.8	5.0	4.0	12.0		7.0	10.8	4.0	1.0	6.0	8.0	
TX	5.7	12.5	4.0	5.0	1.0	2.0	4.0	16.0	26.0			27.0	2.0
UT				1.5						8.7			
VA								6.1		3.6			
VT									3.0		4.4		
WA		5.8		1.0									4.8
WI	1.0		11.0										
WV													

Source: Glasmeier, Amy, "Spatial Differentiation of High Technology Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

SIC#	Industry Name	
3662	Radio, TV Transmit, Signal, Detect Equip	3661 Telephone, Telegraph Apparatus
3721	Aircraft	3674 Semiconductors, Related Devices
3531	Construction Machinery, Equipment	2869 Ind Organic Chem, NEC
3573	Electronic Computer Equipment	3661 Photographic Equipment, Supplies
2834	Pharmaceutical Preparations	3724 Aircraft Engines, Parts
3679	Electronic Components, NEC	2911 Petroleum Refining
		3728 Aircraft Parts, Auxiliary Equip, NEC
		NEC = Not Elsewhere Classified

Table 4:
*Estimated Employment in
High-Technology Industry, 1977*

States

California	641262
Illinois	360317
New York	336848
Pennsylvania	314322
Ohio	295135
Texas	285667
New Jersey	232268
Massachusetts	204630
Michigan	169400
Connecticut	160085
Indiana	153458
Wisconsin	128809
Florida	119048

Percent Total	.71
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Total	3,401,259
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Source: Glasmeier, Amy, "Spatial Differentiation of High Technology Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

A. Proportional Measures of High-Tech Employment

Based on the absolute number of jobs then, Northeast and Midwest states have benefitted from the growth of new technology industries. In fact, in terms of absolute employment, many of the high-tech "winners" are located in the "frostbelt". But sheer numbers of jobs tend to mask the structural differences found in a state's manufacturing base; it is important therefore to examine the proportion of high-tech jobs to total manufacturing employment. Such a measure highlights the extent to which a state's manufacturing base is composed of innovative industries (Table 5).

Comparing state high-tech levels to total manufacturing employment indicates that just 18 states have a high-tech base exceeding the national average (Table 5). According to this measure, the ranking among states varied considerably from that based on absolute numbers of jobs. Only four states (TX, CN, CA, MA) had similar rankings on both absolute number of jobs and on the ratio of high tech jobs to total manufacturing employment. Few Northeast or Midwestern (6) states ranked high on this measure, suggesting their industrial base may be less technically innovative than others.

Because simple proportional measures of employment concentration do not fully account for size differences in overall state economies, location quotients (LQ) were calculated in order to identify states which have a disproportionate share of high-tech employment to total manufacturing employment. That is,

$$LQ = [HTEMP_i / E HTEMP_i] / [SMFT_i / E SMFT_i]$$

where $HTEMP_i$ is total high-tech employment for 1977, in state i ($i = 1...n$) and $SMFT$ is state manufacturing employment (Table 6).

Table 5:
*Percent of Manufacturing Employment Accounted
for by High Tech Jobs, in all 50 States*

State	Total Manufacturing	State	Total Manufacturing
Arizona	41	Missouri	20
Connecticut	39	Virginia	26
California	37	South Carolina	19
Kansas	37	South Dakota	18
Colorado	35	New Hampshire	18
Massachusetts	33	Delaware	17
Oklahoma	33	Kentucky	17
Texas	32	Tennessee	17
Utah	31	Washington	17
Florida	31	Rhode Island	16
New Jersey	30	Michigan	15
Maryland	30	Alabama	14
Louisiana	29	Idaho	14
Illinois	28	Oregon	12
Minnesota	27	North Carolina	12
West Virginia	27	Mississippi	11
New Mexico	26	Georgia	10
Wisconsin	24	Maine	9
Pennsylvania	23	Montana	9
Nevada	23	Alaska	.05
Iowa	23	Hawaii	.03
New York	22	Washington D.C.	.01
Ohio	22		
Nebraska	21		
Indiana	21		
Arkansas	20	National	.24

Source: Glasmeier, Amy, "Spatial Differentiation of High Tech Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

Table 6:

*High Tech Centers: State Location
Quotients Greater Than Unity, 1977*

<u>State</u>	<u>Location Quotient</u>
Arizona	1.80
Connecticut	1.65
Kansas	1.63
Maryland	1.60
Colorado	1.57
California	1.49
Massachusetts	1.43
Florida	1.39
Oklahoma	1.38
Texas	1.33
New Jersey	1.23
Louisiana	1.22
Minnesota	1.18
Illinois	1.15

Source: Glasmeier, Amy, "Spatial Differentiation of High Tech Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

A location quotient provides a simple method for comparing a state's percentage share of a particular economic activity with its percentage share of some base aggregate (Isard, 1960). In this case we compare a state's share of high-tech manufacturing employment to its share of national manufacturing employment. This measure provides a rough assessment of a state's strength in industries using the latest technological innovations and it allows us to highlight states with concentrations of high technology manufacturing employment.

A location quotient of 1 indicates that the ratio of a state's share of high-tech employment to total manufacturing is equivalent to the distribution of high-tech and manufacturing employment nationally. A value greater than 1 indicates a state that specializes in these industries. Using a location quotient allows us to identify states that might be considered centers of technical innovation.

According to this measure, less than 30 percent of the states have a technically innovative manufacturing base. In addition, the regional distribution of states with a high LQ does differ from that based on the absolute levels of high tech jobs. States in the South and West are represented more frequently in this group. Nevertheless, the difference is small. Of the 13 largest states with over 500,000 manufacturing jobs, half had LQ's greater than one. Of these, four were in the Northeast and Middle Atlantic States and one was in the Great Lakes region. If the Plains region is also included, then the difference between the Frostbelt and the Sunbelt disappears. Thus we cannot conclude on the basis of this measure either that high-tech employment or innovative technical activity is concentrated outside the manufacturing belt in states with a relatively new history of manufacturing development.

B. High-Tech Employment Change

At the same time however, there does seem to be a difference between the Sunbelt and Frostbelt in terms of new high-tech employment growth. Changes in employment growth over the mid-1970s suggest that the location of new manufacturing jobs may reduce the concentration in the Northeast and Midwest (Armington, Harris, and Odle, 1983). New high-tech growth, as opposed to in-place employment, has been the focus of attention in the economic development literature (Florida, 1983; Glasmeier, Hall, Markusen, 1984). States not otherwise known as manufacturing centers have demonstrated a capacity to attract new high-tech jobs. Depending on the magnitude of this change, the differential growth in high-tech jobs may indicate that new centers of technical innovation are developing.

In the mid-1970s a great majority of states gained both new high-tech industries and additional high-tech jobs. On average, state level high-tech employment increased by 17 percent. Of the 20 states that experienced an increase greater than the average, 14 were in the South and West. This regional concentration is somewhat misleading, however, given that these states had a limited high tech base to begin with so that small absolute changes result in large percentage gains. Only Texas, North Carolina, and Minnesota, were found both to have a substantial high-tech employment base and to experience a considerable percentage increase in new high-tech jobs.

During the 1970s, manufacturing industries increased by a mere 3.7 percent. This in part reflects a post-Vietnam war decline in demand for military-related products, as well as the impact of the major recession in 1974-75. High-tech employment, though only a modest portion of total manufacturing employment, was important in the overall rate of growth. In only a few states (KS, WI, WY, SD) was the percentage change in manufacturing employment

greater than percentage change in high-tech manufacturing.

States such as New York, Illinois, West Virginia, and New Jersey, actually gained high-tech jobs in spite of an overall decline in manufacturing employment. Other states, such as Ohio, Pennsylvania, Delaware, Maryland and Washington, D.C., experienced the opposite trend of percentage declines in both high tech employment and total manufacturing. Nonetheless, in absolute terms, the top 13 states gained 47 percent of net new high-tech employment created in the mid 1970s. Though such growth is impressive, the top 13 did not gain a comparable share of national high-tech job growth based on their absolute share of overall high-tech employment. In the same sense, then, although the evidence is limited, there is some indication that in the future the South and West may indeed gain a disproportionate share of new high-tech jobs.

IV. High-Tech Industry Diversity and Sectoral Employment Concentration Within States

A. High-Technology Industry Diversity

The dramatic decline of basic industrial employment raises serious questions about the vulnerability of regional economies that are dependent on a few mature industries. This vulnerability is exacerbated by the large size of individual production units characteristic of many mature industries; for example, the closure of one steel plant translates into the loss of several thousand jobs. A closure of this magnitude ripples through an economy as the demand for goods and services supported by the income paid to employees, declines. In light of this experience, states and communities have initiated industrial development programs to diversify their industrial base. The rapid growth of many high-tech industries over the last several years makes them important candidates for such diversification efforts.

Contemporary high-tech centers conjure up images of industry clusters linked together as both inputs and outputs to form new industrial complexes. States with well known centers, such as Silicon Valley in California and Route 128 in Massachusetts, are important but rare. Indeed, few states are thought to have a diversified high-tech base (Fantas Corporation, 1983).

The actual distribution of high-tech industries across states is quite broad. Thirty-nine states have more than 50 of the 100 industries studied. States with relatively few high-tech industries were located outside the traditional manufacturing belt. These undiversified states topped the list for percentage gains in high-tech employment and were found to be mainly in the Southeast, Southwest, and Mountain states (Table 7).

The composition of high-tech employment varies across states and appears to be correlated with size of manufacturing base and employment level. For analytical purposes, in the remaining sections, states are grouped into three categories -- small, medium, and large -- based on their total manufacturing base.

The 13 largest states, those with more than 500,000 manufacturing jobs, had a very diverse high-tech base. At least 90 percent of the industries were found within their borders. The distribution ranged from all 100 industries in California to 88 in Connecticut. For the largest states, having a diversified high-tech base is primarily related to overall size. Large states with a diversified industrial structure and existing industrial agglomerations are likely candidates for continued industrial diversification including high-tech industries. In a limited sense, the most populated states still serve as seedbeds for innovative activities, even though their share of any one industry's employment may be declining.³

³ The possible seedbed effect is crudely verified in research by Harris which shows that large Northeastern metropolitan areas have a higher ratio of independent high-tech firms compared with

Table 7:
*High Tech Industry Diversity:
Number of Industries in Each State, 1977*

State	# Ind- ustries	State	# Ind- ustries
California			
Ohio	98	Kentucky	71
Texas	98	Louisiana	71
Pennsylvania	97	Arizona	70
New York	96	Rhode Island	69
Illinois	93	Utah	67
Florida	92	New Hampshire	66
Michigan	92	Mississippi	63
Indiana	91	Arizona	62
New Jersey	91	Nebraska	62
Massachusetts	90	West Virginia	62
Wisconsin	90	New Mexico	52
Tennessee	89	Maine	48
Connecticut	88	Nevada	44
Missouri	86	Delaware	40
Alabama	85	Vermont	38
Colorado	85	Idaho	35
Minnesota	85	South Dakota	32
North Carolina	83	North Dakota	29
Washington	83	Montana	27
Georgia	82	Hawaii	24
Virginia	82	Wyoming	21
Kansas	79	Washington, D.C.	16
Oregon	79	Arkansas	11
South Carolina	77		
Oklahoma	76		
Maryland	74		

Source: Glasmeier, Amy, "Spatial Differentiation of High Tech Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

Medium-sized states, with between 100,000 and 500,000 manufacturing jobs, exhibit two distinct trends. The first group has a high proportion of high-tech employment to total manufacturing and has a correspondingly high ranking on number of high tech industries present. The second group has relatively low levels of high-tech employment to total manufacturing and in general has fewer high tech industries. Coincidentally, the latter also tends to be composed of the largest states within the medium-sized group (Table 8).

The regional composition of medium-sized states also varied considerably. The first group was composed of Southeast, Southwest and Western states. Almost half the states in the other group were also located in the South. Southern states manufacturing industries appear to share the characteristic of being both high and low-tech.

B. Intra-State Sectoral Concentration

The widespread presence of high-tech industries in both large and medium-sized states, tends to support the proposition that the growth of high-tech industries may reduce a region's vulnerability to unexpected declines in any one sector. The in-state concentration of high-tech employment in a few key industries, however, points up an important countervailing trend (Table 9). In 31 states, five industries accounted for more than 50 percent of total high-tech employment. This sectoral concentration was most prevalent in the medium and smaller states, with the exception of Texas and Wisconsin.

The largest manufacturing states have a higher degree of industrial diversity and a correspondingly lower level of sectoral concentration. In medium-sized states, again two divergent trends occur. States with high percentages of high-tech employment to total manufacturing had high levels of sector concentration. Only Connecticut had less than 50 percent of its high-tech employment

Table 8:

*Profile of Medium Sizes States: Manufacturing Base,
High Tech Industrial Diversity, High Tech Employment Concentration
Percentage Change in Employment, 1972-1977*

State	Total Mfg. Emp. 1977	# of Ind. Present Diversity 1977	% of State Accounted for by High Tech Jobs Mfg. 1977	% Change in High Tech Emp. 1972-77
Arizona	110,000	70	.41	.26
Connecticut	413,000	88	.39	.02
Kansas	172,000	79	.37	.10
Colorado	152,800	85	.35	.19
Oklahoma	162,800	76	.33	.34
Virginia	400,000	82	.31	.09
Florida	380,000	92	.31	.12
Maryland	161,300	74	.30	-.08
Louisiana	194,200	71	.29	.11
Minnesota	338,000	85	.27	.21
West Virginia	118,900	62	.27	.01
Iowa	239,000	72	.23	.32
Missouri	435,000	86	.20	.05
Arkansas	194,300	62	.20	.48
South Carolina	375,000	77	.19	.28
New Hampshire	160,000	66	.18	.33
Kentucky	283,000	71	.17	.14
Washington	265,000	83	.17	-.03
Rhode Island	115,000	69	.16	.15
Alabama	340,000	85	.14	.10
Oregon	203,000	79	.12	.17
Mississippi	230,000	63	.11	.21
Georgia	488,000	82	.10	.22
Maine	103,000	48	.09	-.20

Source: Glasmeier, Amy, "Spatial Differentiation of High Technology Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

Table 9:

States with Greater Than 50% of Estimated High Tech Industry Employment, In 5 or Fewer Industries, 1977
(Descending Order Based on Total Manufacturing)

State	% High Tech Emp. in > 5 Industries	State	% High Tech Emp. in > 5 Industries	State	% High Tech Emp. in > 5 Industries
Texas	50	Kansas	64	Washington, D.C.	88
Wisconsin	52	Oklahoma	53	New Mexico	70
Virginia	50	Maryland	51	Montana	83
Florida	56	New Hampshire	57	Hawaii	76
South Carolina	59	Colorado	58	South Dakota	62
Minnesota	51	West Virginia	66	North Dakota	83
Washington	58	Arizona	74	Nevada	66
Iowa	63	Nebraska	55	Arkansas	94
Mississippi	54	Utah	61	Wyoming	93
Arkansas	62	Delaware	53		
Louisiana	65	Idaho	82		

Source: Glasmeier, Amy, "Spatial Differentiation of High Technology Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

concentrated in five industries. The other group of medium-size states showed much less sectoral concentration; only four of the 11 states had concentrations exceeding 50 percent. Small states show less diversity and have concentrated employment.

The unexpected finding that high-tech industries are widely disbursed but in-state employment is concentrated, points to the possibility that states may be trading off one form of economic dependence for another. A specialization in particular industries does not necessarily mean an area is dependent, however, unless perhaps the employment is concentrated in large production facilities.

Average Plant Size

The favorite image of a high-tech establishment is that it is run by an ingenious engineer who leaves a large company to strike out on his/her own (Deutermann, 1966; Koch, Cox, Steinhauser, and Whigham, 1983). This image, though attractive, does not fit with the data on actual size distribution of high-technology establishments. High-tech plants are considerably larger (92 employees) than the national average (54).⁴ For example, 25 of the 100 industries have an average plant size exceeding 200 employees; 40 averaged over 100. Three industries, in particular aircraft, missiles, and synthetic fibers, all have an average plant size exceeding 1000 employees. These three industries benefit from economies of scale; aerospace industries on the basis of low-volume, large-scale single unit products, while synthetic fibers is a high volume continuous processing industry (Table 10).

⁴ Armington, et. al. found that high-tech establishments consisted of non-local affiliates and were larger than the national average of all establishments.

Table 10:
*Industries With Estimated Average Plant
Size Greater Than 300 Employees, 1977*

Industry	Average # of Employees/Plant
3761 Guided Miss., Space Veh.	2348
3721 Aircraft	1265
2824 Syn. Organic Fibers, Ex Cellul	1122
3764 Guided Miss., Space Veh. Propul. Units	654
2823 Cellulosic Man-Made Fibers	649
3795 Tanks, Tank Components	505
3511 Steam, Gas, Hydraulic Turbines	493
3661 Telephone, Telegraph Apparatus	470
3724 Aircraft Engines, Parts	394
3519 Internal Combustion Engines, Nec.	383

Source: Glasmeier, Amy, "Spatial Differentiation of High Technology Industries: Implications for Planning," Dissertation, University of California, Berkeley, 1985.

The distribution of high-tech average plant size shows considerable variation across states. Of the largest states, 62 percent had an average plant size exceeding that of the nation. Examples include aircraft production in Pennsylvania, New York, California, and Texas, communications equipment and drugs in New Jersey, Pennsylvania, and New York, aircraft engines in Ohio, and Massachusetts, and radio and TV equipment in Illinois.

Medium-sized states again show two distinct patterns. Seventy-five percent of the states with a large high tech employment base had large plants. Four states had large aircraft and missile plants (GA, CN, FL, WA), three had large chemical complexes (LA, WV, VI), and Minnesota had several large computer production facilities.

The second sub-group of medium-sized states, those with a less-developed high-tech base, had smaller plants. Fewer than half of these states' average plant size exceeded the national average. In three of the remaining five, aerospace production facilities explained the large plants.

Without exception, small states had smaller than average sized plants. This can be attributed to the low level of high-tech industry found within them. It is also possible that the structure of the firms in these states differ from others. This may be explained by the fact that in high-tech industries, the importance of a technical labor force and the need for proximity to headquarters mitigates against large firms locating in a remote area. Entrepreneurs, on the other hand, have a greater propensity to locate in or near their home town. Consequently, high-tech industries found in the smaller states are more likely to be locally-owned ventures than branch units of a large corporation (Harris, 1983).

State and local policies designed to attract high-tech industries are premised on the belief that these industries will increase local economic diversity and therefore reduce future vulnerability to declines in more mature

industries. The widespread distribution of high-tech industries suggests that they are good candidates for strategies aimed at promoting economic diversification. But, the presence of a number of industries clustered around a few large employers, signifies that an area may be more vulnerable to changes in one sector's employment. Their vulnerability depends on factors influencing a product's life cycle, such as domestic and foreign competition, the maturation of individual products, and the introduction of automated processes in production facilities. For the most part, these factors are beyond the influence of an individual state or community.

High-Tech Centers

The success of a few states in establishing a high tech industry base has led many others to believe that they too can have a "slice of the high-tech pie". States with a mature industrial base see their future tied to the development of new high-tech industry clusters. The transformation of the Massachusetts economy from old to new industries is held up as an example of how this transition can be made. On the other hand, states in the sunbelt base their future on being able to attract production facilities that will eventually create concentrations of self-reinforcing innovative industries. Such optimistic assessments ignore the fact that very few states actually enjoy substantial concentrations of high-tech employment.

Fourteen states were identified as centers of technical innovation based on their location quotient score. One factor left unexplored is the type of production found in these states. The designation "innovation center" ignores whether production in these states is routine. Conceivably, any one of these states could simply be a production location, leaving the reader to conclude that it is really not an innovative center in the true sense of the word.

Using the 1977 Occupational Employment Statistics matrix for states and the nation, six two-digit industries were examined.⁵ Comparisons were made of the percentage of engineers in individual industries for both states and the nation. Data were not available for all states or for all 2-digit industries in each state. In each state comparison, only industries for which 2-digit data were available were examined. Conclusions are made on the basis of a sub-set of both states and industries. Particular emphasis is placed on the 14 states considered high-tech centers based on location quotient scores. Of these, 13 reported occupational data for one or more industries. Other states were also examined and the results are reported here. The reader should keep in mind that the results are partial due to data limitations.

Although data were available for 32 states, only 15 had one or more 2-digit industries in which the percentage of engineers exceeded the national average. Eleven of the 15 were states with location quotients greater than one. Indeed, only two high-tech centers failed to exceed the average for one or more industry, Oklahoma and Illinois. Oklahoma's poor performance may be due to measurement error, while Illinois no doubt faltered because of its diverse industrial base which includes both high and low tech industries. More disaggregated data are needed to confirm this.

Five other states had a high proportion of engineers in one or more industries studied, but were not considered centers of innovation because of their low score on the location quotient. This group included New York, New Mexico, Oregon, Utah, and Indiana. Of the five, all but New York had an LQ equal to 1.0, indicating that their relative shares of national manufacturing employment and high-tech employment were of equal proportions.

⁵ The two-digit industries include SIC 28, 34, 35, 36, 37, 38.

It is difficult to generalize these findings given the lack of data for all states and all industries within states. Still, the results indicate that states identified as centers of technical innovation have a substantial technical labor force found in conjunction with existing high tech agglomerations. The high levels of engineers in several industries in New York no doubt reflects the existence of corporate research and development activities. The four states with location quotients approaching unity may be up and coming centers of innovation. Analysis of more recent data might clarify this trend.

A strikingly consistent characteristic of these so-called "innovation centers" is their dependency on defense industries, a dependency dating back to the Korean War (Bolton, 1968).⁶ In research on the relationship between high-tech industries and military expenditures, Markusen (1984) reports of significant market relations between high tech industries and defense department procurement. Making this point vivid, ten of the 14 "innovation centers" had a least one, and five had two defense sectors, making up a large portion of their high-tech employment base.

Some states that have historically depended on defense spending, such as California, Texas, and Arizona, have successfully made the transition from being defense centers to areas dominated by producers of new commercial technologies (some would argue that their historical dependence has not changed much). Others, however, such as Connecticut, Kansas, Oklahoma, Colorado, and Florida, remain heavily dependent on defense contracting. For example, although Florida has well over 100,000 high-tech jobs, just two employers, the Harris Corporation and Martin Marietta, account for over 25 percent of the state's high-tech employment.⁷ An interview with corporate officials in the

⁶ Though beneficial in the current period, defense dependence can have negative consequences. One has only to look back in recent history to discover that many metropolitan areas within these states experienced substantial declines in employment at the end of the Viet Nam war.

⁷ The current increase in defense spending has begun to trickle down to communities in many

Harris Corporation revealed that defense related government contracting accounted for between 75 and 85 percent of their business. Furthermore, the Defense Department is underwriting much of the corporation's research and development spending through a cooperative program.

Locational Tendencies of High-Tech Industries at a Metropolitan Level

The state level analysis of the location of high-tech industries masks important differences that may exist within individual states. A companion study by Glasmeier, Hall and Markusen (1983c), on the spatial tendencies of high-tech industries at a metropolitan level, confirms many of our state-level observations.⁸ Specifically, few metropolitan areas within states have substantial concentrations of high-tech employment. Furthermore, high-tech employment in a large number of metropolitan areas is concentrated in a few industries. These results reinforce the findings that there are very few centers of innovation and their high-tech base is dominated by a handful of high-tech industries.

But a number of interesting differences between the state and metropolitan level highlight the complex nature of high-tech employment growth. Despite an overall increase in high-tech employment during the mid-1970s, many metropolitan areas did not share in this growth. Almost one-third of the 266 metropolitan areas studied actually lost high-tech jobs. Although the losers were found in all regions, Northeast and Midwestern metropolitan areas appeared to suffer the greatest losses. For example, two metropolitan areas in

areas of the country. Boosters of defense spending caution however, that such increases may crowd out commercial investment and research and fail to meet commercial goals of industry (Bruckner, 1984).

Portions of this project were completed under contract for the Office of Technology Assessment, contract no. 333-670.0. The development of the data base and the majority of the descriptive analysis was done under contract with the National Science Foundation, contract no. SES 82-08104.

New York state, Syracuse and New York City, together lost an estimated 14,000 jobs.

On the other hand, metropolitan areas experiencing the greatest employment increases reflect those that are popularly considered high-tech centers such as Boston, Massachusetts, San Jose, California, Dallas, Texas, and Phoenix, Arizona. Nevertheless, these states also had their share of metropolitan high-tech employment losers. For example, one-quarter of the metropolitan areas in California, an eighth of those in Texas, and half of those in Massachusetts, lost high-tech employment during the mid-1970s. Only Arizona, with just two metropolitan areas, showed consistent gains over the period. It is important to remember then that even within so called "winning states" the growth of high-tech employment is unevenly distributed across metropolitan areas.

From the preceding state level analysis we saw that states appear to specialize in selected high-tech industries. At such an aggregate level, however, this specialization is open to a variety of interpretations. At a metropolitan level, however, industrial specialization has important implications for long-run economic stability. As Glasmeier, Hall and Markusen (1984) point out, in more than half of the metropolitan areas studied, high-tech employment was concentrated in five or fewer industries. In fact, in 75 metropolitan areas, just one industry accounted for an estimated 70 percent of total high-tech employment.

This evidence suggests that a number of the relationships found to occur across states are replicated at a metropolitan level. Many metropolitan areas host one or a few large employers and a small number of other high-tech industries. In Melbourne, Florida, for example, one large employer has dominated the local economy since the early 1960s. Although the firm employs almost 4000 engineers, the classified or defense-related nature of its products has actually inhibited the development of industrial spinoffs. This suggests that the

growth potential of high-tech industrial complexes is significantly influenced by individual products and markets. Thus, gaining a slice of high-tech employment does not guarantee that a Silicon Valley or a Route 128 will eventually be created.

Conclusions

The distribution of high-tech industries and employment provides a rather surprising picture of spatial diversity: plants are widely dispersed but employment is concentrated; industries are widely represented, but the majority of employment is really concentrated in only a few sectors; and sectoral concentration at a state level can be explained primarily by large production establishments.

The regional distribution of high-tech employment also shows great diversity. Northeast, Middle Atlantic and Great Lake states are well represented in terms of absolute number of jobs. Although these states perform less well on the basis of other measures, still, several have a highly innovative manufacturing base. Significantly, only a few states within *each region* have been substantial beneficiaries of high-tech employment growth. While a marginal change in the distribution of high-tech employment is occurring in other states, this shift is relatively small in comparison to the total, and the type of jobs being created appear to be non-technical and perhaps routine in nature.

The concentration of high-tech employment in 14 states identified as technical innovation centers did not develop overnight. Researchers in the late 1950s (Perloff, Dunn, Muth, 1960) saw the foundations forming for the development of new industrial complexes. For example, the authors proposed that the rapid growth of the aerospace industry in California (and missile production in particular), and its heavy use of electrical machinery, would result in the a

development of a sophisticated electronics industry in Los Angeles. By this and other accounts, government programs such as NASA and military weapons systems are key in explaining the historical origins of many of these complexes.

The competition between the Frostbelt and Sunbelt ignores the strength of the manufacturing belt in absolute numbers of high tech jobs. Shifts that are occurring may eventually help equalize the distribution of manufacturing jobs nationally. New England, California and Texas still maintain a considerable lead in the distribution of technical employment within these industries. Only a redistribution of research and development functions will alter this pattern.

The link between technical innovation and high-tech industries is poorly understood. Gaining high-tech jobs does not automatically translate into the development of a technical manufacturing base. Key ingredients such as research and development activities, administrative functions attached to corporate headquarters, and advanced producer services are still concentrated in the Northeastern and Midwestern states (Stanback and Noyelle, 1984). The link between high-tech industries and defense expenditures is also poorly understood. Several sectors such as computers, semiconductors, and scientific instruments rapidly evolved into commercial industries. Others such as aircraft and ordnance remain almost total military-oriented. This dichotomy translates into different development paths for states and communities. Further examination of inter-industry linkages among different high-tech sectors is needed in order to understand the long term consequences of regional growth based on high-tech industries.

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