High-Tech Activity and Urban Economic Development in the United States: Implications for Shanghai

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Introduction[1]

Since the early 1980s, researchers have been struck by the dynamism of new industries, dubbed "high-tech," and their apparent roles in driving differential regional growth rates.[2] Older American industrial and financial cities like New York and Chicago, growing slowly and subject to considerable deindustrialization, no longer seem capable of performing as "seedbeds of innovation" (Markusen and McCurdy, 1989) while places like Silicon Valley and Route 128 outside Boston have become famous as prototype new industrial regions (Saxenian, 1994). Although some of the purported drivers of high-tech location, including University research and development activity, are not borne out by clear evidence (Markusen, Hall and Glasmeier, 1986), economic development policies at the state and local level have become preoccupied with fashioning strategies that would attract, retain and "home-grown" high-tech industries and firms.

How can we determine how "high tech" a city is? Our view is that technology intensity is best captured by looking at the scientific and technical composition of the workforce in an industry (Markusen, Hall and Glasmeier, 1986; Chapple, Markusen, Schrock, Yamamoto and Yu, 2004). Our choice of science-and-technology occupations (S&T), a human capital-based measure, reflects a growing interest in skilled labor, rather than resources or physical capital, as a driver of economic development (Markusen, 2004, Markusen and Schrock, 2006; Mather, 1999).

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[1] The first portion of this chapter is based heavily on Chapple, Karen, Ann Markusen, Gregory Schrock, Dai Yamamoto, and Pingkang Yu. 2004. "Gauging Metropolitan "High Tech" and "I-Tech" Activity." *Economic Development Quarterly* 18 (1): 10-29.

Using Occupations to Identify High Tech Industries

In a recent study (Chapple, Markusen, Schrock, Yamamoto and Yu, 2004), we refined the widely-used science and engineering measure to include managers with scientific and engineering backgrounds and certain groups of computer professionals, a group we call science and technology (S&T) occupations. We then ranked all manufacturing and service industries at the three-digit SIC level by the shares of their national workforce engaged in the S&T occupations. We explicitly incorporated services because we reject the notion that manufacturing is a more important driver of employment growth than services.

Conforming to popular conceptions, computer services and electronics are identified as high-tech by this method, but so are a number of sectors not included in many other high-tech definitions: missiles and space vehicles, aircraft, pharmaceuticals, engineering and architectural services, medical instruments, management and public relations, and research, testing and evaluation services. Some of these are among the fastest growing of all high-tech industries. For instance, jobs in drugs; engineering and architectural services; research, testing and evaluation services; and management and public relations all grew faster nationally in the 1990s than did electronics employment and many of the other more popularly perceived high-tech industries.

High Tech Metropolis

With these definitions, we then ranked as “high tech” the thirty US metropolitan areas that added the greatest number of net new jobs across all sectors in the period of

1991 to 1999. In our rankings, the Chicago and Washington DC metropolitan areas host the largest numbers of employees in high-tech industries as of 1997 (Table 4.1). Both are home to high-tech industry establishments with more than 300,000 jobs, outdoing Silicon Valley, which earns third place, with Boston fourth.

The findings refute the belief that the American sunbelt is the clear winner in high-tech. In addition to Chicago and the four other east coast cities in the top ten, Detroit also makes the top twenty, with more high-tech industry jobs than Phoenix, San Diego, Denver, Portland and Austin. Nor are high-tech jobs concentrated on "the coasts." The mid-continental cities of Detroit, Chicago, Minneapolis/St. Paul, Austin, Phoenix and Denver make the top twenty.

The more mature industrial cities do well in the study because they are not penalized for being diversified. Some studies of high-tech regions (e.g. DeVol, 1999) rely on the percent of the regional workforce in high-tech industries. With such a measure, relatively young cities that missed the industrial revolution, like Phoenix or Austin, will appear very high-tech because they lack more mature manufacturing functions in their economies and thus in the denominator of total employment. The evidence strongly suggests that cities like Chicago, Boston, New York and Philadelphia are exhibiting an ability to supplement their more mature manufacturing and financial sectors with dynamic new activities and adding more net new high-tech jobs than many of the more popularly presumed emerging high-tech centers.

These findings bear lessons for Shanghai, China's premier industrial city and similar in this regard to American cities like New York, Boston and Chicago. Shanghai is similarly going through a process of restructuring, in which manufacturers, especially

in textiles, are moving to lower cost locations while the service sector is expanding. We believe that an occupational approach to identifying Chinese high tech sectors, both manufacturing and service, would yield a list of sectors in which Shanghai possesses a strong competitive advantage. It is important, too, to see that a number of service sectors are exporting their activities and are essential to the viability of China's manufacturing activities.

Metropolitan Diversification and Resiliency

We discovered a relatively broad range of differences in degree of specialization and diversification among the cities we studied in the US. Washington DC, Seattle, Austin and New York are among the most specialized of the high-tech metros, while Boston, Chicago, Minneapolis/St. Paul and San Diego are among the most diversified (Table 4.1). Diversification is not related to regions of the country, the relative "age" of metro or absolute size.

Of the top ten high-tech cities, four are highly specialized. Washington DC's high-tech jobs are heavily concentrated in computer services; research, development and testing services, engineering and architectural services and management/public relations; New York specializes in financial services, insurance, research and engineering services and management/public relations; and both Silicon Valley and Seattle specialize in high-tech manufacturing. Detroit's well-known specialization in transportation equipment is apparent, not because autos are high-tech (they don't qualify despite their automotive engineers) but because Detroit has large numbers of people working with engines and turbines, computer services, engineering and architectural services, and management and

public relations, many of them auto-related. China's major cities, too, are likely specialized in similar fashion.

Some metros possess economies rich in high-tech manufacturing and poor in high-tech services. Silicon Valley, Seattle and Austin top this list, with high-tech manufacturing to high-tech service ratios 2.5 times the national average or higher. Interestingly, western and southern US metros dominate the list of manufacturing-specialized high-tech areas. Yet other metros from these regions are high-tech manufacturing poor – Houston, Atlanta, San Antonio and Las Vegas. With the exception of the Twin Cities, the northeast-midwestern metros fall at or below the national mix of high-tech manufacturing to services, revealing their strong high-tech service base.

The nature of high-tech activity across metro areas differentially positions them for the future. Recessions place great stress on both incipient, youthful industries and mature ones ripe for restructuring. Those metro areas which are more high-tech diversified may find themselves better positioned to weather a downturn than those that are highly specialized. Among the latter, employment trends will be highly sensitive to the performance of lead industries. Seattle's overall performance, for instance, is heavily tied to the aerospace industry, New York's is tied to finance, marketing and management, and Silicon Valley's to electronics and computing. In the US recession in 2001, each of these cities were more vulnerable to unemployment and displacement than the more diversified metropolitan economies such as Chicago, Boston, and Minneapolis/St. Paul.

Implications for Shanghai and Chinese Cities

The American experience with high tech development offers important lessons for Chinese cities such as Shanghai. Shanghai, as the unquestioned industrial and financial capital of China, is posed to play significant roles in the remaking of the national economy. But it also faces challenges of its own as a relatively mature city, as mature manufacturing sectors move to lower cost locations. Shanghai has options. It could suffer the slow growth fate of other older industrial cities around the world (Rio, for instance) or become a highly specialized finance and service center and thus vulnerable to cyclical swings and structural changes like the city of New York. Or it could attempt to remake itself as a high tech region in its own right.

If Shanghai leaders find this third option attractive, the American experience is instructive. We caution against too narrowly defining high tech and argue for a human capital and skills-based criterion to identify high tech activity. Equating high tech with electronics and computing narrows the field in damaging ways, since other fields, from aircraft to biotechnology to business services may be comprised of high skilled activities and have promising growth futures.

We reflect on three sets of implications from our high tech redefinition study for Chinese economic development policy makers in what follows. Given the increasing importance of human capital as a driver of economic development, an occupation-oriented development policy should be formulated to supplement traditional industrial targeting practices. Second, more attention should be paid to promoting high tech services rather than solely manufacturing. Third, greater efforts should be made to promote diversification of Shanghai's high tech industries and further the whole urban economy.

Targeting Occupations as well as Industries

For the past three decades, economic development planners have been identifying and targeting selected industries in communities based on their export potential. This practice rests on the view that some industries offer greater wealth-creating prospects than others due to existing or potentially higher productivity and lower cost advantages the local economy offers in these industries over other locations. Since the 1980s, the meteoric success of electronics and computing has encouraged localities to compete for firms and plants in these sectors. The spectacle of Silicon Valley has captured the imaginations of many policymakers around the globe and thousands of visitors have flocked to the Valley to try to discern its secrets and replicate them in their own cities. In fact, few places will ever be able to match the "first mover" advantages of Silicon Valley or benefit from the enormous and continued government military spending that has underwritten much of the Valley's research and purchased many of its leading edge products (Gray, Golob, Markusen and Park, 1999).

However, technology content is not confined to electronics and computing. Many other sectors demand and innovate on high tech talent: pharmaceuticals, biotechnology, aerospace, telecommunications, architecture and engineering, and computer software, to name a few. We use an occupational definition to identify high tech sectors because it is our view that human skill is the most important asset of an urban economy, not the particular set of firms or plants that currently characterize the region. Technology-laden workers are increasingly mobile between firms, and it is their presence in the city and

their commitment to it, rather than to particular firms, that gives large high tech cities their edge (Markusen, 1996).

We are now taking this emphasis further by exploring an alternative to focusing on firms and industries in economic development practice: envisioning metropolitan regions as ensembles of occupations rather than of industries (Markusen and Barbour, 2003). In the parallel studies of economic development (Markusen, 2000, Markusen and Schrock 2001), we have laid out a series of rationales for using occupations as a lens to view the specialization and potential of a regional economy. A brief recapitulation will suffice here.[3]

In this conceptualization, a metropolitan economy is comprised predominantly of people in their roles as decision-makers and workers. They are starting up (and closing down) firms, buying and using resources, building plants and equipment, hiring others and configuring work to generate marketable goods and services. In this conception, we visualize and characterize economies by "what workers do, not what they make" (Thompson and Thompson, 1985).

As analysts, we can draw mental maps of regional economies based primarily on occupation rather than on industry. Each occupation is distinguished by its skill, educational content and work tasks. Individual workers are key decision-makers in an occupational framework, because they decide whether to acquire skills and how to deploy them, given their options in labor markets (another conceptualization). But other decision-makers are also important – those who supply skills and training, including schools and colleges and private sector firms.

[3] For a fuller treatment, see Markusen and Barbour, 2003.

With the occupational lens, we picture Silicon Valley would emerge as a region of technology managers, venture capitalists, aeronautical and electrical engineers, inspectors and testers, and commercial artists. The occupational frame helps us to see the relatively unique pools of talent possessed by a region. Not all such regional occupational specializations can neatly mapped onto a single or set of industries. Some are dispersed across a broad number of industries, and this dispersion appears to be modestly increasing (Markusen and Schrock, 2006).

Approaching economic development as an occupational rather than an industrial phenomenon offers alternatives paths for economic developers. For instance, when an industry is in structural decline because it is just simply cheaper to produce elsewhere or because substitutes are destroying its market, working with occupational groups offers an alternative to simply trying to prevent plant closings.

Given their evolved industry orientation, economic development practitioners in the past few decades have worked extensively with firms, industries and business associations, seeing them as their customers. In contrast, a practice re-oriented around occupations would seek occupational and occupation-shaping partners. Prominent among these would be membership associations based on occupational lines, from trade and craft unions (electricians, machinists, writers, musicians, operating engineers, nurses, actors, janitors) to professional associations (mechanical engineers, economists, doctors, accountants). Strong ties would also be forged with institutions and organizations that recruit, educate, train, and retrain workers.

The occupational frame gives priority to labor rather than physical capital as the key to regional development. An occupation-oriented economic development strategy

would make significant investments in human capital not just through the general educational system but also through a specialized workforce training system that matches skill development of workers with employers' needs. As one of China's higher education centers, Shanghai has a good general educational system that fosters one the nation's most educated workforce. Its leaders should consider establishing a specialized workforce training system to prepare workers with special skills demanded by employers (Schrock, Hudson, Yu, LaFloe and Dorr, 2002). The training system should consist of partnerships around industries or occupations that bring together government, non-profits, labor and businesses to identify the common needs of business and workers and to leverage the training done privately and academically through the use of targeted governmental and non-profit programs.

Promoting High Tech Services Rather Than Manufacturing

Worldwide, employment in services has been growing faster than in manufacturing. This is in large part a function of tremendous gains in manufacturing productivity compared with relatively poor gains in services. Some business services are growing precisely because they enable manufacturers to work more efficiently. In countries where the planned economy was once in control, economic development planners often ignore services at their peril.

American high tech employment has grown disproportionately in the service sector (Table 4.2). Science and technology occupational concentrations correspondingly rose much more rapidly in services than in manufacturing sectors.

Those metropolitan areas in the US that excelled in adding high tech jobs are relatively specialized in high tech services rather than manufacturing. Eight out of the top ten high tech job-adding metros possess more jobs in high tech services than in high tech manufacturing (Table 4.1). Silicon Valley and Seattle, with their large manufacturing sectors are the exceptions. Silicon Valley, too, relies heavily on adjacent San Francisco for services.

The US job generation record of high tech services compared with manufacturing suggests that Chinese economic development planners should include services when addressing high tech strategy. To date, Chinese initiatives in high tech urban development, such as establishing high tech industrial parks, narrowly focus on a small pool of high tech manufacturing sectors. Given its pride of place in the Yangtze Delta economic region, Shanghai could enhance its high tech service role vis-à-vis its hinterland. Outer smaller industrial cities such as Suzhou, Wuxi, Changzhou and Nantong heavily rely on Shanghai for services, and a strong high tech service sector in Shanghai would help to propel these cities toward innovative adaption. In recent years, large foreign investments in electronics and computer equipment plants have favored lower cost locations in the near cities and exurbs of Shanghai, a development which underscores Shanghai's potential as a service center. The service share of Shanghai's overall employment rose from 21.6 percent in 1978 to 44.9 percent in 2000 (Yin et al, 2002,) but it remains far lower than other major global cities.

High tech services are closely aligned with producer services. All the high tech service sectors identified in our high tech redefinition study are producer service sectors.[4]

[4] They are Computer programming and data processing services (SIC 737), Engineering, architectural and surveying services (SIC 871), Research, development, and testing services (SIC 873), Management and

Over the past three decades, producer services have experienced rapid growth caused by increasingly complex and specialized systems of production. One of the key functions of producer services is to introduce external expertise into manufacturing activity (Beyers and Lindahl 1996a). In addition, a recent study of high tech producer services reveals its role in fostering innovation due to the embedded entrepreneurship and technical expertise of skilled workers in high tech service firms (Schrock, 2003). For Shanghai and other Chinese cities emancipated from the planned economy, high tech producer service sectors could fuel the nation's growth dynamic by introducing advanced technology to many industries and generating entrepreneurial opportunities. Shanghai is uniquely positioned to benefit from this type of activity.

The challenges facing high tech service sectors in China are a function of the country's remaining socialist economic institutional practices, which are slowly disintegrating with marketizing reforms. State-owned and operated production units are subject to centralized coordination, the economic plan and an exclusive element - the state work unit. The central economic plan discourages competition within the system, thus restraining the incentives for specialization. The state work unit reduces the demand for external expertise by internalizing all the possible professional and information services. The producer service sectors remain under-developed in this system and have only recently begun emerging with reform efforts.

Another barrier for high tech producer services is deficient legal protection of intellectual property. People and firms in knowledge intensive sectors are the frequent creators, users and distributors of intellectual products. The protection of the value of

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public relations services (SIC 874) and Other business services (SIC 899.) Here the definition of services refers to the sectors falling into the services category in the SIC classification, thus it does not include

these products is the prerequisite for their business. Although a series of laws and administrative regulations for intellectual property have been enacted in China since 1985, enforcement of the law is inadequate. China's accession to the World Trade Organization creates pressure on the Chinese government to improve intellectual property protection, which it must do to satisfy the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). China's ability to advance beyond a low wage manufacturing stage will depend upon its ability to foster a producer services sector.

Promoting Economic Diversification

The findings of our study suggest that high tech cities are not penalized but rewarded for being diversified. Highly diversified cities like Chicago top the high tech job-adding list, outdoing the high tech service cities like New York or the high tech manufacturing cities like Silicon Valley. In addition, our findings suggest a city's high tech job adding capacity has little association with its degree of technology dependency. The high-tech star, Silicon Valley, is not exhibiting stronger capability in adding high-tech jobs than the mature industrial cities like Chicago and New York, although its overall specialization rate in high tech is triple the national average. Chicago and New York, in contrast, are not high-tech specialized at all (see Table 4.3).

Shanghai in our view is more like Chicago than New York or Silicon Valley. A second tier city located within the San Francisco's metro economy, Silicon Valley is specialized in an array of high tech manufacturing sectors including electronics, computing and aerospace and hosts significant branch plants of large national and foreign firms (Gray, Golob, Park and Markusen, 1999). It is much like Suzhou in terms of

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communication, finance and insurance.

location, scale and industries, especially since Singapore built its only industrial park in China there. New York is strong in financial and management services, but its mature manufacturing sectors have largely exited itself (Tables 4.3).

Shanghai could avoid the fate of New York in the coming decades by modeling itself more on Chicago. Chicago has a diversified economic base, with strength in services and an ability to upgrade and retain its manufacturing as well. Shanghai is the premiere industrial as well as service center in China, much like Chicago is in the U.S. Its size and diversity positions it well to attract and retain a broad mix of high tech activities. The mix should include high tech services sectors such as data processing, engineering service and management consulting that would help introduce foreign technologies into Chinese manufacturing. Such a mix would enable Shanghai to protect itself against potential cyclical downturns, structural decline in particular sectors and disappointing results in innovative sectors (such as the recent telecommunications bust in the U.S.). Diversification will also strengthen the evolutionary import-replacing trajectory common to large fast-growing cities.

Diversification has yielded substantial benefits for other regions. Taiwan, for instance, once relied on labor-intensive manufacturing. But after successfully incorporating much of Japanese and American technologies into electronics and semiconductor lines, Taiwan has become one of the world's major producers of computer equipment and electronics. This is attributable at least in part to the Taiwan government's efforts in promoting economic diversity from the 1960s onward.

Diversification strategies require a careful assessment of the city's comparative advantages. Unique strengths could be built on to create Shanghai specializations

internationally. The Dutch cut flower industry, for example, employs a unique set of house growing techniques and creates high level of wealth for Dutch workers and farmers. Israel's agriculture is another example. The early Japanese success with small, fuel-efficient cars in the international market is another example of how scarcity of resources (air quality, petroleum) drove innovation unique to that country. Shanghai planners should take stock of the human capital and know-how of the region to determine opportunities for new, successful products and services.

To diversify its economy, Shanghai and Chinese economic planners should seek to eliminate barriers to local competition. Vigorous competition among locally based rivals creates persistent competitive advantage in an industry (Porter, 1990). Japan sets the best example the world over, where in every leading product area, such as automobile and semiconductors, it hosts more than ten firms competing for the small domestic market. Domestic champions then are able to assert world leadership. For contemporary local industries to survive the influx of foreign rivals, firms must be able to strengthen themselves through local competition, which was discouraged in the planned economy. However, pro-competitive policies should not be applied abruptly, as in the former Soviet Union, but should be phased in over time and accompanied with tax, land use, technical assistance and workforce training that will enable managers to learn how to compete in a very different market and ensure a superior distribution of wealth and assets as well as preventing corruption from emerging.

Diversification and long-term prosperity will be easier to achieve with further market-oriented economic reforms. The Chinese economy is much more diversified now than it was at the beginning of the reform. But the government still bars the entry of

domestic private firms into many sectors such as telecommunication, airlines, petroleum chemistry, steel and iron, news and others. It also tightly regulates private firms operating another dozen sectors including automobile manufacturing, electronic appliance and travel agencies. In addition, China has a very stiff governmental approval system for founding firms, with arbitrary and often very high registration capital requirements that deter many entrepreneurial endeavors. Technology alone cannot ensure the latecomer prosperity, as demonstrated by the failure of the westernization movement in China one and a half centuries ago and the failure of Soviet Union's planned economy (Yang, 2002.)

Taiwan's developmental path is a good model for China. China's sectoral distribution in 1993 was similar to Taiwan's in 1965 (Jian, 1996). In the 1950s, Taiwan had a heavy proportion of state investments in most industries. In the 1960s, the government began its market liberalization process by enacting the Regulations for the Encouragement of Investment (REI). As a result, the proportion of the output of state-run enterprises over the total industrial production value declined from 57 percent in 1952 to 21 percent in 1980 and further to 18 percent in 1990. This process occurred in a relatively slow and digestible way for Taiwanese enterprises and workers.

Conclusion

We have compared Shanghai's prospects with lessons drawn from American high tech experience over forty years. While Shanghai is unique and faces a more competitive and integrated world economy than most nations have in the past, its future trajectory is

very much shapeable by the kinds of economic development and related policies that the government of the city and the nation undertake over the coming decades. We have called for an occupationally oriented economic development strategy, an emphasis on high tech services and an effort to diversify the portfolio of industries and activities present in the Shanghai economy. We believe that Shanghai is admirably positioned to play major regional, national and international roles in the economy and that it has the potential to leaven its daily bread with high tech activities that will generate growth and stability far into the future.

To achieve these goals, we recommend a portfolio of policies that include the following. To facilitate more high tech service activity, Shanghai should introduce land use planning changes that will overcome scarcity of buildings and space. It should also extend business assistance to service sector firms, foreign as well as domestic, and entrepreneurs rather than confining it to manufacturing. The city should use tax and other incentives to attract foreign firms to Shanghai with particular attention to how they fit into the new diversified portfolio. It should create venture capital funds and incubator facilities to nurture new start-ups and small, promising high tech businesses. The business and labor market information infrastructure should be improved.

These economic development, fiscal and land use initiatives can be supplemented with changes in regulatory and educational systems. High tech manufacturing and services would benefit from the creation of streamlined pro-innovation regulatory standards, the elimination of discrimination against domestic private investments, and sponsorship of independent testing product certification and rating services. Finally and not the least important, Shanghai should adopt a human capital strategy that targets key

occupations and build a workforce training system that matches skill development of workers to employers' needs and to the longer term flexibility and evolutionary needs of the economy.

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Table 4.1

Highest Job-Adding Metros Ranked by Total High Tech Jobs, 1997; Absolute Job Growth, 1991-99, High Tech Job Share, 1997, and High Tech Specialization, 1997

MSA/PMSA	High Tech Industry Jobs, 1997 (000)	Total Job Growth, 1991-99 (000)		High Tech Job Share, 1997 (%)		High-Tech Specialization, 1997	
		Job Growth	Rank	Job Share	Rank	Specialization Index	Rank
Chicago	347.1	528.0	2	12.4	16	1.25	25
Washington, DC	321.6	337.3	6	20.3	4	2.19	2
San Jose	289.1	163.0	29	41.3	1	1.56	14
Boston	281.5	262.6	14	20.9	3	1.3	23
New York	250.3	277.6	13	10.1	21	1.85	5
Philadelphia	222.5	216.0	18	13.1	13	1.26	24
Dallas	197.9	484.5	4	16.4	9	1.54	15
Seattle	174.9	257.8	15	21.1	2	2.23	1
Minneapolis-St. Paul	162.6	318.5	7	15.3	11	1.22	26
Houston	162.5	392.9	5	12.2	17	1.49	17
Orange County	152.4	201.5	20	18.4	6	1.2	27
Atlanta	151.1	642.4	1	10.2	20	1.64	8
Detroit	138.8	295.7	9	8.8	25	1.67	7
Phoenix	116.0	515.5	3	13.0	15	1.46	19
San Diego	112.7	187.6	24	16.4	8	1.19	28
Denver	94.5	286.3	11	14.5	12	1.61	12
Portland, OR	77.7	218.8	17	13.0	14	1.37	22
Austin	75.7	230.5	16	19.7	5	1.98	3
Tampa-St. Petersburg	73.2	299.0	8	8.8	24	1.4	21
Raleigh-Durham	69.0	195.4	23	16.8	7	1.44	20
Kansas City	61.8	183.4	25	9.4	22	1.5	16
Charlotte	61.3	200.0	21	10.3	19	1.56	13
Salt Lake City	60.6	196.7	22	16.2	10	1.18	29
Fort Worth	54.6	171.1	26	10.9	18	1.68	6
Columbus, OH	53.7	157.6	30	9.1	23	1.48	18
Orlando	43.6	280.4	12	7.6	26	1.61	11
Riverside-San Bernardino	32.7	214.8	19	6.1	27	1.16	30
San Antonio	28.1	170.4	27	6.1	28	1.64	9
Nashville	27.4	164.7	28	5.7	29	1.64	10
Las Vegas	23.1	292.1	10	4.9	30	1.85	4

Source: 1997 Economic Census and Bureau of Labor Statistics, Current Employment Series. Higher specialization index scores reflect a greater concentration of high-tech employment in certain industries; lower scores indicate broader distribution among high-tech industries. The coefficient of variation measures the spread of a set of data as a proportion of its mean. It provides a measure of relative variation and is scale-free, so it is particularly useful in making comparisons between different cities. For each metro area, its specialization index (coefficient of variation) is calculated as the ratio of the standard deviation of all high tech sectors' employment divided by the mean.

Table 4.2

Science and Technology (S&T) Occupational Employment in Services and Manufacturing, United States, 1989 and 1998

	Share of Total S&T 1989	Share of Total S&T 1998	S&T Employment Growth 89-98 (%)	Employment Growth 89-98 (%)
Manufacturing	36.6	25.5	-4.1	-3.2
HT Manufacturing	26.1	17.0	-10.5	-10.1
Services	28.0	41.0	100.5	32.2
HT Services	22.9	35.1	110.5	51.6

Source: Bureau of Labor Statistics, National Industry-Occupation Time Series Matrix, 1989, 1998.

Table 4.3

HT Industries by Location Quotient: Chicago, New York and San Jose in Comparison

SIC	Description	Chicago, IL PMSA	New York, NY PMSA	San Jose, CA PMSA
1310	Crude Petroleum And Natural Gas	0.00	0.00	0.00
1480	Nonmetallic Minerals Services, Except Fuels	0.00	0.00	0.00
2110	Cigarettes	0.00	0.00	0.00
2810	Industrial Inorganic Chemicals	0.69	0.05	0.00
2820	Plastics Materials And Synthetic Resins, Synthetic	0.89	0.02	0.00
2830	Drugs	2.32	1.08	0.84
2860	Industrial Organic Chemicals	0.51	0.26	0.00
3480	Ordnance And Accessories, Except Vehicles And	0.00	0.05	0.00
3510	Engines And Turbines	0.50	0.00	0.32
3550	Special Industry Machinery, Except Metalworking	0.97	0.00	2.68
3570	Computer And Office Equipment	0.42	0.14	14.31
3660	Communications Equipment	2.14	0.15	13.20
3670	Electronic Components And Accessories	0.90	0.11	11.52
3720	Aircraft And Parts	0.07	0.12	0.00
3760	Guided Missiles And Space Vehicles And Parts	0.00	0.00	22.87
3810	Search, Detection, Navigation, Guidance,	0.50	0.04	1.99
3820	Laboratory Apparatus And Analytical, Optical,	0.99	0.14	7.24
3840	Surgical, Medical, And Dental Instruments And	1.01	0.19	4.00
3860	Photographic Equipment And Supplies	0.43	0.10	0.00
4820	Telegraph And Other Message Communications	0.00	0.00	0.00
4890	Communications Services, Not Elsewhere	0.10	0.48	0.00
4930	Combination Electric And Gas, And Other Utility	1.03	1.57	0.00
6010	Central Reserve Depository Institutions	0.94	3.13	0.10
6310	Life Insurances	1.06	2.18	0.11
6710	Holding Offices	0.00	0.00	0.00
7370	Computer Programming, Data Processing, And	1.18	0.93	3.56
8710	Engineering, Architectural, And Surveying	0.84	0.73	1.72
8730	Research, Development, And Testing Services	1.39	1.17	3.17
8740	Management And Public Relations Services	1.69	1.85	0.86
8990	Other Business Services	0.50	1.08	0.76
	Total HT Sector Employment	0.92	0.75	3.07

Source: 1997 Economic Census