THE NYC SOFTWARE/IT INDUSTRY

SECOND HALF
PP. 47 TO END

VIII. EDUCATING AND RECRUITING SOFTWARE WRITERS

This section looks at the demand for and supply of software specialists in NYC compared with competitive regions. The overall U.S. and worldwide demand for software-related specialists is determined by technological innovation. Demand is met in any region in two ways, by (1) developing and maintaining a pool of trained workers in the area, and (2) supplementing this pool with a net import of trained workers from other parts of the United States and from abroad. The degree to which NYC is considered a good place to find software specialists is at least partly controlled by the NY State and NYC governments, which have fiscal and regulatory powers to influence the priorities of schools and universities. The other way for NYC to obtain specialists is to recruit them from other areas (U.S. and foreign) where they are trained; it is important for NYC and other software-development centers that U.S. immigration policies are responsive to the need for trained software personnel.

A. Demand for Software Employees

With the growth of he Internet, software experts are in short supply nationally. This shortage can be measured in NYC by the growth in on-line help-wanted ads, in salaries for software personnel, and by projections of software jobs in NYC compared with other cities.

1. Demand Measured by Help-Wanted Ads

It is natural for software specialists to look on the Internet for job vacancies. A major New media web site for such vacancies in NYC is "@NY." For the year 1998, the site tabulated the posted listings and has found that the largest single job title is "software programmers," accounting for 36 percent of all jobs in 1998, even though it is not specifically for software personnel. Listings for this job category grew 51 percent between the first and second halves of 1998. Although the survey is not strictly scientific, the data are one indication of significant growth in demand for Silicon Alley personnel in 1998. (See Table 8-1.)

Table 8-1. *Ranked Growth of Software-Related Job Listings on the @NY Web Site, by Title, 1998*

Rank		Percent of Total Jobs	Jan.-June 1998	July-Dec. 1998	Growth, Percent
1	Office Staff	5 %	69	127	84.1 %
2	Programmers	36 %	552	836	51.4 %
3	Marketing	19 %	284	418	47.1 %
4	Executive	8 %	116	170	46.5 %
5	Editorial	5 %	84	122	45.2 %
6	Interns	4 %	55	79	43.6 %
7	Design	23 %	363	491	35.2 %
	Total	**100%**	**1,523**	**2,243**	**47.3%**

Source: @NY, "Silicon Alley Jobs Report," January 8, 1999. The lists are only of companies that use the SiliconAlleyJobs.com service on a regular basis. The 1,583 blind postings (from headhunters) or group listings were excluded; only the 3,887 classified postings from identified employers are included. A total of 121 unclassified job listings are not included (difference between 3,887 jobs counted and 3,766 jobs shown).

The rapid growth of office staff in 1998 may reflect the maturation of the Internet industry, as companies use new venture-capital money to improve their clerical and secretarial support.

2. Projected Demand is Strong for NYC and Region

As benchmarks for estimating demand, the growth of NYC software-related jobs is reviewed and the growth of such jobs in NYC is compared with the growth of other software-development centers. Narrowly defined as the five boroughs, NYC is one of the top five locations of software developers. Based on comparative job growth projections for NYC and NY State by companies in the software industry, NYC will be the third fastest-growing area, after Los Angeles and Seattle, but ahead of Silicon Valley. NY State is slightly behind New Jersey in the projections, but ahead of Connecticut.

Existing Employment: NYC Compared with Other Areas. Using a narrow definition of the software industry that includes only four of the nine 4-digit SIC codes in the 737 category, NYC (five boroughs) was in fifth place after Silicon Valley, Greater Boston, Seattle, and Los Angeles. However, the large regions that constitute Silicon Valley and Greater Boston might be more fairly compared with the New York Metro area. (See Table 8-2.)

Table 8-2. *Employment in Selected Software Subcategories, NYC and Six Other Cities/Areas, 1996, Ranked by Total Jobs*

	Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Rank	**Industry and SIC Code**	**Silicon Valley**	**Greater Boston**	**Seattle**	**Los Angeles**	**NYC**	**Chicago**	**Austin**	**Total**
1	Prepackaged Software 7372	26,955	21,311	18,780	5,586	1,497	1,963	4,162	**80,254**
2	Computer Programming 7371	22,089	6,731	3,713	9,821	8,652	5,526	1,737	**58,269**
3	Computer System Design 7373	14,300	9,171	839	2,442	2,096	1,691	391	**30,930**
4	Info retrieval Services 7375	3,742	1,439	393	1,733	1,629	2,816	175	**11,927**
	Total	**67,086**	**38,652**	**23,725**	**19,582**	**13,874**	**11,996**	**6,465**	**181,380**

Source: Bureau of Labor Statistics, ES-202 data by county, as summarized in the Citizens Budget Commission, *The Media and Communications Industries in New York City*, December 8, 1998, p. 9. Rankings by NYC Comptroller's Office. Silicon Valley is defined as San Francisco, Santa Clara, Alameda, San Mateo, and Santa Cruz Counties. Greater Boston includes Bristol, Essex, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester Counties. Seattle is King County. Chicago is Cook County. Austin is composed of Travis and Williamson Counties. For industry definitions, see Table 1-1.

NYC Projections for 1999 Compared with Other Regions. A sample of 600 medium-sized software companies (all of them primarily in the software business and with fewer than 1,000 employees) surveyed in November 1998 have reported their 1999 job-growth projections. They indicate faster growth in Silicon Alley than Silicon Valley. The fastest growing region of 13 surveyed in the fourth quarter of 1998 was southern California, at 30 percent, followed by the Northwest (Greater Seattle-Redmond) at 25 percent and the NYC metro area at 17 percent. Northern California (Greater Palo Alto) comes in at 16 percent, tied with the Great Lakes region. (See Table 8-3.)

Table 8-3. *Projected New Jobs, 230 Software Firms, 1999, Top 5 U.S. Regions, Ranked by Percent Change*

Rank		No. of Firms	Current No. of Employees	Projected 1999 Change	
				Number	Percent
1	Southern California	44	3,428	1,021	29.8
2	Northwest U.S.	22	2,166	537	24.8
3	NY Metro	31	1,642	286	17.4
4	Northern California	90	9,762	1,573	16.1
5	Great Lakes	43	3,373	542	16.1

Source: CorpTech, "Computer Software Industry Report," December 1998, downloaded from Corptech.com, January 13, 1999. Based on a CorpTech survey conducted in November 1998.

These job-growth projections are much higher than for NYC as a whole or for any other substantial industry sector. However, with the Y2K problem under control by 2000, the number and type of software jobs is likely to change in 2000 and 2001.

NY State Compared with New Jersey and Connecticut. The projections are similar using data for the three of the states in the region, with New Jersey showing the fastest projected growth, nearly 20 percent, and Connecticut the slowest, about 17 percent. For the entire Tri-State region the projected increase was 18.3 percent. (See Table 8-4.)

Table 8-4. *Projected New Jobs, 47 Software Firms, 1999, by State, NY, CT, NJ, Ranked by Percent Change*

Rank	State/ Region	No. Firms Surveyed	Current Number of Employees	Projected Change in Employees	
				Number	Percent
1	NJ	11	592	118	19.9%
2	Tri-State Region	48	2,567	470	18.3%
3	NY	25	1,532	276	18.0%
4	CT	12	443	76	17.2%

Source: See note to Table 8-3. NY=New York State, CT=Connecticut, NJ=New Jersey.

B. Educating More Software Writers

In the face of growing demand for software personnel, in NYC and its suburban counties, and nationally, the City will be challenged to maintain its competitive position as a software-development center. To generate the necessary trained personnel, NYC needs to work with its schools, universities, and other educational institutions to train software programmers to world-class skill levels, and must also seek to recruit from outside the City.

1. The Levels of Educational Achievement

While the greatest need is for top-level programmers, the various intermediate levels of educational institutions provide the support needed for an active software industry. The public schools should be producing literate and math-literate graduates. Community colleges should be using their certification programs to generate network engineers (for Microsoft, Novell, Unix networks), network administrators, and telecommunications specialists. Most programmers will be trained in four-year computer science or electrical engineering programs. Master's programs in software and New Media (for example, the relatively new programs at Columbia and NYU)

can be very useful in developing particular skills. The crucial elite, however, is composed of those trained in Ph.D. programs at research universities. The quantity of Ph.D.s in computer science and electrical engineering at NYC universities is small. In terms of quality, compared with Silicon Valley or the Boston/Route 128 area, NYC is not performing well at any level of the educational system.

2. Improving Math, Science, and Computer Skills in the Schools

The deficiencies of many NYC schools in teaching math and science and in providing access to computers are thoroughly documented. Just to cite two examples, in the 1990s about three times as many math teachers are uncertified as in the rest of the state, and while the overall ratio of students to computers is 19, the ratio to up-to-date computers is 115.[31]

To rectify the deficiencies, the Board of Education should be recruiting more qualified math, science, and computer teachers and should be working toward meeting its plan of six students per computer in the high schools and eight per computer in the elementary and middle schools.[32]

In the meantime, computers are sitting unused in some classrooms because no one is trained to use them. This might be a useful function for an association of retired executives, i.e., to rotate among the schools making sure that computers purchased for the classrooms are being installed and used.

3. Continuing Education

Technical schools, community colleges, and continuing education programs have an important role to play in developing specialized skills. Some programs are a vital part of the software-skills continuum and NYC has been in a leader in a few of these areas. For example, the Borough of Manhattan Community College has obtained nearly $1 million in support for its multimedia program, one of eight colleges in the nation (and the only community college in the northeast) to receive a "Working Connections" a grant from the American Association of Community Colleges along with an NSF curriculum grant.

These institutions may have a special role to play in 2000 and 2001 when the programmers working on updating older software to make it Year 2000 Compliant will have done their work. In Europe the retraining of these programmers to work in the post-2000 environment is viewed as an important challenge.[33]

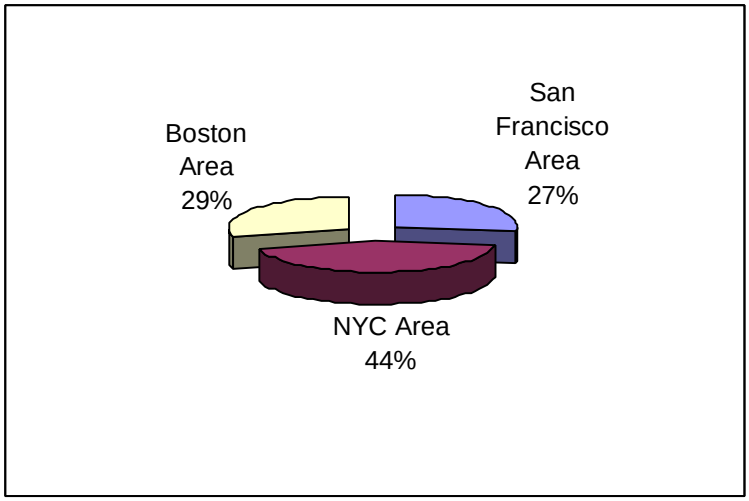
4. How NYC HEIs Compare with Silicon Valley and Boston

NYC higher-education institutions (HEIs) institutions award nearly the same number of degrees in computer science and electrical engineering as the Boston and San Francisco areas combined.

[31] City of NY, Office of the Comptroller, *Math and Science Programs: Making Them Count* (Comptroller's Office, March 1999), pp. 22, 63.
[32] *Ibid.*, pp. 74-76.
[33] Interview with Bert T. A. Koot, CompuSense b.v.

In fact if the same extensive boundaries were used for NYC that are used to describe Silicon Valley, the NYC area would include several northern New Jersey institutions that would probably give the NYC area a larger number of degrees than Boston and San Francisco combined. (See Chart 8-1.)

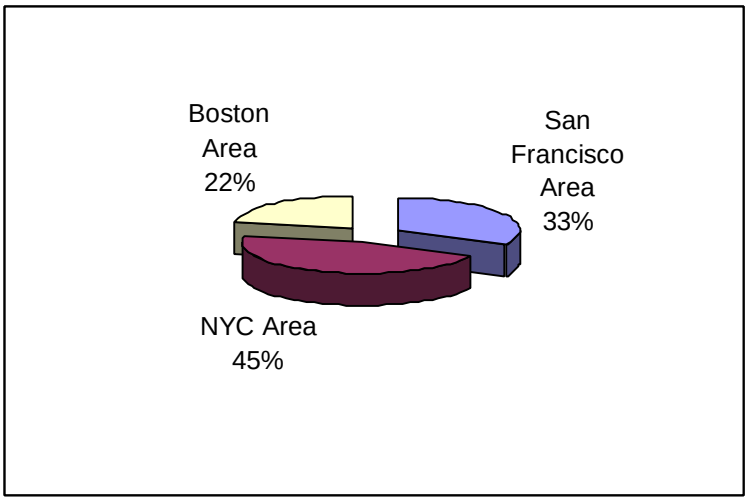
Chart 8-1. *Undergraduate Computer Degrees, Three Largest Labor Sources NYC, Boston, San Francisco, Shares, 1995*



Source: See Table 6-5. The degrees are in computer science or electrical engineering in NYC, and the two other major sources of computer specialists, the Boston and San Francisco areas. 100%=the sum of degrees from these three areas.

The same relationship holds true for the graduate degrees. (See Chart 8-2.)

Chart 8-2. G*raduate Computer-Related Degrees, Three Largest Labor Sources*
NYC, Boston, San Francisco, Shares, 1995



Source: See Table 6-5. The degrees are in computer science or electrical engineering in NY and the Boston and San Francisco areas. 100%=the sum of degrees conferred by universities in all three regions.

Looking at numbers alone, NYC is holding its own in training software specialists. But because NYC lacks the R&D centers that ring Boston and are focused on Santa Clara County south of San Francisco, it does not bring its graduate students to the same level of intensity that comes with a business-academic partnership.

Within NYC, by far the largest number of software graduates are produced by CUNY, which in 1995 awarded more than 1,000 computer science or electrical engineering degrees, about 40 percent of the degrees awarded in NYC. More than one-third of these degrees were at the graduate level. It would be useful as a guide to possible future City and State policy to review which colleges are most important in training these students, and find out what links they have to employers. NYU and Columbia together awarded less than half as many degrees in the software-relevant fields as CUNY. (See Table 8-5.)

Table 8-5. *Electrical Engineering and Computer Science Degrees Awarded, 1995, Ranked by No. of Degrees*

Rank		Number of Degrees Awarded			Percent of Total		
		Undergrad.	Graduate	Total	Undergrad.	Graduate	Total
	United States	**39,333**	**20,446**	**59,779**	**100.0**	**100.0**	**100.0**
1	California	4,199	2,555	6,754	10.68	12.50	11.30
2	New York State	3,638	2,693	6,331	9.25	13.17	10.59
3	Texas	2,330	1,377	3,707	5.92	6.73	6.20
4	Illinois	1,844	1,141	2,985	4.69	5.58	4.99
5	Massachusetts	1,318	1,023	2,341	3.35	5.00	3.92
	NYC Area	**1,329**	**1,139**	**2,468**	**100.0**	**100.0**	**100.0**
1	CUNY campuses	680	389	1,069	51.2	34.2	43.3
2	Brooklyn Polytechnic Univ.	134	226	360	10.1	19.8	14.6
3	NYU	123	154	277	9.3	13.5	11.2
4	Columbia Univ.	68	141	209	5.1	12.4	8.5
5	Pace Univ.	87	106	193	6.5	9.3	7.8
6	NY Inst. of Tech, Manhattan	56	96	152	4.2	8.4	6.2
7	Manhattan College	64	10	74	4.8	.9	3.0
8	St. John's Univ.	66		66	5.0		2.7
9	Fordham Univ.	30		30	2.3		1.2
10	Long Island Univ. Brooklyn	4	17	21	0.3	1.5	0.9
11	Yeshiva Univ.	11		11	0.8		0.4
12	Wagner College	6		6	0.5		0.2
	San Francisco Area	**961**	**710**	**1,671**	**100.0**	**100.0**	**100.0**
1	Stanford Univ.	126	427	553	13.1	60.1	33.1
2	UC-Berkeley	318	178	496	33.1	25.1	29.7
3	San Jose State Univ.	254	88	342	26.4	12.4	20.5
4	Univ. of San Francisco	160	4	164	16.6	0.6	9.8
5	San Francisco State Univ.	103	13	116	10.7	1.8	6.9
	Boston Area	**639**	**753**	**1,392**	**100.0**	**100.0**	**100.0**
1	MIT	268	330	598	41.9	43.8	43.0
2	Boston Univ.	102	176	278	16.0	23.4	20.0
3	Northeastern Univ.	117	156	273	18.3	20.7	19.6
4	Univ. of Mass., Boston	40	24	64	6.3	3.2	4.6
5	Tufts Univ.	31	29	60	4.9	3.9	4.3
6	Harvard Univ.	28	21	49	4.4	2.8	3.5
7	Boston College	38	1	39	5.9	0.1	2.8
8	Brandeis Univ.	15	16	31	2.3	2.1	2.2

Source: U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics, as reported in Citizens Budget Commission, "Media and Communications Industries in New York City," December 8, 1998, Table 26, p. 68 (percentages and rankings added by the NYC Comptroller's Office). Degrees awarded earlier in the 1994-95 academic year are counted as being awarded in 1995.

C. CUNY and SUNY Computer-Related Degrees, 1992-1997

As public institutions, CUNY and SUNY should in principle be responsive to City and State economic-development concerns. It is certainly true that the institutions are producing graduates in computer-related fields. Together, the CUNY and SUNY systems in School Year (SY) 1997 produced 3,598 graduates of bachelor's-level programs in computer science or the related fields of engineering and mathematics. (See Table 8-6.)

Table 8-6. *Computer-Related BA-Level Degrees, by CUNY Colleges (Ranked by No. of Degrees) and SUNY Total, SY 1997*

Rank		Computer & Info Sciences	Engineering	Mathematics	Total
1	City	56	203	14	273
2	Baruch	177	0	11	188
3	Queens	132	0	20	152
4	Lehman	100	0	19	119
5	Brooklyn	88	0	26	114
6	Staten Island	38	22	13	73
7	NYCTC	0	66	0	66
8	Hunter	38	0	17	55
9	John Jay	27	0	0	27
10	York	0	0	14	14
	CUNY Total	656	291	134	1,081
	SUNY Total	691	1,254	572	2,517
	CUNY+SUNY Total	1,347	1,545	706	3,598

Source: *CUNY Student Data Book*, 1992, pp. 121-122; 1993, pp. 127-128; 1994, pp. 129-130; 1995, pp. 135-136; 1996, pp. 141-142; 1997, pp. 141-143. Printout 98/87 from SUNY provided by Rodney Alexander, Director, The Institute of Business Trends Analysis, Borough of Manhattan Community College. SY=School Year; SY 1997 is the year ending June 1997.

However, of the 3,598 graduates in computer-related fields, only 40 percent were from CUNY colleges. Interestingly, although SUNY produced many more graduates overall, it had in 1997 about the same number of graduates in computer science as CUNY, i.e., close to 700.

What the figures don't show is the lack of funding for computer science at CUNY. The shortages show up in lack of computers, lack of software, and lack of instructional staff.

More important than first-degree graduates for innovation in the software industry are the MA and Ph.D.-level degrees. CUNY accounted for only 34 percent of these degrees overall. However, it produced slightly more computer science degrees than SUNY, 240. Also, in the crucial area of Ph.D.-level graduates in computer science, CUNY generated only 11 in 1997 and SUNY only 30. (See Table 8-7.)

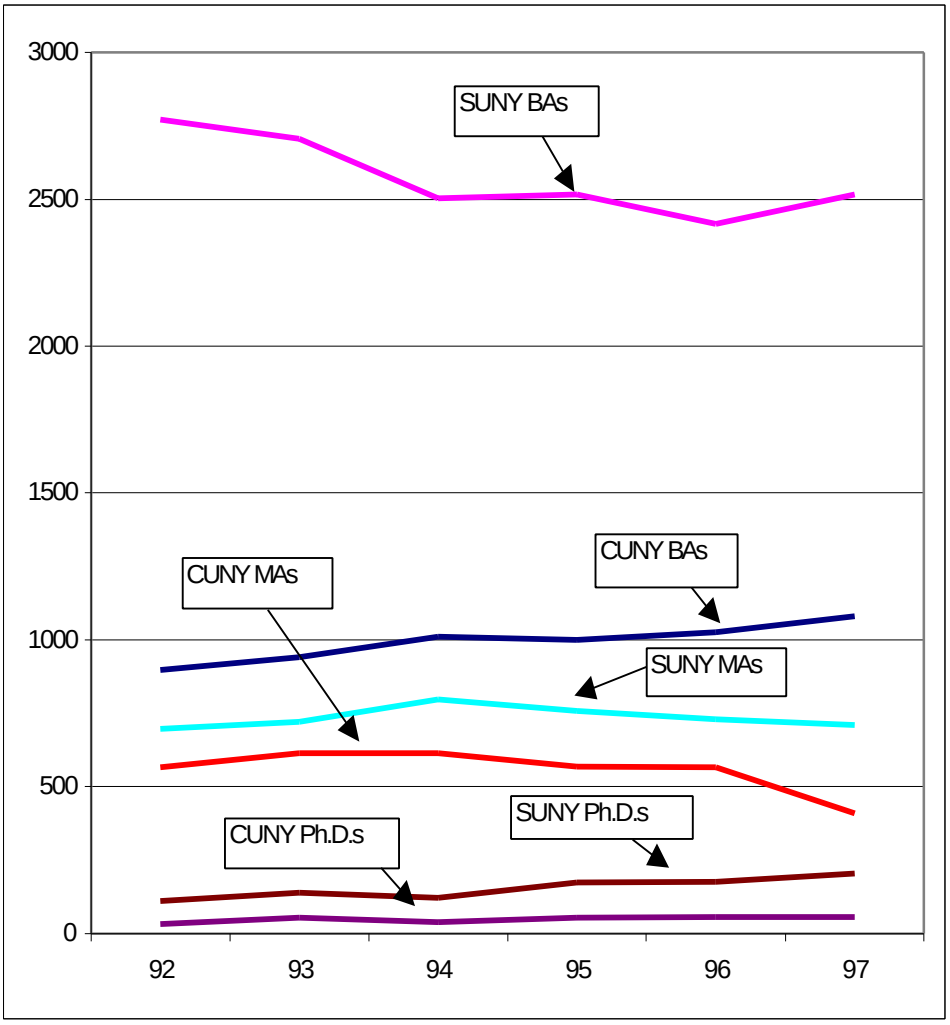
Table 8-7. *Computer-Related Higher Degrees, CUNY and SUNY, SY 1997*

Rank		Computer & Info Sciences	Engineering	Mathematics	Total
1	City	86	96	31	213
2	Brooklyn	41	0	11	52
3	Baruch	45	0	0	45
4	Queens	24	0	18	42
5	Graduate School: Ph.D.s	11	17	8	36
6	Staten Island	17	0	7	24
7	Lehman	11	0	11	22
8	Graduate School: M.Phil.s	1	13	7	21
9	Hunter	4	0	7	11
	CUNY Total	240	126	100	466
	SUNY MA Level + Cert.	205	356	172	733
	SUNY Ph.D. Level	30	105	45	180
	SUNY Total	235	461	217	913
	CUNY+SUNY Total	475	587	317	1379

Source: See Table 8-6.

The picture from 1992 to 1997 is not very reassuring. The number of BAs in computer-related fields has fallen at SUNY and has risen very little at CUNY. The number of SUNY MA degrees has barely held its own, while the number of MAs at CUNY has fallen significantly below 500 per year. Both CUNY and SUNY are increasing their Ph.D. output, but from a tiny number. (See Chart 8-3.)

Chart 8-3. *Computer-Related Degrees, SUNY and CUNY, SY1992-SY1997*



Source: See Tables 8-6 and 8-7.

Columbia and NYU are producing more Ph.D.s than CUNY, but, in the words of a representative of the software industry, "it is common knowledge that they do not compete with Stanford and MIT." Furthermore, the university resources in NYC are dissipated by turf wars between public and private universities and among universities.

Above all, the kind of close cooperation between the universities' business schools and Wall Street is lacking between their computer-science departments and private companies in the industry. This issue is the subject of Section X.

D. Recruiting Software Personnel

What the City can't grow for itself, it must import. Educating a population takes time. In the meantime, the software-writing work force is needed right away. The importing of software writers requires recruitment.

1. Recruiting Programmers

Another approach is to try to recruit programmers from other parts of the country, notably the Boston and San Francisco-San Jose areas. Firms in these areas are advertising for personnel on web sites based in NYC. It might be useful to have NYC job fairs in Boston and San Francisco (or Palo Alto or San Jose) to talk with local software students. The Boston and Silicon Valley companies might even welcome this approach. As a sign of what may be to come, on March 8-9, 1999, some Internet start-ups and potential Internet investors from NYC joined those in the Bay Area at the second annual "Alley to the Valley" conference. The two main "presenters" are the *AlleyCat News* and the NYC Economic Development Corporation. The *AlleyCat News* reports editorially: "We found… in our efforts to organize this year's Alley to the Valley an increased interest in establishing partnerships, in co-investing, in taking the long view. The competition between East and West Coast companies… has been replaced by a desire to partner smart."[34]

The idea of recruiting top programmers might be extended to universities in other countries. This would require the Federal Government to continue keeping open the potential for green cards for highly skilled programmers. The Immigration and Naturalization Service's H1-B visa program provides visas valid for up to six years to 65,000 skilled technology workers per year. High-tech U.S. firms are lobbying to have the number increased to 115,000 visas per year. At the same time, opponents of the visas are concerned about layoffs of workers in declining technologies such as defense industries, and argue that these workers are less likely to come out of retraining with jobs if overseas workers are recruited.[35] Microsoft has created an institute in India to train programmers. This idea may have some applicability to NYC-area software companies seeking a flow of new qualified staff.

2. A Model for Recruiting Professorial Stars

There was a time when SUNY and CUNY were eager to bring in star professors and NY State-funded programs to bring in well-known faculty, for example, as Schweitzer Professors. Queens College has succeeded in attracting a professor with an international reputation, but reeling in a fish of this size is a rare occurrence in recent years for CUNY.

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[34] *AlleyCat News*, 3:1 (January 1999), p. 5.

[35] Robert Pear, "Higher Quota Urged for Immigrant Technology Workers," *New York Times*, Feb. 22, 1998, p. B1; Jeri Clausing, "Debate over Visas for Foreign Workers Focuses on Layoffs," *New York Times*, CyberTimes, June 17, 1998. Rodney Alexander and Chris O'Sullivan, project co-directors, "NY's Engineering and Technically Skilled Labor Supply" (NY: Borough of Manhattan Community College, Institute for Business Trends Analysis, February 1999), p. 6.

The State of Georgia, following a strategy developed for it by McKinsey & Co. in the early 1990s, has been more aggressive about luring stars. It has established a fund, the Georgia Research Alliance, to attract researchers from other states to Georgia Tech, the University of Georgia, Clark, Atlanta, and other universities in the state. Also, through an Eminent Scholars program, the state has funded 17 positions and chairs at $1-1/2 million each, with an additional $1 million available for research facilities.

Georgia hopes that industries will grow up around the universities. In the meantime, attracting professors with a proven capacity to obtain grants has the immediate economic effect of bringing in significant external (typically Federal) research funds, which have their own multiplier effect in the local economy.

E. Conclusions

Demand for software personnel in NYC was extremely strong in 1998, and is expected to increase in 1999. Meeting this demand is crucial for the development of the software industry in NYC. Building up supply, however, is generally a long-run endeavor that requires the improvement of math and science courses in the City's middle schools and high schools, as well as its universities. Most of the computer-related degrees awarded in New York are from CUNY and SUNY. However, weaknesses in these programs are starting to show as the pace of graduation in computer-related fields fell between 1992 and 1997 in SUNY, and only rose marginally in CUNY, despite the large gains in industry demand.

One possible solution for the lack of software personnel in the City is to import trained specialists from outside the City. The City's Economic Development Corporation has taken a step in this direction by presenting at 1999's "Alley to the Valley" conference held in the San Francisco area. Another alternative is to keep the doors open to skilled workers from abroad. The City could facilitate this process by urging the NYC Congressional delegation to press the Federal government for an increase in the annual number of H1-B visas.

IX. VENTURE CAPITAL FOR SOFTWARE START-UPS

In the Coopers-NYNMA survey cited in Section VI, the New Media firms gave NYC's financial sources about one-third the importance and a little better than one-third the value of NYC's creative talent.[36]

This might be surprising to some. As the home of Wall Street, NYC is usually not associated with a dearth of capital. But for the software start-up firm, it's easier to raise venture capital (VC) money in Menlo Park than Manhattan. So much so, that some Wall Street firms interested in the VC business are basing their technology experts in Menlo Park.

What happened to dent NYC's edge in VC financing, and what can be done to make NYC more capital friendly for start-up firms?

A. The Role of Venture Capital

The software industry, like any high-technology firm, has long cycles of design, writing, and testing before it can sell a product. This period must be financed.

U.S. financial institutions adopted some of the practices of the British merchant-banking tradition in the colonial era. As merchants prospered, they added the role of being bankers to other merchants; in time, some of them specialized in the banking side. These bankers would provide seasonal financing and some capital. Although prepared to take more risk than traditional bankers, they preferred to deal with established firms. In the United States, this mission of providing capital to middle-sized or large-sized firms has become the work of corporate and investment bankers.

Since investment bankers and their professional colleagues in law and accounting are expensive, and their transaction costs need to be covered by the issuer, they have a minimum-size financing that used to be $5 million and has grown to $20 million. Consequently a gap has grown between the ability of principals in small firms to finance their early years from their own resources and the point at which they can be "taken public" by a Wall Street underwriter. The use of personal savings and credit cards goes only so far when a firm may have several lean years before it has the potential of earning money. In the case of technology-oriented firms, this gap can be long and difficult. This gap is the focus of VC firms.

B. MIT's Invention of the VC Firm to Support Technology

Back in 1958, private venture-capital firms did not exist. The closest thing to them was a consortium invented at the Massachusetts Institute of Technology (MIT) after the Second

[36] With the maturing of the New Media industry and the raft of independent public offerings occurring between March and June 1999, the answers in 1999 might be more positive toward the proximity of Wall Street.

World War. MIT was founded in 1862 with the ambition to infuse industry with science, but it remained strictly a local engineering school until it seized the idea that academic research could help revive the New England region from its decline as a manufacturing center. In the 1930s, MIT President Karl Compton recognized that New England possessed research resources to a greater degree than the rest of the nation. He participated in a regional consortium of business, political, and academic leaders, and argued that this regional resource should be capitalized.[37]

After the war, Compton renewed his efforts and found that, paradoxically, despite New England's great financial resources, the creation of new science-based industry was blocked by a lack of financing. New England's capital was concentrated in life insurance and investment trusts and then invested in large companies in other parts of the country.

Compton decided to put local wealth to work to fund new companies in New England. He persuaded other Boston leaders like Merrill Griswold, head of the Massachusetts Investment Trust; Donald David, Dean of the Harvard Business School (HBS), and Ralph Flanders, President of the Jones and Laughlin Machine Tool Company in Vermont (and former head of the Federal Reserve Bank of Boston). Their goal was to establish a vehicle for supplying risk capital to new, technologically innovative companies.

Up till then, the technical and financial worlds had tended to operate separately, coming together on opposite sides of negotiation over the financing of a technically based firm. Now financial, business, and technical expertise were brought together in a common organization with sources of capital that had often previously been excluded from investing in new risky ventures. Legal barriers designed to protect the assets of small investors precluded large financial institutions from investing any of their funds in a new firm based on a novel concept.

A new institution, American Research and Development (ARD), was therefore formed out of a coalition between HBS and MIT, combining business-school skills with engineering skills, and involving administrators, teachers, and students. HBS provided graduates with managerial expertise who could advise, evaluate and, when necessary, replace a firm's founders. MIT provided persons with a technical background who could evaluate a start-up's technology base. The financial community and its legal representatives provided the bulk of the funds, and used their political connections to gain legal approval for financial institutions (required by law to invest their funds conservatively) to participate in financing ARD, which used the funds to invest in risky new firms. The concept was that by distributing its investments among a number of new firms, the financial risk would be reduced to an acceptable level, even if only a few of these ventures were eventually successful.[38]

For insurance companies to invest in ARD's start-up companies, regulatory changes were required in several key states and a waiver from the Securities and Exchange

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[37] Henry Etzkowitz, "Enterprises from Science: The Origins of Science-based Regional Economic Development," *Minerva*, Autumn 1993.

[38] This is the same principle as the Small Business Investment Company, discussed next.

Commission (SEC). The SEC established a new precedent by determining that it was proper for investment companies to join together with institutional and individual investors to invest jointly in new companies.

C. The Small Business Investment Act

MIT's successes were institutionalized in the Small Business Investment Act of 1958. The Federal Reserve Board that year published a report showing the "capital gap" between the $500,000 maximum that "angels" (small investors) will put up and the $5 million that was then the minimum amount to take a firm public.

The Act allowed banks to invest up to 5 percent of their equity in small business investment companies (SBICs). The SBICs have had an internal rate of return of more than 13 percent for the past 20 years.[39]

D. Why Is NYC Getting So Little Venture Capital Money?

The amount of money in Venture Capital (VC) investment has been growing rapidly, but only a small fraction makes its way to NYC.

1. NYC Gets Little VC Money

There is a shortage of VC money, and NYC is not getting very much of it.[40] VC investment grew by a net of $97 million in 1970 but was down to $10 million in 1975. The Steiger Amendment in 1978 lowered capital gains taxes from 49 percent to 28 percent, and after this VC money grew to $600 million in 1978. In 1981 the Economic Recovery Tax Act reduced the capital gains tax further, to 20 percent, and in response VC money grew again to $1.3 billion in 1981 and $4.2 billion in 1984.[41] By 1984 the pool of capital was $16 billion.

In 1982, one-sixth of all the VC money in the United States went to Santa Clara County, CA. Three states, CA (with 44 percent), MA (14 percent) and TX (8 percent) accounted for two-thirds of the money. NY was fourth with 5 percent. In 1998, only $700 million of the $17 billion invested went to companies in NY, behind CA, MA, VA. VA is a good model; it turned itself around.

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[39] Saunders Miller, Senior Policy Advisor, Small Business Administration, presentation to the 2nd Annual NYC Venture Capital Conference, 1998.

[40] A few years ago, the president of the National Venture Capital Association told Congress there was a $6 billion shortage of VC money. Peter K. Eisinger, *The Rise of the Entrepreneurial State: State and Local Economic Development Policy in the United States* (Madison, WI: University of Wisconsin Press, 1988), p. 247.

[41] Eisinger, p. 246.

2. Why NYC Is Short-Changed

Given that Wall Street and many well-known VC firms are in NYC, some cannot understand why there is a shortage of VC money for software start-ups. The reasons include the following:

- Many NYC-based VC firms have been focused on leveraged buyouts, which seek to capitalize the assets of a company. A small software start-up, however, typically has no assets other than the brains of the principals and an idea. Copyrights and patents take time (and money) to obtain and even then may not end up protecting very much because of the speed of change in the software industry.
- Wall Street underwriters aren't much good for start-ups, because they like to come in when the firms are ready for a public offering. Some firms won't touch an offering below $15 to $20 million because of the fixed costs involved in the transaction. Some VCs have even moved out of the business of helping start high-tech firms, preferring to concentrate on the less risky task of funding their growth at the so-called mezzanine stage of development. The downstream move of the VC industry has left a gap upstream.
- VC firms focus on the stage after the owner/managers have used their personal assets and credit to get the company going, and are prepared to take high risks provided there is a prospect of a high return. The relatively high costs of start-ups in NYC lead to lower expectations of returns by VC principals.
- NY State and NYC are not viewed as friendly to those who are creating wealth, because of the relatively high income and wealth taxes. As cited earlier, NY State is the highest taxed state in the nation when local taxes are averaged in.[42]

E. Silicon Valley's VC Edge

After assessing the reasons for Silicon Valley's venture capital strength, i.e., its knowledge of the industry and the self-perpetuating nature of capital growth, the section describes a possible model for a response by NYC and NY State.

1. Knowledge of the Industry

Since software innovation is highly risky, knowledge of the industry is at a premium when it comes to deciding on financing a software system or application. In part because the industry grew up in Silicon Valley and the key educational institutions are nearby, the needed knowledge to assess a new idea is likely to be in Silicon Valley.

Since VC funding depends on long-term personal contacts, it makes sense that NYC, as a center for medicine, finance, advertising, and enterprise, has a knowledge base that makes it more likely to be successful on software's applications side, where content issues are more important[43]

[42] Public Policy Institute, Business Council of NY State, March 1999.
[43] Interview, Irving Kahn, Kahn Brothers, March 1999.

2. Self-Perpetuating Venture Capital

Like the merchant bankers of England, the owner-executives of successful Silicon Valley firms have reinvested in their industry. "Silicon Valley's VC industry emerged out of the region's base of technical enterprises… [They] became unusually involved with the ventures."[44]

This is an extension of the principle of path dependency. Companies that are successful breed other companies that are successful because knowledge of the industry remains with the people who have been financially rewarded by their success.

3. The "Band of Angels" Model

The Band of Angels was formed in Palo Alto at about the same time as the Investors Circle, which was created in 1991 by Susan Davis in Chicago. In the early 1990s, the Band of Angels decided that the Investors' Circle model of cooperation would be the best for them because it maximized due diligence among members. The basis of this model is a monthly show-and-tell with two or three investor-members' introducing favorite start-ups to the other investor-members. Angel member David Davison in Palo Alto is now using the Investors' Circle model to ask Silicon Valley entrepreneurs to donate stock back to a socially responsible incubator that nurtures them.

The Investors Circle model, which the Kaufmann Foundation chose out of 80 approaches that it studied as the optimal approach, is evolutionary and is designed by the members. Dee Hock, the founder of VISA, describes the model as "*chaortic*," i.e., suspended between *chaos* and *order*. Geese in flight come together in a disorderly way but they follow certain rules and end up flying in a very orderly way. Successful associations have certain core principles from nature, and promptly share and evaluate information.

F. What NYC Can Do

To improve NYC's availability of VC money, two approaches suggest themselves.

1. Encourage VC Investors to Invest in NYC

In a 1998 book, VC principals in a survey said that they would invest more with three factors in place:

- Better knowledge of principal(s), 63 percent. Showcases for small firms are one way to improve knowledge of the principals of start-up firms.
- Better tax incentives, 44 per cent. Historical data indicate that the best tax incentive is a lower tax on capital gains. The NYC and NY State personal income tax also affects the degree of interest of the VC industry in NY investments.

[44] Saxenian, p. 39.

- Availability of exit routes (ability to sell equity), 44 percent.[45] A secondary market for VC investments might be a way of providing such an exit route.

The first and third of these factors give Silicon Valley its VC edge, because the knowledge of software is concentrated there and consequently the confidence both in the initial investment and the investor's ability to resell the investment or obtain participants.

2. Target Investments in Start-Ups

The City is experimenting with various ways to encourage start-ups, particularly in high technology. Recently the City's employee pension funds have committed funds to "alternative investments" which include VC investments. As an area of potentially high returns, the software industry deserves close scrutiny on a priority basis.

3. Remind Start-Ups of the 1998-1999 Successes

The best thing NYC may have going for it in the VC arena is the speed with which start-ups in NYC make it to their first public offering. By that benchmark, NYC is doing well, as two dozen Internet-related companies are being capitalized in the March-June 1999 period. While it may be harder to raise initial venture capital in NYC, it may be faster getting to the next step.

G. Conclusions

Although NYC is home to Wall Street, the nation's financial center, NYC software companies say they find it harder to obtain venture capital in NYC than in Silicon Valley. Venture capital is vital to start-up software firms as it finances firms whose primary assets are technical skills and good ideas. This type of financing has not traditionally been associated with the City's investment banks, which instead focus on issuing high-value public offerings of asset-rich companies. To remedy this, the industry might imitate investor circles in other cities, which bring together the many technical and financial resources available locally. These circles, modeled on Silicon Valley Angel groups, would provide and promote cooperation, due diligence, and capital reinvestment. The City pension funds, meanwhile, should investigate the possibility of providing some venture capital to the industry.

[45]Patrick Coveney and Karl Moore, *Business Angels* (Chichester: John Wiley & Sons, 1998), p. 92.

X. MODELS FOR UNIVERSITY-INDUSTRY PARTNERSHIPS[46]

The economic strength of a region is very much affected by policies of its universities. Universities are traditionally the home base of nonrivalrous knowledge.[47] Students and recent graduates of these universities have for decades constituted a critical part of the creative activity in the Silicon Valley area, dating back to the formation of Hewlett-Packard in 1939.[48] This was also true in the Boston/Route 128 area, going back to the Digital Equipment Corp. (DEC) in 1957.[49]

The fact that research-oriented universities accumulate knowledge that is valuable for potential entrepreneurs is an important aspect of their economic function. This knowledge base serves as a source of energy for further regional economic growth and a competitive edge for the region's economy.[50]

Links to universities have had the benefit of solving key needs of software companies, i.e., space, talent, and financing. Other regions have sought to replicate the successes of Stanford and Boston by copying the final outcome such as a science park, rather than seeking to understand why the model worked. The successes of both Stanford and Boston grew out of their analysis of their regional strengths and weakness, and the implementation of long-term strategies to address those weaknesses.

The common thread that makes university-industry cooperation instructive is how these efforts have worked, and especially how governments (executive and judiciary) have contributed. The beneficiaries of a move in this direction by NYC area universities would be the universities themselves, their professors and students, and the larger economy, which would have a higher probability of creating more high-technology jobs.

While the economy needs more open, entrepreneurial universities, and more open systems, the obstacles to this goal need to be acknowledged.

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[46] Parts B-D of this section, plus Part B of Section IX and Parts B-D of Section XI, and related recommendations in Section XII, were drafted by Prof. Henry Etzkowitz of SUNY at Purchase.

[47] Developing new ideas is rivalrous in the academic environment, but a premium is placed on maximum dissemination of these ideas to students.

[48] Two recent electrical engineering graduates from Stanford University started the eponymous Hewlett-Packard Co. in Palo Alto. Apple Computer Co. was started in 1975, in Cupertino (south of Sunnyvale, southwest of Santa Clara) by engineers in California. Steven Jobs, who had been with Hewlett-Packard, co-invented with Stephan Wozniak the Apple I in 1976. Alan Kay wrote his 1969 doctoral thesis at Utah on the possibility of a "personal computer" (PC), was chief scientist at Atari when Jobs was there, then joined Jobs at Apple and contributed to the Apple II's becoming the first widely sold PC in 1977. The BSD open-source version of the UNIX operating system, which had been developed at Bell Labs 10 years earlier, was developed at the University of California at Berkeley in 1980.

[49] DEC was started by two recent graduates of the MIT Digital Computer Laboratory. In 1960 DEC developed the first commercial computer to use a keyboard and monitor instead of punched cards and in 1965 it developed the first minicomputer.

[50] The past contributions of research universities provide a basis for future innovation. Meanwhile the creation of innovative firms in the region creates a path for further innovation that is improved with each new traveler along the path. See W. Brian Arthur, *Increasing Returns and Path Dependence in the Economy* (1994). Cited in Hyde (1998).

A. Problems with Closer University-Industry Relations

Universities and companies are organized for different purposes. Universities are designed as long-term custodians and teachers of knowledge. They were commonly created by gifts and not by individuals seeking to obtain a monetary return, and depended on the commitment of their students to pursue religious vocations involving the study and copying of Hebrew, Latin, and Greek secular and liturgical texts and music.

Business enterprises, on the other hand, were launched not by gifts but by stockholders seeking a return on their investment. Although, in order to obtain a royal charter, a business had to espouse and claim a social purpose, the backers of a business were not so motivated by the social purpose that they would view the loss of their investment with equanimity.

These origins are reflected in the different cultures of universities and business, especially regarding profiting from intellectual activity and acknowledging intellectual debts.

1. Concerns about Profiting from Intellectual Activity

Academics are uncomfortable with the profit motive, because many are motivated primarily by pure intellectual curiosity.[51] MIT early on tried to change this and its disciples went to change Stanford. MIT had lost a leadership role by the 1980s, when it was considered "arrogant" by DEC in comparison with Stanford.[52] But private-sector money now pays for about 25 percent of MIT's research compared with about 5 percent as recently as 1985.[53]

Universities have been largely slow to follow where MIT has led. Intellectuals may see the negative side of business more strongly than the positives. Democratization of cuisine may make better food available to more people but it may offend those who only respect the best. The conflict between "art" and "commercial art," between "literature" and "popular writing," between popular movies and more recherché theater, are at the heart of suspicions of academic-industry cooperation.

Scientists are also worried that injecting the profit motive into science may have three very specific negative consequences:

- Skewing professors' activities toward corporate applications rather than basic research.
- Making professors more secretive.
- Delaying publication.

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[51] George Stigler of the University of Chicago has written in detail on this subject in "Intellectuals and the Marketplace."
[52] Saxenian, p. 67.
[53] Carey Goldberg, "Urging a Freer Flow of Scientific Ideas," *New York Times,* April 6, 1999, p. F3.

A study of 2,000 biotech researchers found that 400 of them delayed publishing their results for more than six months, or did not to publish at all, because of relationships with corporate sponsors.[54]

What it may come down to is a clash of cultures, of the single-mindedness of the corporate executive seeking profits against the single-mindedness of the researcher seeking truthful answers to complex questions.

Michael Lewis, the author of *Liar's Poker*, who is working on a book on Silicon Valley, summarizes the difference between NYC and Silicon Valley as a cultural one of this kind. On the East Coast, he says, engineering is viewed as a form of "manual labor." On the West Coast, on the other hand, "it is worshipped."[55] Ironically, as discussed in Section XI, the West Coast software culture has been *less* protective of secrets than its East Coast counterparts.

2. Concerns about Acknowledging Intellectual Debts

Another problem with industry cooperation with the academic world is that business acknowledgment of intellectual debt is not a priority. It is based on what is legally required, which may not be a lot. Socially responsible businesses may feel a higher ethical responsibility, but it is not a central concern.

But for academics, with their careers tied to making a contribution to the history of ideas, the obligation to acknowledge intellectual debts is central and goes far beyond the law.

This aspect of university-industry relations has not been addressed directly. In a university department, intellectual originality is prized, and to some degree that limits the ability of academics to cooperate. A professor, sometimes two (rarely more), author an article or book, and speculation commonly arises regarding the relative contributions of jointly authored work. Plagiarism, i.e., claiming someone else's work as one's own, is a major sin, a violation of the principle of honest acknowledgment of intellectual debts that underpins the quest for truth.

In Silicon Valley, on the other hand, the culture allows and even encourages use and even sale of other people's work. Certainly, historical notes are kept of the contributions of each programmer and firm, but the reality of the weakness of copyright and patent law is well recognized. In the interest of rapid achievement of a business goal, the relative contributions of participants in the process are not the focus of attention.

"In the computer business... there is a whole lot of copying going on."[56] The collective goal of the community is to push ahead with products. It is accepted that every

[54] *Loc. cit.*
[55] E-mail, March 1999.
[56] Cringely, p. 142.

programmer uses other people's work. Bill Gates sold to IBM the MS-DOS operating system that he essentially purchased from Seattle Computer Products for $50,000.[57]

Part of what has happened in Silicon Valley is that the computer software "designer" has emerged from among the "writers." It is not enough to write software. One must find the business use, the marketplace, and the concept. Dan Bricklin invented the first computer spreadsheet, VisiCalc, but Mitch Kapor saw its market and in 1983 turned it into Lotus 1-2-3.[58]

B. Stanford's Science Park

Stanford was founded in the late 19th century in a semi-rural location south of San Francisco, which was then a shipping, trading, and financial center. The beginnings of an electrical industry were grafted onto the city by graduates of Stanford, who installed and maintained technology imported from the East, supplemented with their own inventions and products.

Stanford's technology successes date back to the 1930s, when a visionary, Frederick Terman, led Stanford's electrical engineering department. In the 1970s, the area became a center for development of the silicon chip as the core of the next generation of computers. As computer entrepreneurs centered on Palo Alto, they gradually took over from the groves of fruit trees. The county in which Palo Alto is located, Santa Clara County (and more broadly the entire area between San Jose and San Francisco), became aptly dubbed "Silicon Valley."[59]

Two of the key elements of the industry-linked university came together at Stanford in the 1930s: (1) close connections between the university's science and engineering departments, and (2) links between academic departments and local science-based firms. Terman, after receiving his bachelor's and master's degrees from Stanford, went on to earn a Ph.D. in electrical engineering from MIT, which as we have seen was already significantly engaged with the Boston business community. He then joined the Stanford engineering faculty in 1925, became head of the electrical engineering department, and had ambitions to make it a major center.[60] Two firms (Heintz and Kaufmann and Federal), in conjunction with Terman's expansion of Stanford's electronics programs, can be credited with the founding of the West Coast electronics industry in the 1930s.

Part of Terman's strategy was to create an industrial context for the department so that graduates could remain in the region. Students in electrical engineering visited area firms such as H K, Eitel-McCullough, and Litton Engineering, where they learned about the potential of electronic devices. In the late 1930s, he encouraged two students named

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[57] Seattle Computer Products used at least some code from Digital Research's CP/M, the operating system used in the Kaypro. MS-DOS was Miscrosoft's new name for QDOS, which stood for "Quick and Dirty Operating System." See Cringely, pp. 129-135.
[58] Cringely, p. 141.
[59] Credit for the name is given to the editor of *MicroElectronic News*.
[60] Saxenian, pp. 14-15.

Hewlett and Packard, to form a firm in a garage based on their invention of a resistance-tuned oscillator.

Pre-war Stanford was still a regional institution, with elite social status but not yet a leading research university. During World War II, Terman formulated a long-range plan for Stanford's development based on his observations of war-related research centers at MIT and Harvard. Terman proposed a 20-year development program, linking the physical sciences with electrical engineering.

When Terman returned to Stanford after World War II, he began a program of organizing centers modeled on MIT's Rad Lab. Electronics research was pioneered by Stanford but during the war was pursued more aggressively at the Rad Lab, supported by the military. Stanford found funds for permanent research professors who in the Depression could be found painting their own laboratory floors. Now, they were released from all but essential teaching duties during the post-war period, to manage ever-larger groups of junior researchers.

Despite Terman's initial belief that financing would not be a problem if development was limited to a relatively few carefully selected fields, considerable financial support was required to realize this vision. A shopping center, industrial park, and research relationships with Federal agencies and companies provided the financial base for Stanford's post-war ascendance.

The Stanford Research Park originated as a university real estate venture to utilize surplus land to make money for the university as an ordinary industrial park. The high-tech cast of the Stanford Park's tenants was an unintended outcome of a development strategy based upon decades of informal interaction among academic research groups, centers, and firms.

C. Public-University Models

In NYC, as we have seen, most of the software training is done by the various components of the City University of NY (CUNY), which is governed by a 17-person Board of which 10 members are appointed by the NY State Governor and five by NYC's Mayor. Can entrepreneurship thrive in a government-run academic institution?

1. Stony Brook as Area Nexus

The State University of NY (SUNY) at Stony Brook has proved that public institutions can harbor enterprise. In the 1990s, Stony Brook has created a sophisticated knowledge-based regional economic development strategy. Components include a technology transfer (patenting and licensing) office, a biotechnology center, and an incubator facility. It has also formed an alliance with other research institutions in the area (Cold Spring Harbor Laboratory, Brook Haven National Laboratory, and North Shore Hospital), to found a new organization, the Long Island Research Institute (LIRI). LIRI was created to organize institutions (political, industrial, and academic) to improve the local climate for

innovation.[61] LIRI offers strategic management consulting to existing firms, especially in the declining defense industry. LIRI advised companies in the Long Island military industrial complex how to find new civilian outlets for their technologies. An affiliate was also established to provide seed venture capital.

Stony Brook departed from NY State's traditional science and technology policy, which has focused on supporting existing industries by infusing them with new technologies. These policies, designed primarily to assist "sunset" industries and encourage relationships of universities with large corporations, did not fit all regions of such a diverse state as NY.

The Stony Brook strategy of developing new, small companies was in striking contrast to the approach of working with older, larger companies, such as GE or Xerox, that universities in other parts of the state had taken. The Stony Brook Center for Advanced Technology (CAT) differed significantly from other state-sponsored centers, which were typically oriented to link faculty to existing industry. A technological area for fledgling companies was selected in which the university had special strength, biotechnology. Moreover, a gap in the development of biotechnology firms was identified that the university could help fill. Based on the observation that such companies typically spend a considerable portion of their start-up capital equipping their laboratories and plants, if some needed facilities were provided by the university, it was thought that a Stony Brook location would be "more attractive to these companies." Providing firms with access to shared R&D infrastructure was matched by an effort to expand the research capacities of the faculty.

The Stony Brook Center took as its main mission the expansion of faculty research in biotechnology and reorientation of its direction. A seed-grant program was established with NY State funds. Its aims included the encouragement of faculty to explore the technological implications of their research. A faculty beneficiary of the program reported upon the efficacy of seed funding from the Center in generating external funds, both from industrial and Federal sources. "I have turned the $30,000 of Center funding and in every case I have multiplied that by ten." A considerable number of small grants were given out; many of these projects resulted in new lines of research that attracted additional sources of support.

The Center has run a prototype of the Small Business Innovation Research (SBIR) program, directed at uncovering the commercial potential of research findings. For almost a decade, the Center operated this fund to seed new faculty research projects that had some near-term commercialization potential. Typically, faculty members have utilized the grant program to take a basic research finding that had originated in their laboratory and examine it from a product-oriented perspective. The proposals were evaluated both on business and scientific criteria by technology-transfer experts, scientists and business people such as corporate vice-presidents for technology

[61] Henry Etzkowitz, "Technology Transfer at SUNY Stony Brook," SUNY Science Policy Institute Report , 1995.

acquisition. Some faculty members reoriented their research line to make it fit within the objectives of the Center. The Center also played a matchmaking role, encouraging cooperation among faculty members with complementary research interests.

In addition to its role in encouraging faculty members to take account of social goals in the outcome of their research and its economic and financial contribution to academic research the center has had an effect on the intellectual life of the university. For example, the center encouraged interdisciplinary interactions among faculty from the Health Sciences, Engineering College, Life Sciences, Physical Sciences, the College of Engineering, and the School of Medicine, through a bioengineering symposium series that it helped organize. Through this seminar, faculty from the computer sciences, material sciences, and electrical engineering met researchers who did various kinds of medical imaging and medical informatics. As a result, some very interesting cross campus projects were developed in bio-materials and bio-mechanics. Another series of connections emanated from meetings between groups in chemistry with groups in physiology, biophysics, biochemistry, and microbiology.

2. Quasi-Incubators in Brazil and Portugal

The usual incubator houses all of the activities of start-up firms. But two kinds of quasi-incubators, the "virtual" incubator and "limited-service" incubator, are also useful.

The Virtual Incubator. At the University of São Paulo in Brazil[62] a virtual incubator operates solely along the business development continuum as a provider of a range of support services, without having a building to house firms. Instead, it provides extensive incubator services to start-ups in Brazilian homes. This approach has also been used in the United States, where the suburban home is often a financial support structure for firm formation. Several occupants of the SUNY Stony Brook incubator pay their start-up costs with home-equity loans. For a software start-up, a child's outgrown bedroom in a NYC apartment can be the functional equivalent of a Silicon Valley garage. São Paulo has also developed an innovative industrial liaison program that includes "student companies" in its repertoire. Each school (e.g., engineering or social science) has a student-organized firm, located in office space on campus (with a telephone and a computer), offering services based upon the skills the students are learning.

A Limited-Service Incubator in Portugal Based on Student Interns. Portugal in 1973 founded the University of Aveiro, a campus oriented to science and engineering, to help revive its declining northern region. Most area firms in ceramics and wood pulp have fewer than 50 employees, the owner is typically the manager, and the production processes are low to mid-tech. Links between these firms and the university have been created through student internships arranged by individual faculty members and departments (especially management science and production engineering). Initially begun as informal arrangements between individual teachers and companies, internships are increasingly officially encouraged by the university. The director of a liaison office

[62] Under the leadership of Professor Ary Plonski, Vice-Rector for External Affairs of the University of São Paulo, who had previously designed such an incubator for the Hebrew University of Jerusalem.

arranges meetings between a group of firms in an industrial sector and teachers whose disciplines might be relevant. The actual work of transferring knowledge and connecting company problems to university capabilities typically rests upon the shoulders of an undergraduate student. Introducing a software package to meet a firm's needs and training employees in its use has been found to be the most useful first step that can be taken in upgrading the capabilities of these companies.

D. The Potential for University Enterprise in NYC

The purpose of reviewing other university programs is to provide a basis for considering what more might be done at universities in NYC. This section establishes the importance of interaction and the ability of NYC to provide it.

1. Learning from Computer Science: University of Pennsylvania

During World War II the term "computer" referred to females with BAs in mathematics who did complex calculations using mechanical calculators. To speed up ballistics and other calculations in WWII, the Army commissioned the Moore Engineering School of University of Pennsylvania to build an electronic digital computer. But the Moore School did not see the opportunity represented by the computer and did not develop an academic base on the wartime project.

2. MIT, Stanford, Carnegie-Mellon

MIT, on the other hand, developed new academic units on the basis of wartime research on radar and electronics. Stanford, based on Terman's analysis of MIT's strategy also, as we have seen, sought government contracts and established research centers in electronics. These research groups became one of the sources of a new academic discipline. In the wake of Sputnik, a new research agency was founded in the Department of Defense to take a longer-range view of technology development. The Advanced Research Projects Agency (ARPA), now famous as the originator of the Internet, was also crucial to creating the academic discipline of computer science in the United States. ARPA focused on building up three departments: MIT, Carnegie-Mellon University (CMU) and Stanford, soon adding Berkeley for its special expertise in its open-source version of UNIX, known as BSD (Berkeley Software Distribution). These departments become the core of a new discipline synthesized from elements of electrical engineering, applied mathematics, psychology and philosophy. People were drawn from these fields as the first academic computer scientists to train new Ph.D.s.

Interaction between people from different disciplines has been crucial to the development of computer science.[63] Many of these interactions were based on existing intellectual strengths of the university. For example, at Yale and Rutgers psychology/computer

[63] Lois Peters and Henry Etzkowitz, "Academic Computer Science" Rensselaer Polytechnic Institute: Center for Science and Technology Policy, 1987.

science interactions were important. At Johns Hopkins University, medical research, a long-time academic strength, interacted with computing.

As other universities realized the importance of the new discipline, a second wave of departments was created. The computer science department at Columbia University, for example, was founded in the early 1980s as an offshoot of CMU, adopting many of its academic practices, but with a special focus on computer theory. Some of the elements of the CMU department have since been spun off into separate units including a robotics department and a Center for Speech Recognition. These units have been an important source of new firms in the Pittsburgh region.

E. Conclusions

Partnerships and consortia among universities, high-tech industry, and governments to develop job growth will work if the initiatives build on each community's strengths while recognizing its weaknesses, and if they adopt models based on this knowledge. Building a science park on set-aside land is not enough to jump-start an industry unless it is combined with the expertise of local industry and academic leaders. The Stanford Science Park, the Stony Brook incubator, and the quasi-incubators of Saõ Paulo, Brazil and Aviero, Portugal, are examples of successful joint programs. Cooperation among NYC's universities, business leaders, and government would aid the long-term development of the City's software industry.

XI. MODELS FOR REGIONAL COOPERATION

It's not enough to train and attract software experts to NYC. They must be nurtured and retained. This requires developing a business climate that is encouraging for software entrepreneurs. It means working toward an open, regional economy.

A. The Open-Economy Model

Jane Jacobs in 1969 observed that certain cities did not develop an entrepreneurial climate, and suffered economically as a result.[64] A quarter-century later, AnnaLee Saxenian used the Jacobs thesis to explain why Silicon Valley (Santa Clara County, and more broadly the counties between San Jose and San Francisco) overtook Route 128 (Boston's beltway) in development of computer hardware and software.[65] She attributes Silicon Valley's edge to the entrepreneurial culture prevailing in its scientific and technical community. The culture encourages small start-ups and does not post obstacles in the way of exchange of information and mobility of employees.

Rutgers Professor Alan Hyde in 1998 has taken Saxenian's argument to a higher level of specificity, attributing Silicon Valley's success in part to differences among the legislative, judicial, and business cultures prevailing in California, Massachusetts, and NY.[66] He argues that Silicon Valley is more open. Non-compete covenants and trade secrets in Silicon Valley and elsewhere in California are enforced less rigorously than in other states, including Massachusetts and NY. Hyde observes that non-compete covenants with employees have since 1872 been illegal in California, while they are legal in virtually every other state, including Massachusetts and NY.

With respect to trade secrets, Hyde argues that while the laws are in practice similar (California has a statutory prohibition against revealing trade secrets, whereas in NY State and elsewhere violations are prosecuted according to common law), the real difference is the culture. Judges in Santa Clara County take a laid-back view of trade secrets and tend to side with the employee. Also, Hyde says that firms seeking to enforce trade-secret laws against ex-employees run into informal sanctions from other companies in the region that view trade-secret prosecution as harassment of young companies.

In economic terms, a more open system is one in which the widely accepted legal definition of intellectual property is narrowly construed. In other words, it is a

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[64] Jacobs, *The Economy of Cities* (NY: Random House, 1969), pp. 97-98. She noted, for example, that Eastman Kodak's monopolistic practices, which included doing battle with former employees who competed with Kodak, were a bad influence on Rochester. Kodak, she said, deadened entrepreneurship in Rochester; the emergence of Xerox in Rochester was not counter-evidence because the Haloid Company merely purchased the rights to an invention that originated in NYC.

[65] AnnaLee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 1*28 (Cambridge, MA: Harvard University Press, 1994).

[66] Hyde, "The Wealth of Shared Information: Silicon Valley's High-Velocity Labor Market, Endogenous Economic Growth, and the Law of Trade Secrets," July 1998, http://andromeda.rutgers.edu/~hyde/WEALTH2.htm.

community in which as much information as possible is consigned to the public domain. The Internet as it exists in 1999 is a good example of such a community. Clearly, for those seeking to generate revenue from the Internet, this free access to information is a problem not an asset.

Technological development, as symbolized currently by the Internet, is replete with paradoxes. One is that people with valuable human capital tend to bring it not where it is scarce but where it is abundant.[67] Another is that investment in technology can be expensive, and recouping the investment requires being able to sell the result, which means denying or restricting access to those who don't pay. But Adam Smith's Invisible Hand, by which private pursuit of profit produces maximum gain for everyone, doesn't work with intellectual property, because it is in everyone's interest to diffuse new information and technology (knowledge, unlike physical resources or labor hours, is not "used up" in the process). That is why the 1976 U.S. Copyright Act, which since 1978 exclusively governs copyright issues in the United States, is limited in its protections and allows for "fair use" of other people's work.[68]

An approach suggested by Paul M. Romer as a way of resolving this paradox is to divide knowledge ("human capital") into "rivalrous" and "nonrivalrous" types.[69] Briefly, access to rivalrous information is restricted (charged for or kept secret); access to nonrivalrous information is not. Then a community with a more open attitude to intellectual property is one in which nonrivalrous human capital is maximized.

The implications of favoring nonrivalrous knowledge run along certain clear lines:

- Government subsidies of research can be justified economically as contributing to the stock of nonrivalrous knowledge.
- Restrictions obtained by patent-holders (and copyright holders) should be limited in scope and duration.
- Contracts restricting employee revelation or use of "trade secrets" should be of limited enforceability.
- Interpretation by the judicial system of the applicability of non-compete or trade-secret covenants or contracts should be narrow, i.e., favoring the employee.

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[67] Robert E. Lucas, Jr., "On the Mechanics of Economic Development," *Journal of Monetary Economics*, 22:1 (July 1988), pp. 3-42. Cited in Paul M. Romer, "The Origins of Endogenous Growth," *Journal of Economic Perspectives*, 8:1 (Winter 1994), p. 19.

[68] Copyright law, according to one legal text, "complements the First Amendment. There might now be a vigorous marketplace of ideas if those with a talent… could not be sure of payment for their work. It encourages the exchange of ideas and viewpoints by talented individuals with the hope that the public will benefit. But looked at from another point of view, copyright law places limits on the free marketplace of ideas… Courts have held that ideas, theories, historical incidents, standard forms, facts, and news are not generally protected by copyright…" Ralph L. Holsinger and Jon Paul Dilts, *Media Law*, 3rd Edition (NY: McGraw-Hill, 1994), p. 573.

[69] Romer (1994), p. 16. Romer is cited in Hyde (1998), who asserts that he is the first to link Saxenian's and Romer's work.

B. Building on NYC's Strengths

The recurring strength of cities is as a source of interaction, recombination and renewal. The decline of cities was predicted with the post-war shift to the suburbs, facilitated by the Interstate Highway system. The predominance of the mega-corporation based on relatively stable technology appeared to give credence to a suburban future. However, the economy has since become more dynamic, more closely connected to the development of new technology, especially technology associated with academic and artistic pursuits. The need for big cities may have come again in a new form.

1. The City Is the Ultimate Incubator

By allowing the convenient outsourcing of many elements, an urban location gives the founders of a new firm the ability to concentrate on the firm's special innovation.[70] This new economy underscores the traditional strength of the City in bringing together diverse groups and encouraging their interaction. Growing knowledge-based companies is an economic development strategy supported by governments (local, state, or national) that recognize the economic value of research. Finally, and most recently, it includes the translation of government supported research into economic uses, transcending the traditional role of industry as having the presumption of sole responsibility for this task.

Increasingly, economic development is a joint academic-government-industry responsibility. Interaction among these institutional spheres is the defining hallmark of a new era of innovation. This section discusses some of the historical models of high tech economic growth and the best practice lessons that can be drawn from them. Universities were crucial to many of these instances, through both their research and teaching roles. The creation of computer science as an academic discipline shows the importance of interdisciplinary interactions between new and old fields. The software industry has the potential not only to develop new sources of high-tech jobs, but also to upgrade jobs in low- and mid-tech industries.

2. The Potential Importance of NYC in Content Development

As the focus of the economy continues to shift from manufacturing toward information and as the cost of hardware decreases; the need for content to sell software (on and off the Internet) becomes increasingly important and valuable. By "content" is meant the artwork, videos, music, games, and chat rooms that are made possible and controlled by software.

The academic world has so far been only marginally relevant to one of NYC's success stories, the New Media industry. Based upon the demand for content on the Internet, artists have been the source of many of the new firms in this field. Indeed, NYC's artists' community has a strong tradition of entrepreneurship, not only from seeking recognition

[70] Jane Jacobs, *The Death and Life of Great American Cities* (NY: Random House, 1961).

and selling their artistic wares, but also from pioneering the redevelopment of neighborhoods such as Soho. Artists' self-help organizations, theater groups, galleries, and performance spaces, exporting art to cultural centers around the country, serve as the spawning ground for entrepreneurial artists.

3. The Challenge to NYC's Universities and Engineering Schools

The entrepreneurial university is only at the earliest stages of development in NYC even though many schools have technology-transfer offices and a few have incubator facilities. No NYC school has made their academic reputation as an engine of economic development. Yet, NYC has all the ingredients to become a leading site of high-technology firm formation, such as major research universities, venture capital firms, intellectual property law firms, important corporate and government research laboratories, and cultural attractions. What could be missing?

What may be missing to explain the relative lack of technology-based regional economic development in NYC is that while sufficient institutional conditions exist to a high degree, the necessary *cross-cutting networks*, among financial resources, scientific talent, and business expertise, are weak in NYC.

NYC has large institutions, both firms and universities, with relatively little incentive for interaction within and across sectors. Mary Good, former Undersecretary for Technology in the U.S. Department of Commerce, described how at newly emerging high tech clusters that she has visited, such as Missoula and Bozeman, Montana, local university officials took the lead in bringing together government and business leaders. The NY Academy of Sciences (NYAS) is taking this role on behalf of the knowledge sector in NYC. Although some academics and industrialists would like universities to restrict themselves to their traditional roles of training students and publishing research findings, many governments fund programs to encourage academic institutions to generate new economic activity. Some venture capitalists advise prospective academic founders of companies that the best way to launch their firm is to remain on campus and work with students to develop the early stages of their technology.

C. The Entrepreneurial State and Locality

States and localities have come to realize that when they lose jobs, they lose taxes and replace the taxes with new expenses to assist people who are no longer earning money and receive public assistance. One way that states and localities have responded is to provide tax reductions to companies that say they are considering moving away. This approach is a "company-specific" approach. The problem is that once one company receives such aid, the line of other companies immediately forms. This approach has been questioned.[71]

[71] "The policy of bribing businesses to stay in New York … is a lousy way to create jobs," according to Bill Stern, former head of the NY Urban Development Corporation. "It favors established businesses over new ones… and is grossly unfair to small businesses." "A Fight to the Death?" *The Economist*, July 11, 1998. Or Jim Dwyer, "Need a Handout? Be a Corporation," *NY Daily News*, January 24, 1999, p. 8.

Instead of a "company-specific" approach, some states and cities have adopted an "industry-specific" approach to economic development. Certain industries qualify for special assistance. In NYC, for example, an office has been created for the film and broadcasting industries, to facilitate obtaining permits for shooting films.

Others have followed an investment approach with industry-specific guidelines. The NYC employee pension funds in 1983 created an alternatives investments pool with a venture capital component focusing on industries that might offer a better-than-average return; because of the risk-avoiding principles of the "prudent person" rule, the investments must meet certain conditions.[72] In 1982, NY State created the Corporation for Innovation Development to assist industrial innovation.

NYC is a good incubator, but will the companies stay?[73] Will the software companies that are being capitalized in the first half of 1999 remain in NYC when they are making a profit?[74] The City and State taxes, especially capital gains taxes, become more prominent when the company starts making a profit.

Temporary economic-development inducements can lead to jobs on the run when the inducements expire. A long-run approach is to level the playing field for all firms in all industries, cutting broad-based taxes like the NYC and NY State personal income tax, and investing in quality-of-life improvements in the local business climate.

1. State High-Tech Policies: North Carolina

Can state governments do anything to help along the process of job creation in technology industries? Since the 1970s, state governments have established science and technology agencies to spur science-based economic development by supporting research centers at universities, technology extension services for older firms, and venture capital funds to assist new firms. They have become more active in the 1980s, supporting both universities and business. Economic strategy has shifted at the state and local level toward regional knowledge-based development. Older regional policies were oriented toward luring firms from elsewhere, either by "improving the business climate" (i.e., lowering taxes or reducing pressures for higher wages) or, more directly, by offering inducements to firms to relocate. The new thesis is: "Grow your own firms."

North Carolina has become the high-tech center of the south because of a science-based economic-development strategy that dates to the early 1960s, when the Research Triangle's Research Park was founded. The park was the physical manifestation of a

[72]The trustee of a fund [assumed in that era to be male] "shall conduct himself faithfully,…he is to observe how men of prudence, discretion and intelligence manage their own affairs." Citation from Harvard v. Amory, 1830, in Eisinger, p. 255.

[73] This question was asked by William Tucker of elevator.com in "Silicon Alley Comes of Age at Last? and Gets Ready to Leave Town," *NYPost*, Editorial Pages, March 22, 1999.

[74] Ireland provided five years' tax holiday to new start-ups and Ireland now accounts for the manufacture of 70 percent of the computers sold in Europe. But as the five years end, some companies are moving on.

successful strategy of using the state's political clout to attract branch laboratories of Federal agencies. This research base was then used to attract the R&D laboratories of leading technology firms, such as IBM, to locate in the park. The state's three leading universities were the official geographic points of the triangle.

2. Pennsylvania

Pennsylvania has elements of the academic-industry-government partnership in place. In Pittsburgh and the surrounding western Pennsylvania region, an innovation-friendly environment has been developing with a wave of formation of new high-tech firms. Pennsylvania's Ben Franklin program has encouraged linkages between universities and industry by supporting cooperative research projects. Ben Franklin also made available "seed venture capital" funding for start-up firms.

In less research-intensive states, economic-development policy has taken the form of providing set-up costs for scientists to move their research to the state. The belief is that such a faculty member has the job-creating impact of building a bridge or a tunnel. The immediate economic effects are in the multiplier effect of the research groups and the grants they bring with them. The potential long-term effect is that a start-up firm may arise from the research and thrive in the local economy. A high-tech firm-formation strategy is becoming the core of regional science policy and is reinforced at the Federal level where partial funding is available for state programs.

3. Virginia

The Northern Virginia Technology Council is a strong regional network of 900 high-tech companies actively seeking to encourage cooperation, networking, and start-ups. A Netrepreneur program provides mentoring and private equity. New Vantage Partners focuses on the investor side.[75]

4. Austin, Texas

Austin created the Texas Capital Network and is seeking to expand its services as The Capital Network. The non-profit organization matches entrepreneurs and investors for a fee. It has about 300 investors and has processed 3,000 start-ups. It works with a regional incubator and the Texas Angel Investors, modeled on the Band of Angels in Silicon Valley. The program is also linked with IC^2, a foundation that brought together the University of Texas at Austin, the City of Austin, and local investors.[76]

D. Working with the Federal Government

Recently, the Federal government allocated funds to support Manufacturing Extension Service sites (NY State has a site). This new and direct active role of the Federal

[75] Web site: newvantagepartners; e-mail: NVTC.org.
[76] The Capital Network is run by David Gerhart, who moved to Austin to escape "long commutes from work in Silicon Valley to an affordable home."

government in supporting industrial development is a new element in the innovation environment in the United States.

It has been more than a century since the U.S. government took its last great initiative to advance civil technology by giving the states Federal land for universities devoted to agricultural and mechanical arts and sciences. However, the United States, beginning with a rationale for a patent system in its Constitution, has always encouraged technically oriented economic development, and some state governments have done so aggressively. For example, NY State sponsored the Erie Canal and the Federal Government sponsored coastal-mapping surveys and expeditions to the interior such as those of Lewis and Clark to determine natural resources. These projects nurtured the growth of civil engineering, oceanography, and geology early in the 19th Century.

Since World War II, the U.S. government has indirectly supported technological innovation through military research spin-offs. The United States has also funded the National Institutes of Health, which, through their programs of fundamental research, have encouraged the growth of the nation's biotechnology industry.

Although industry funding of academic science declined during the early post-war era, it was the decline in Federal funds for academic research in recent years that has made university-corporate links salient again. But that was only the proximate cause. The research base established with Federal funds at leading public and private research universities contained a wealth of only partially tapped knowledge that it was believed could be translated into economic development.

The Bayh-Dole Act of 1980, which assigned the intangible property of scientific and technological knowledge emanating from federally funded research, to the university in which the discovery was made, is showing signs of becoming as significant to academia as the Morrill Act of 1862. The earlier law donated Federal land to support the development of higher education for the improvement of agricultural and industrial practice. The later law has grown in importance during the years since its passage into the virtual equivalent of a land grant to the entire research university system.

E. Conclusions

Cooperation has been an essential element of the software industry's development. Silicon Valley's success has been attributed in part to a lax culture in relation to intellectual-property rights. The California legal system is viewed as taking a more relaxed attitude toward trade-secret laws than other states; some of this relates more to the attitudes of the judiciary and local business leaders than differences in statutes. NYC has built on its strength in the arts and emerged as an important player in the New Media industry. But the State and City governments have played little role in this process other than participation in conferences and precedent-setting help to individual companies such as DoubleClick and Theglobe.com. Better models have been initiated elsewhere- notably in Virginia and in Austin, Texas- for fostering academic-industry-government cooperation at a regional level.

XII. CONCLUSIONS AND RECOMMENDATIONS

What could happen with the right kind of investment, by the Federal, State, and City Governments, along with private companies and foundations?

A. Conclusions

This report concludes that the location of the computer software industry is dependent on an infrastructure of space and connectivity, people, financing, and community partnership.

NYC has strengths and weaknesses in every one of the areas. NYC has space, but it is expensive. It has the best of creative talent, but weaknesses on the technical side. It is the world center of finance, but has neglected the technology start-ups. It has the potential for tremendous regional energy in technology, mostly unrealized.

Every city's industrial structure is path-dependent. The path is a given. The future of NYC's software industry depends on growing, attracting, and keeping people with needed skills. For NYC, this means such priorities as developing and attracting software writers, nurturing a literate and computer-friendly work force, paying attention to telecommunications needs, and filling gaps in the financing continuum.

1. The Pressing Need for a More Computer-Literate Work Force

In the face of the current stage of the Information Revolution, NYC's software industry is facing a critical shortage of trained and skilled software workers.

The software industry will require not only the intensive involvement of software specialists, but other NYC workers, because

- *Investors* will be needed to finance the growing needs of companies converting content to product, and analysts will be required to keep abreast of the new technologies.
- *Accounting firms* will be needed to keep track of Internet sales and ingenious new ways will be required to make it easy for people to buy products on the Internet without opening up a whole new universe of potential frauds. The percentage of retail sales that will be on the Internet has been projected at 6 percent, and signs are that this projection is too low.
- *Law firms* will be needed to deal with issues of copyrights and patents as content and delivery systems multiply. Relative to the Internet, the intellectual property problems are stupefying and the solutions will require a whole new army of attorneys specialziing in the Internet.
- *More teachers and a greater investment on computers* will be needed at the high school and university level to ensure that relevant software is introduced, explained and used, so that graduates are ready to take their place in a wired workplace.

2. Some Elements of Software Leadership Are in Place in NYC

NYC is in better shape than it may appear. Using the categorization by the industry (NYSIA) of software-industry activities into five groups, NYC is strong in three:

- The City's large corporate headquarters presence means that NYC probably has the largest concentration of in-house corporate software development staff in the nation. The job numbers suggest that Wall Street firms have been cutting back on such staff as they have merged. But many software specialists remain. A growing number of "old media" firms, such as publishers and advertising agencies, are looking at New Media issues and have brought in software specialists to help them with their planning and implementation. The problem with this category of software personnel is that existing methods of capturing job numbers miss them. A software expert working for a publisher is counted as a publisher.
- NYC is also probably in first place in the number of systems integrators, SIC code 7373, the custom developers of computer systems. This would include web-site designers. A large number of small Internet, e-commerce and web-site development companies have made NYC the national center of the New Media and Internet industry.
- NYC is also probably first in the number of systems consultants, who might be categorized as management consultants (for example, the consulting arms of accounting firms) but in many cases are working on software issues and sometimes (EDS, for example, or CSC) are working almost exclusively on software systems. The deep-pocket and sophisticated Wall Street clientele ensures that a large number of companies in NYC are kept busy solely by catering to this industry.
- But NYC is weak, although still among the top 10 locations in the country, in packaged software of the kind marketed by Microsoft and IBM.
- NYC is also weak in education and training in software development.

It is imperative for the City's future that the educational issue be addressed so that the City's slow start on packaged software can also in due course be rectified. Meanwhile, an influx of technologically advanced immigrants has helped to close the gap part way between the demand for staff and the short supply.

Silicon Valley has attracted the largest cluster of venture capital firms. NYC only recently has grown some of its own. However, the recent or imminent capitalizations of two dozen very young Internet-related firms make clear the value of being close to Wall Street. Several networking groups meet regularly to bring together investors and start-up firms.

Finally, several organizations are actively tackling the problems of the industry, including the professional software (NYSIA) and New Media (NYNMA) association, and the NY Academy of Science (NYAS).[77]

[77] Judith Messing, "How to Boost High Tech in NY Area? It's Academic," *Crain's NY Business*, January 11, 1999, p. 13.

3. The Missing Piece

The missing piece in comparing NYC and its main competitors is the lack of a university-business nexus in the form of industrial parks and buildings devoted to young technology companies. The 55 Broad Street renovation was intended to be such a building, but it cannot accommodate a large number of small new firms.

A key to the success of MIT and Stanford in attracting students and stimulating entrepreneurship around them is the existence of R&D centers where advanced research is taking place under the leadership of academics. NYC is not making full use of Federal and state programs for incubators; a mayoral information technology office might work on such ideas. University-linked incubators, whether virtual or real, would strengthen both the educational and the entrepreneurial functions of the City.

Federal and NY State programs already exist for creating incubators and innovation centers. NYC should actively seek or create such centers for software and should add governmental muscle to the work of the NY Academy of Sciences (NYAS) project.

A regional focus to the software industry, which the NYAS is taking, means that some key Federal and industrial research labs in the area can be counted as part of NYC's assets. They include the IBM/Watson center in Westchester, the Lucent Bell Labs in New Jersey, and the Brookhaven lab on Long Island.

B. General Recommendation: Focus on the Industry

The main recommendation is that the software/IT industry needs the attention of the City and the public. NYC has lagged behind other areas, and unnecessarily so. With an aggressive and coordinated effort by NY State, NYC and other regional governments, the industry, and the academic community, the City can consolidate its existing strengths and deal with its weaknesses. With more attention to the industry, the need for educational reforms and regional cooperation should be obvious.

Government officials with responsibility for economic development tend to focus on retaining and attracting large firms. The threat of job loss or prospect of gain is substantial and immediate. Focusing on start-ups, on the other hand, is a long-term goal.

NYC has traditionally focused on finance and real estate as its engines of growth. Growing high-tech jobs requires a shift in the thinking of business and government leaders concerned with economic development, toward a strategy of growing new firms from the technical and artistic expertise residing in the region.

NYC is producing programmers and computer-savvy graduates by the hundreds, but its educational institutions lack the close ties with entrepreneurs that is true in the Boston and San Francisco areas. A small Citywide office should be created to work on building these relationships, possibly with an initial sunset life of five years or so.

Funding for the office might be on a three-way basis, with the City and State matching whatever businesses contribute for the office. It should work closely with the software industry (NYSIA) or the federally supported Industrial Technology Assistance Corporation, or both.

Here are some suggestions for such an information technology office to consider:

- The office could work with software job fairs to help schools and universities recruit software teachers and faculty from other cities, such as Boston and the San Francisco-San Jose corridor, but also other technology centers such as Pittsburgh, Austin, Dallas, Los Angeles, and Washington, DC.
- It could also work with the NY Congressional and State delegations to ensure that the immigration doors remain open for skilled software personnel from other countries and spur a more active role in developing new intellectual-property rules to extend copyrights to the Internet. So long as people with needed skills are barred from entry to the United States, the work will go abroad rather than stay here.
- It could try to bring in software experts to teach as adjuncts in the CUNY or private universities, as a way of bridging the gap between what is known and how quickly it is taught.
- It could help focus public attention on classification of software applications. Better public policy decisions are made when the underlying classifications and data are more realistic and reliable.
- The office could also cooperate with various existing networking organizations to expand software fairs, for example by creating a web site fair, to show people how they can create their own web sites and what they can do with them.
- The office could help those seeking to invest in start-up companies, or join one, to be exposed to the various networking groups.
- The office could work with the NY Public Service Commission, Con Edison, Bell Atlantic, and other utilities and agencies to get attention paid to the telecommunications needs of start-up companies, and also attempt to obtain for smaller businesses the lower electrical and telecommunication rates now enjoyed by large companies.
- It could seek to obtain cuts in telephone rates tied to telephone taxes so that phone service is less expensive for Internet-related companies, for which telephone charges can be a significant component of costs.
- It could actively promote phasing out NYC's unique taxes, the unincorporated business tax, the remaining commercial rent tax, and the unique City taxation of S Corporations and C Corporations. These taxes fall most heavily on small businesses.
- It could be based in the Science, Industry, and Business Library, in the former Altman's Department Store, where the CUNY Graduate Center is also being relocated. Or it could be co-located with pilot incubators (virtual or real or both) in the CUNY Computer Science Department, NYU's Interactive Telecommunication Program (which already has an entrepreneurial ethos), or Brooklyn Polytechnic.
- It could encourage NYC and NY State officials to examine whether and how the legislative, legal, and business climates can be improved to encourage the development of new software companies.

The proposals that follow are examples of the kind of pro-active support of the industry that the office could consider.

C. Addressing NYC's High Cost of Doing Business and Living

The three main concerns relative to the high cost of doing business are space, connectivity, and taxes.

1. Space: Incubators and "Accelerators"

Start-up software firms need inexpensive, wired space. The City should think in terms of incubator buildings or even "technology parks" in the boroughs other than Manhattan, or on Governor's Island. The City can help by using existing programs for tax credits or subsidized mortgages.

The City should contribute to funding creation of incubator projects at each college and university in NYC, public and private, both community colleges and four-year institution, preferably on a matching basis with NY State and private sources. Proposals for projects specializing in different fields should come form the schools themselves while the City should provide technical as well as financial assistance to these projects, perhaps from a new office for this purpose within the EDC. An incubator facility with subsidized space for technology firms, to locate for a limited period of time, with support facilities and business advice to take the first steps in an environment where they are in close touch with peers. A possible model is the Center for Entrepreneurship at Linkoping University in Sweden, which provides this kind of support for recent graduates, especially in software.

The amount of office space available for redevelopment in lower Manhattan, alone, was not long ago estimated at 35 million square feet. Space and land are available also in Staten Island, Governor's Island, Queens, Brooklyn, and the Bronx. Certainly incubator facilities do not have to be newly constructed, but even without extensive renovation physical incubators may be costly because of the rentals NYC buildings are expected to earn, which may be much higher than a typical start-up can afford. Brazil's approach is to provide municipal subsidies to incubator facilities. A less costly approach is to offer "virtual" incubators, assisting start-up firms with services, but not a physical location. But many entrepreneurs feel that a major benefit of an incubator is the opportunity to interact with fellow firm founders, which requires a physical place.

2. Communications Connectivity

To bring down the cost of telecommunications, the City should encourage the Public Service Commission to allow competition for the business of smaller companies. Bell Atlantic should be encouraged to introduce more aggressively ADSL and other new technologies that bring down the cost of communication. The City should open up cable

television networks to interactive communication with wide deployment of cable modems.

3. Taxes

Government services contribute to the quality of life, and taxes are needed to pay for them. On the other hand, as the City economy recovers and the ratio of dependent residents to working residents falls, the opportunity for targeted tax reductions presents itself.

The City should work with the software/IT industry to identify tax burdens that impede its development. Specifically, it should jointly propose legislative recommendations that would reduce (perhaps by raising the threshold) or phase out unique business taxes such as the Unincorporated Business Tax, the commercial rent tax (already scheduled for elimination), the non-recognition of the pass-through privileges of the Subchapter S Corporation, and the alternative tax on shareholders of Subchapter C Corporations.

D. Educating and Recruiting Software Personnel

NYC has no time to lose in bringing its educational resources up to competitive standards.

1. Reinvigorate Math, Science, and Computers in the Schools

As the Comptroller urged in March 1999, the Board of Education needs to pay more attention to the sad state of math and science programs. While waiting for teaching staff to be trained in use of computers, schools might encourage retired or even active executives g to volunteer to talk with teachers and students and bring computers in the classrooms to a functioning and pedagogically useful status.

2. Expand the Role for NYC's Community Colleges

The same concern about the schools may be raised at the university level, both for CUNY and the private universities, although the New Media programs at Columbia, NYU, and the Borough of Manhattan Community College are a success and fill some of the needs of the industry. When an industry is expanding rapidly, as is the case with software, academic resources are hard-pressed to keep up with the demand for training. One approach, used by the Foot Hills Community College District in Silicon Valley is to draw large numbers of persons from the industry into the academic world as part-time teachers. For example, De Anza Community College has a computer science department with a small core of full-time people, supplemented by hundreds of adjunct teachers drawn from Silicon Valley companies. The department has trained everyone from high school dropouts to humanities Ph.D.s to be programmers, filling much of the immense demand for qualified persons from Valley companies that traditional academic departments could not meet. The important feature of the community colleges is that they can respond

quickly to skill needs, using industry personnel to train students, for example, as network specialists.

3. Attract Eminent Software Researchers to NYC's Universities

The Georgia "eminent scholars" program is a model for attracting researchers by providing research funds from local sources. Texas has also adopted a similar strategy. The Stony Brook Biotechnology Center used NY State funds to supplement researchers' Federal grants in order to encourage them to explore the practical implications of their research. "Pump priming" of researchers already in place, as at Stanford, and offering incentives to cooperate across institutional boundaries, as in Canada, are additional strategies to maximize human resources.

E. Generating More Venture Capital for Software Start-Ups

NYC's employee pension funds have authorized the allocation of a portion of their assets to be made available for alternative investments, including venture capital. NYC's software industry should be considered for investment since it may offer high returns, while the investment will at the same time encourage start-ups and help the NYC economy.

A $25 million loan program was authorized by the City Council for loans to technology-oriented industries. This was converted to Loan Guarantee Fund. It should be activated by the Mayor as soon as possible.

F. Encouraging University-Industry Cooperation

Greater university-industry cooperation will benefit both sides as well as the City and regional economies.

1. NYC Student Internships

The significance of software is not only to the creation of new high-tech firms but to enhancement of low- and mid-tech firms. A variety of models have been developed, including "student companies" and internship programs, to assist firms that lack technological expertise. Upgrading such firms through the teaching function of the university can give students "real world experience" while also connecting sectors of industry to academia that ordinarily have little contact. Students are engaged in technology transfer while the process helps develop the work force. NYSIA has a successful internship program with CUNY.

2. Coordinating Resources at Columbia, NYU, and Other Private Universities

Encourage area engineering and arts schools to reorganize themselves into a "virtual MIT." It has long been noted that the several engineering schools in New York City do not have the "critical mass" of their counterparts in other regions. Once a small technical college, MIT, grew into a great technological university since the early 20th century. A liberal arts university can also develop a major engineering school as Stanford has done during this period. Another institution-building model was the creation of Carnegie-Mellon University through merger of engineering and arts institutions, under visionary intellectual leadership. Vannevar Bush turned down the deanship of the Columbia Engineering school in the 1930s, warned by friends that it was too weak even for him to make a difference. Research did develop in NYC in the 1980s and Brooklyn Polytechnic University has recently received an important gift that gives it great opportunities. It is unlikely that any one of these leading local players alone can achieve the breadth and depth of an MIT or Stanford in the foreseeable future. But together with Pratt, Cooper Union, and other local schools, the elements of a major technological university already exist in NYC. Cooperative projects looking toward eventual merger, encouraged by public/private funding, could provide a road to creating a virtual and even an actual MIT for the City.

3. Concentrating Computer-Science Resources within CUNY

CUNY needs to consider the potential of a University-wide School of Computer Sciences and Arts (or a Software Engineering Institute) that might draw on the resources of the Colleges (including the business programs) and the Graduate Center. In addition to expanding existing computer science programs, the School or Institute would provide a home for new centers and departments to be created from the intersection of computer science with other disciplines such as visual arts and molecular biology. The Georgia Tech School of Computer Science and the University of Washington's interdisciplinary department combining computer science and biotechnology are among the possible models. New City, private sector, and foundation funding could be the basis for this expansion. Such an initiative would also serve to renew the CUNY's connection to a local financial base that was largely lost in the fiscal crisis of the 1970s and the subsequent state takeover of public financing of the four-year colleges. The state would continue to supply general base funding while the City would take special responsibility for new initiatives with special local relevance.

G. Encouraging Regional Cooperation: A NY State Role

NYC needs to involve the entire region in a coordinated approach to strengthening the area's software industry. Regional laboratories and others institutions outside NYC could be very important contributors, and suburban living conditions may be more attractive to some of the talent that NYC would like to lure to the region. NY State could lead this regional approach. Many of the proposals suggested above would require NY State and even Federal involvement.

1. An SBIR Program for NY State

Specifically, NY State could organize an application for a Small Business Innovation Research (SBIR) program targeted at software companies in the region. The Federal SBIR program provides a set-aside of research funds for small business. The Federal program is targeted at meeting the research needs of Federal agencies or commercializing technology arising from research supported by the Federal government. A state program should be more closely targeted to local opportunities and needs such as the intersection between software and the arts. A state program can also supplement the Federal program by encouraging and assisting applicants for participation in the Federal program. The state can also assist by filling gaps that currently exist in the Federal process such as the time period between the end of a phase I award and the beginning of a phase II award. From its establishment in 1982, the SBIR program has offered competitive grants that have often been used by researchers in universities and large companies as a means to fund their own firm. (Indeed, the official funding of a firm can wait until after notification of a successful application has been received.)

The Federal program currently operates at the level of $1.2 billion in grants given out in stages, phase 1 to show proof of concept, phase 2 to develop a prototype, and phase 3, achievement of private sector funding to take the final steps to the market. NY State currently has small funding programs to support technology entrepreneurs; it should expand and develop these programs into a major initiative that would attract attention within and without the state. Even the Federal SBIR program may not be as well known in NY as it should be. The SBIR workshop at the January 1999 software summit attracted only a half-dozen persons, despite the greater likelihood of achieving early stage funding from this public source than from private venture capital that usually wishes to wait until the later stages of new-firm formation to invest. The SBIR has provided a model for public investment to fill the gap in early-stage financing.[78]

2. Bringing Together Regional Software Resources

Another strategy is to combine NYC university resources with those of regional universities, industry, and government, through consortia under the umbrella of a non-profit institute or association with a regional vision. Academic resources in a particular field are often scattered among a broad range of public and private schools. Individually, they each may lack critical mass. If they could be brought together through the incentive of organizing a center jointly, rather than as an individual school according to the present CAT model, a "virtual MIT" could be created. In Canada, the incentive of receiving a greater scale of research funds than any could attract individually is the carrot that draws groups of researchers from universities across the country together compete for a "Center of Excellence." The recent interest shown by the NY Academy of Sciences in the regional software industry suggests that it might be able to play this kind of umbrella role in the future. Now, the prospect of grant money for research needs to be pursued.

[78] Henry Etzkowitz, Magnus Gulbrandsen, and Janet Levitt, *Government Funding Sources for Technology Entrepreneurs and Innovative Firms* (NY: Harcourt Brace, forthcoming).

APPENDIX A. SOFTWARE INDUSTRY DETAIL, NYC

A. Industry Definition and Subcategories

The following charts detail the software-industry subcategories, i.e., the seven non-hardware 4-digit codes within Standard Industrial Classification (SIC) code 737. The two other 4-digit codes relate to hardware. See note to Table 1-1 and references.

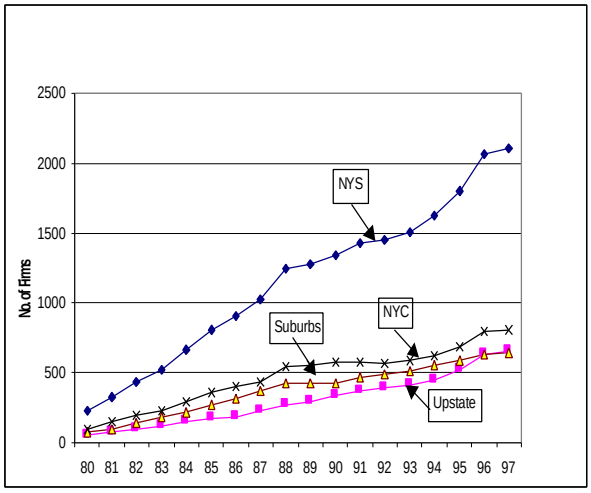
B. Computer Programming Services, SIC Code 7371

Computer-programming services is the basic category for software. It is shared fairly evenly among NYC, the NYC suburbs and upstate. It hasn't grown as rapidly as other categories. However, some computer programming firms indicate they classify themselves under "other" computer-related services (Code 7379) rather than Code 7371.

1. Number of Firms

The number of firms in computer-programming in NY State grew most rapidly in the 1980s and in 1993-1996, to about 2,100 in 1997. The growth in the number of firms in NYC was slower than upstate and the average for the state, possibly because NYC firms are more specialized than in the other regions and are therefore more likely to have firms classified in the other categories. (See Chart A-1.)

Chart A-1. *No. of Firms*

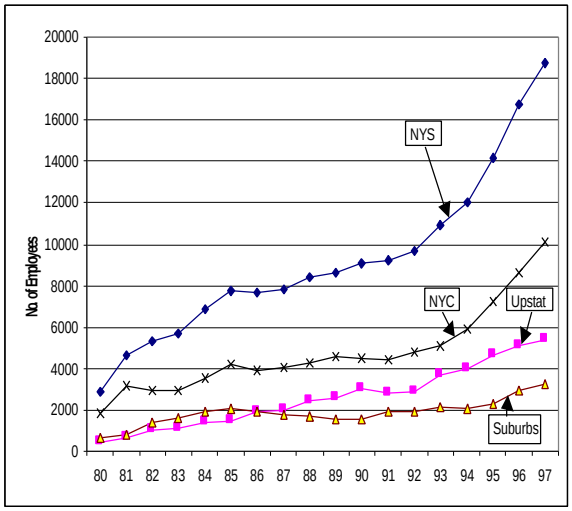


Source: NYS Department of Labor

2. Number of Employees

Though the number of firms did not grow rapidly, the number of employees in computer-programming services in NYS has grown rapidly after 1992, to about 19,000 jobs. The number of employees in NYC increased even more rapidly, pulling away from the upstate and suburban areas, to more than 10,000 jobs, more than half the state total. (See Chart A-2.)

Chart A-2. *No. of Employees*

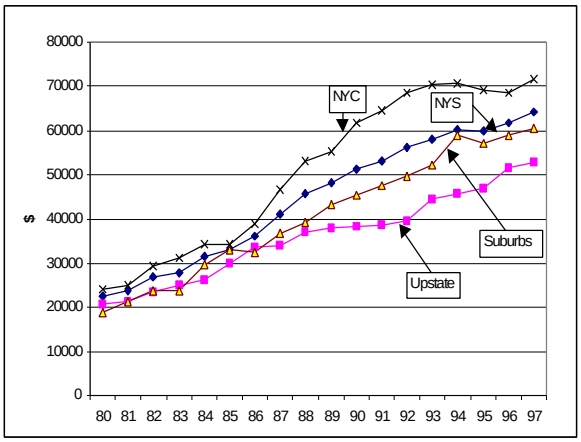


Source: NYS Department of Labor.

3. Average Wage per Employee

The average wage rate per employee in computer programming services area in NYC increased from 1985 to 1994, decreased from 1994 to 1996, and then went up again. The average wage rate in NYS and upstate decreased from 1994 to 1995, increased again after 1995. The average wage rate was higher in NYC than in upstate and NYC suburb areas. (See Chart A-3.)

Chart A-3. *Wages/Employee*



Source: NYS Department of Labor.

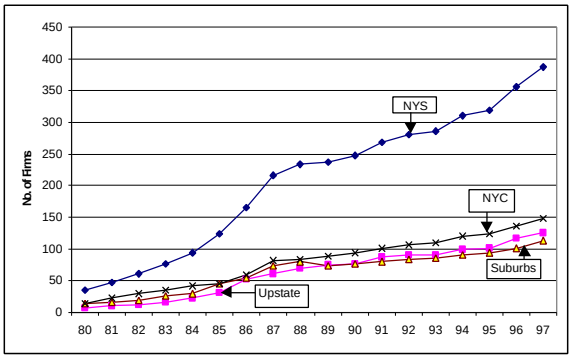
C. Pre-Packaged Software, SIC Code 7372

Pre-packaged software is a relative small category for software, accounting for about 5 percent of the number of firms and over 7 percent of the number of employees in computer-service industry in NY State in 1997.

1. Number of Firms

The number of firms in prepackaged software area in NYS increased sharply in 1984-1987. The increase slowed after 1987. The number of firms in NYC has been higher than that in upstate and the NYC suburbs since early 1980s. (See Chart A-4.)

Chart A-4. *No. of Firms*

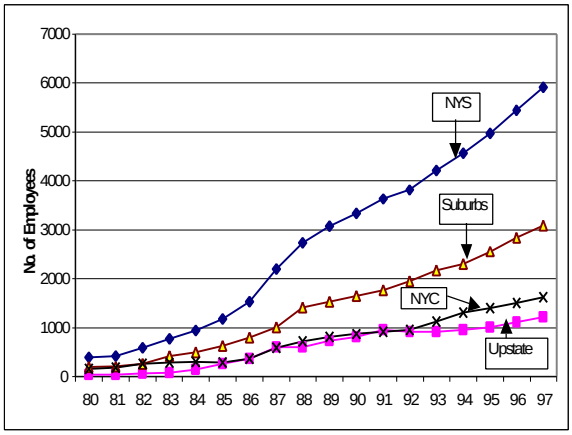


Source: NYS Department of Labor.

2. Number of Employees

The number of employees in prepackaged software area in NYS increased sharply before 1987. The increase slowed after 1987. The number of employees in NYC has been lower than that in the suburbs. The larger number of firms and smaller number of employees show that the average scale of firms in NYC is smaller the NYS average. (See Chart A-5.)

Chart A-5. *No. of Employees*

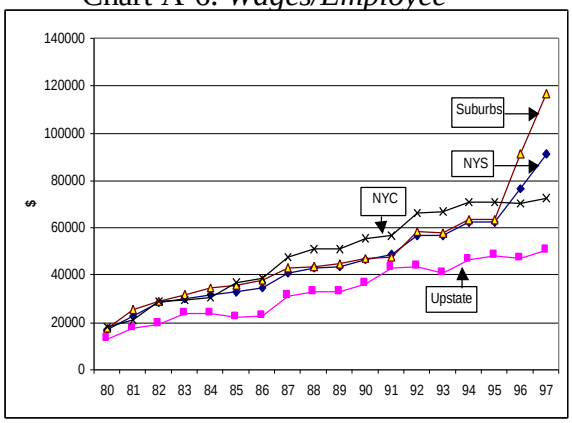


Source: NYS Department of Labor.

3. Average Wage per Employee

The average wage per employee in prepackaged software area in the suburbs increased dramatically in 1996 and 1997, raising the state wide wage per employee. The increase in wage per employee has been slow in NYC and upstate. The average wage in NYC has been lower than that in the suburbs since 1996. (See Chart A-6.)

Chart A-6. *Wages/Employee*



Source: NYS Department of Labor.

Putting together wages and employees, the total wages in prepackaged software area increased significantly since 1995, because of the dramatic increase in total wages in the NYC suburbs, which accounted for about $360 million of the approximately $540 million in the industry statewide. NYC's share was slightly above $100 million in 1997 and the upstate share was slightly more than half of the NYC share.

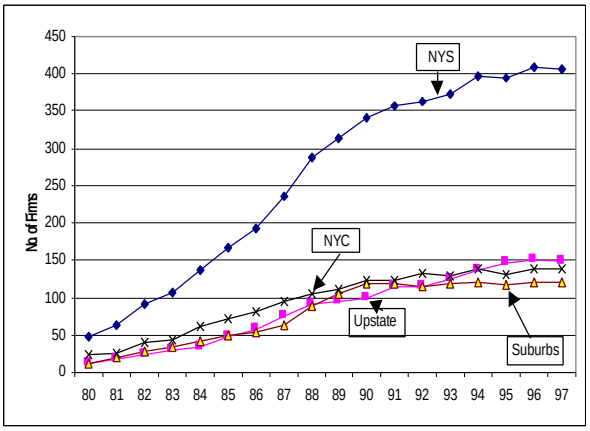
D. Computer Integrated Systems Design, SIC Code 7373

Computer integrated systems design accounts about 5 percent of the number of firms and 7 percent of the number of employees in computer-services industry in NYS in 1997.

1. Number of Firms

The number of firms in computer integrated systems design in NYS increased significantly in the 1980s. The growth rate has slowed since the early 1990s. The number of upstate firms exceeded the number in NYC slightly since 1995. (See Chart A-7.)

Chart A-7. *No. of Firms*

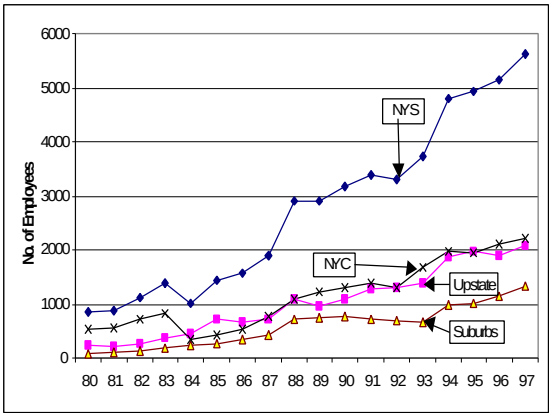


Source: NYS Department of Labor.

2. Number of Employees

The number of employees in computer integrated systems design in NYS grew dramatically in 1993 and 1994, mainly because of the increase in the number of employees in NYC (in 1993), upstate and suburbs (in 1994). The growth rate has slowed since 1995. The number of NYC employees slightly exceeded the number upstate in 1993-1994 and 1996-1997. (See Chart A-8.)

Chart A-8. *No. of Employees*

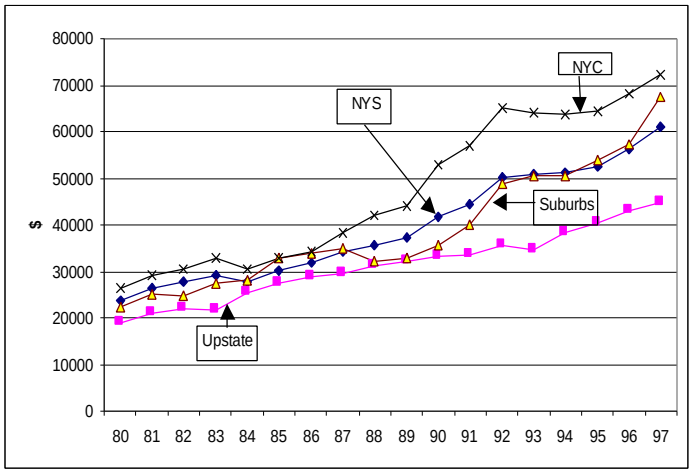


Source: NYS Department of Labor.

3. Average Wage

There were sharp increases in average wages in NYC and the NYC suburbs in 1989-1992 and 1996-1997. The average wages decreased in 1993-1995 in NYC. NYC's average wage has been the highest since 1980s, but the big increase in the suburbs in 1997 significantly reduced the gap. (See Chart A-9.)

Chart A-9. *Wages/Employee*



Source: NYS Department of Labor.

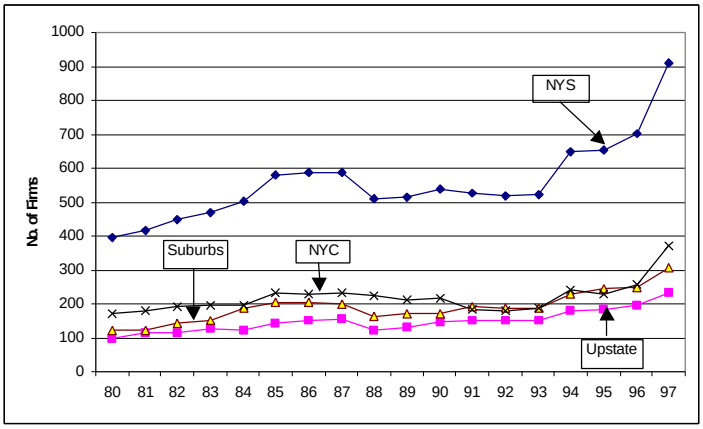
E. Data Processing and Preparation, SIC Code 7374

Data processing will be moved under the NAICS system to the information heading (51), under information services (514).

1. Number of Firms

The number of firms in data processing and preparation area in NYS decreased in 1988, remained stable from 1989 to 1993, and increased significantly since 1994. The number of firms in NYC decreased slightly since late 1980s, increased in 1994, 1996 and 1997. The dramatic growth in the number of firms in NYC was the main factor affecting the increase in the number of firms in NYS in 1997. (See Chart A-10.)

Chart A-10. *No. of Firms*

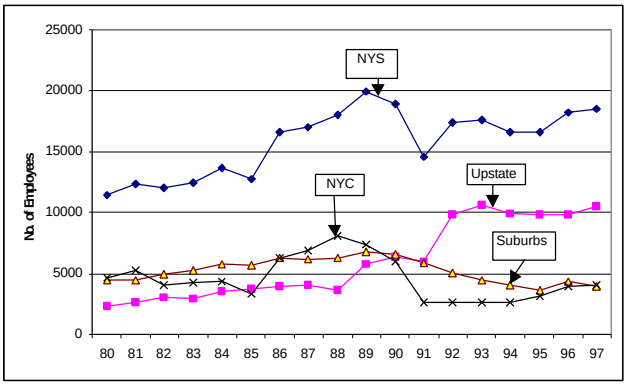


Source: NYS Department of Labor.

2. Number of Employees

The number of employees in data processing and preparation area increased in 1980s, declined in 1990 and 1991, increased in 1992 and 1993, decreased slightly afterwards, and increased again in 1996 and 1997. The number of employees in NYC went down from 1989 to 1991, remained constant from 1992 to 1994, and increased since 1995. The number of employees in upstate went up, while that in the suburbs went down in the early 1990s. (See Chart A-11.)

Chart A-11. *No. of Employees*

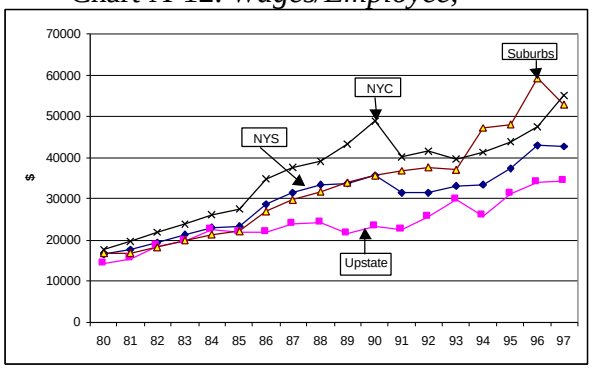


Source: NYS Department of Labor.

3. Average Wage

The average wage in data processing and preparation area in NYC went down sharply in 1991, and picked up since 1994. The average wage in the NYC suburbs increased from 1980 to 1993, jumped up in 1994 and 1996, and decreased in 1997. The average wage in NYC exceeded that of the suburbs again in 1997. (See Chart A-12.)

Chart A-12. *Wages/Employee*,



Source: NYS Department of Labor

The change in total wages has a similar pattern as the change in the number of employees. But the increases in total wages in NYS, NYC and upstate were greater than that in the numbers of employees.

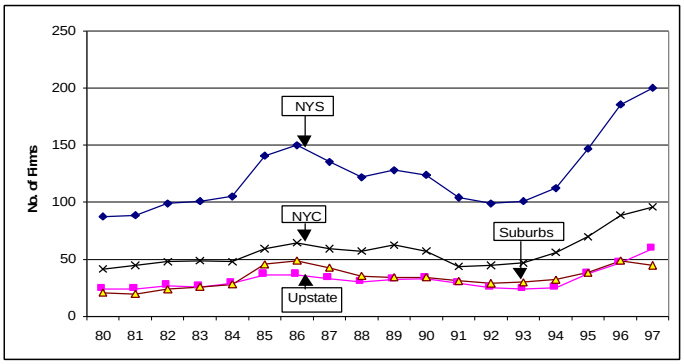
F. Information-Retrieval Services, SIC Code 7375

Information-retrieval services are heavily content-oriented and therefore will be moved in the NAICS system to the publishing heading (51), as an information service (514), rather than the professional, scientific and technical heading (541).

1. Number of Firms

The number of firms in the information-retrieval services area increased until 1986, decreased in 1987-1988 and 1990-1992, then picked up dramatically since 1993. The number of firms in NYC followed similar patterns. The number of firms in NYC has been more than that in upstate and suburbs. (See Chart A-13.)

Chart A-13. *No. of Firms*

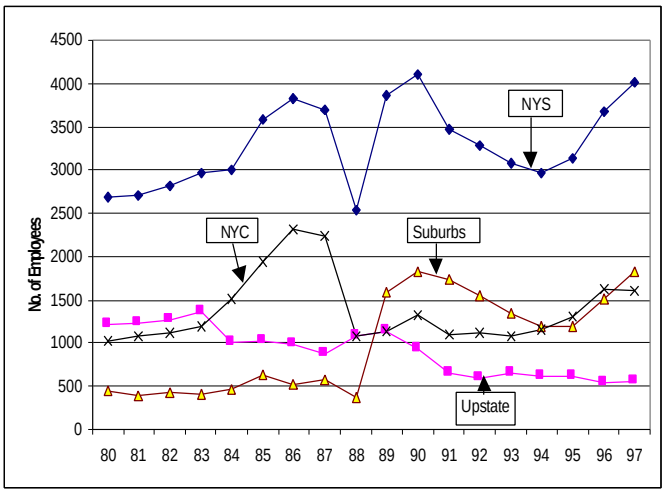


Source: NYS Department of Labor.

2. Number of Employees

The number of employees in information-retrieval services dropped sharply in 1987 and 1988, increased sharply in 1989 and 1990, decreased again in 1991-1994 period, and picked up again since 1995. The information retrieval services in NYC followed similar patterns, but the increase in 1989-1990 and 1997 were not as sharp as that in NYS. The dramatic increases in the number of employees in NYS in 1989-1990 and 1995-1997 were mainly due to the increase in the suburbs. (See Chart A-14.)

Chart A-14. *No. of Employees*

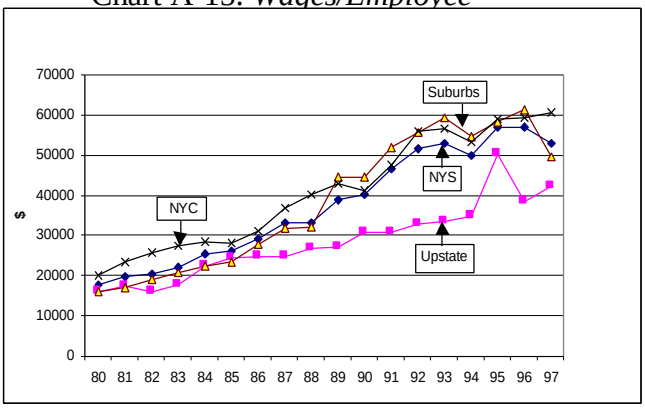


Source: NYS Department of Labor.

3. Average Wage

The average wage for employees in information-retrieval services firms increased until 1993, then dropped in 1994 and 1997. The average wage in NYC was the highest until 1988. The average wage in the NYC suburbs exceeded that in NYC in 1989-1994 and 1996. The suburban average wage dropped in 1997 and NYC's average wage became the highest again. (See Chart A-15.)

Chart A-15. *Wages/Employee*



Source: NYS Department of Labor.

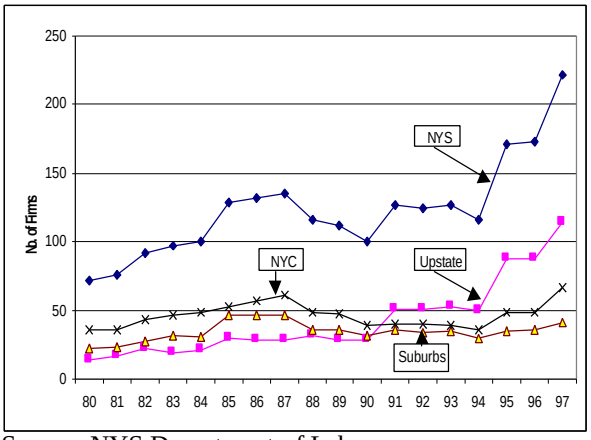
G. Computer-Facilities Management, SIC Code 7376

Computer-facilities management belongs under computer services (rather than facilities management) because it tends to be heavily software-driven.

1. Number of Firms

The number of firms in computer-facilities management in NYS decreased in 1988-1990 and 1994, increased significantly in 1991, 1995 and 1997. The increase in the number of firms in NYS was due to the increase in the number of firms in upstate. The number of firms in upstate has exceeded that in NYC since 1991. (See Chart A-16.)

Chart A-16. *No. of Firms*

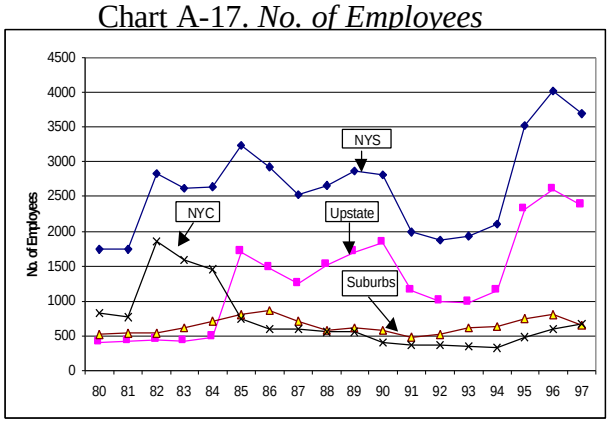


Source: NYS Department of Labor

2. Number of Employees

The number of employees in computer-facilities management in NYS increased in the late 1980s, decreased in the early 1990s, increased again in 1992-1996 and decreased again in 1997. The fact that the upstate curve is similar shows that the NYS changes are driven by upstate. The number of NYC employees in 1997 was about the same level as in 1985. (See Chart A-17.)

Chart A-17. *No. of Employees*

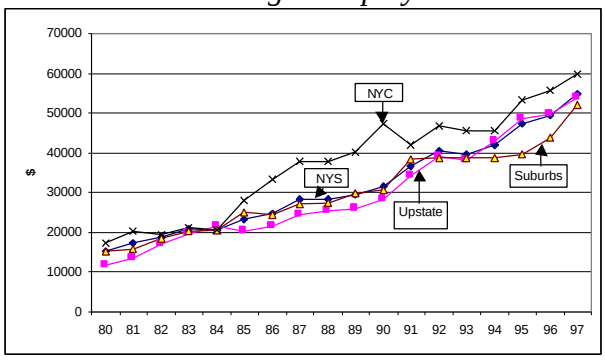


Source: NYS Department of Labor

3. Average Wage

The average wage in computer-facilities management area in NYC has been the highest since 1985 and kept growing except 1991 and 1993-1994 period. But the gap between NYC's average wage and that in upstate and the suburbs shrinks recently. (See Chart A-18.)

Chart A-18. *Wages/Employee*



Source: NYS Department of Labor

Total wages ordinarily vary most with the number of employees, except that NYC's total wages exceeded that of the suburbs in 1997. The total wages in upstate account for $130 million of the NYS total of $200 million, or 65 percent of the total.

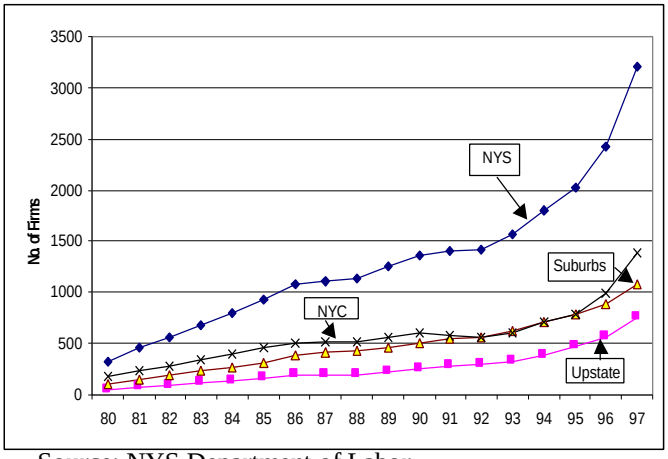
H. Computer-Related Services, SIC Code 7379

Computer-related services represent all other computer services not captured by the other titles, not counting hardware-related leasing and repair, which are excluded from our four-digit analysis (although these numbers are included in the overall three-digit 737 SIC category).

1. Number of Firms

The number of firms in computer-related services increased continuously in NYS, upstate and the suburbs. The number of firms in NYC decreased in 1991 and 1992, increased since then, pulling away substantially from the upstate and NYC suburban areas in 1995-1997. (See Chart A-19.)

Chart A-19. *No. of Firms*

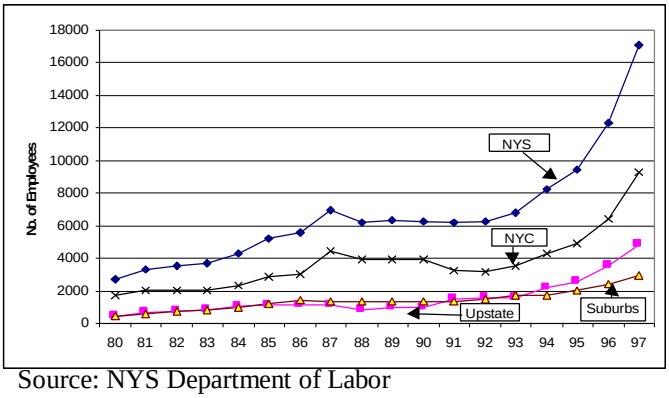


Source: NYS Department of Labor.

2. Number of Employees

The number of employees in computer-related services in NYS dropped in 1988, remained stable from 1989 to 1992, and grew substantially after 1993. The number in NYC dropped in 1987 and 1991-1992, and increased dramatically after 1993: NYC is the main source for the growth in the state. (See Chart A-20.)

Chart A-20. *No. of Employees*

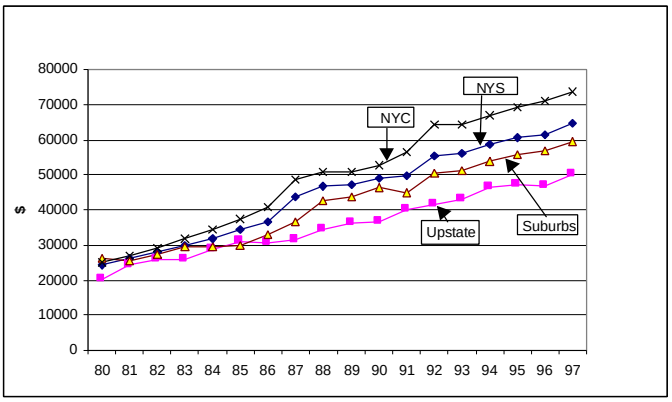


Source: NYS Department of Labor

3. Average Wage

The growth route in average wage in computer-related services area in NYS, NYC, upstate and suburbs follow similar patterns. The highest growth rates were in 1987 and 1992. The average wages in NYC has been the highest since 1981. (See Chart A-21.)

Chart A-21. *Wages/Employee*



Source: NYS Department of Labor.

Total wages in computer-related services in NYS and NYC increased after 1992. The increases in recent years are substantial. NYC's total wages in 1997 accounted for $700 million of the $1,100 million in the state, or more than 60 percent of the total. Total wages upstate exceeded wages in the NYC suburbs after 1994.

APPENDIX B. TRENDS IN NYC SUBURBAN COUNTIES

A. Industry Definition and Subcategories

The following charts are details on the subcategories of the software industry, i.e., the seven non-hardware subcategories of Standard Industrial Classification (SIC) Code 737. The subcategories are all the 4-digit codes in the 737 category except the two that relate to hardware. See the note to Table 1-1 and references.

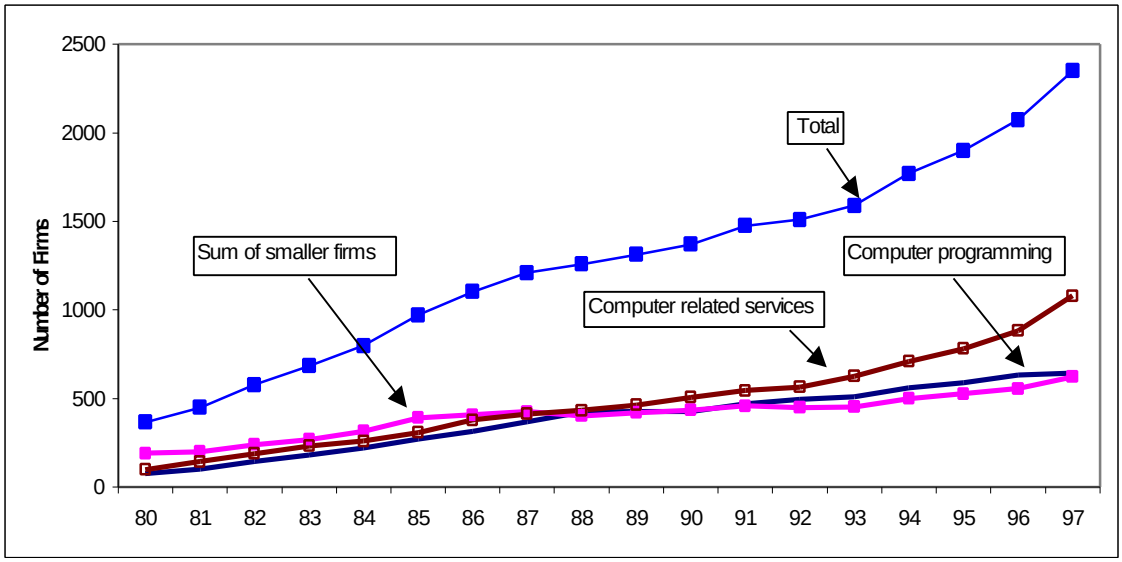
B. Trends in NYC's Suburban Counties

The analysis for the NYC software industry is repeated for the NYC suburbs (i.e., the five downstate NY State counties east and north of NYC.)

1. Number of Firms

The number of firms in NYC's suburban counties grew significantly in the 1980s to 1987. Then the growth slowed down slightly until 1993, and has picked up again since 1994. (See Chart B-1.)

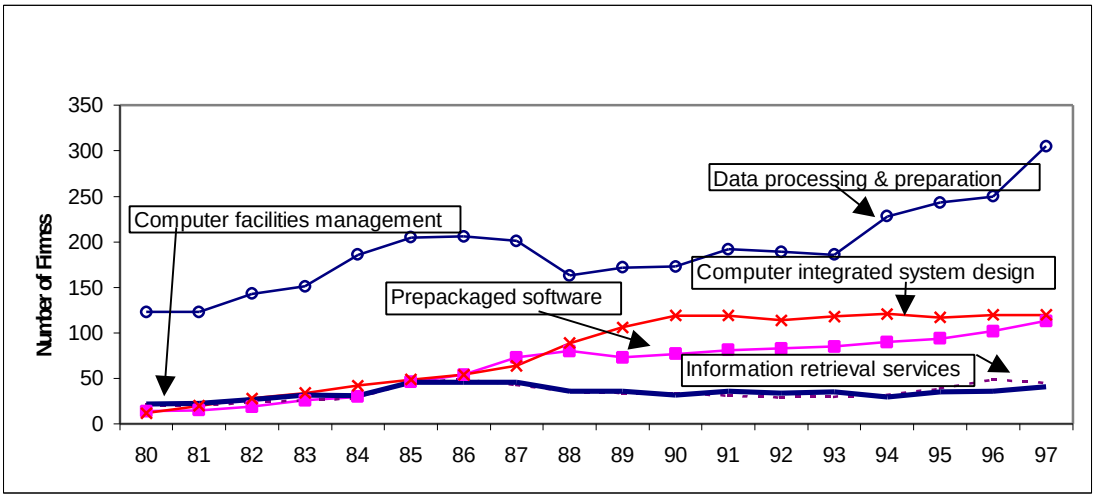
Chart B-1. *No. of Firms, Software Industry, NYC Suburbs, 1980-1997*



Source: NYS Department of Labor. The NYC suburbs is composed of five counties that, along with the five NYC counties/boroughs, make up the "Combined NY Area." To the east, they are Nassau and Suffolk Counties, which constitute the "Nassau-Suffolk Primary Metropolitan Statistical Area (PMSA). To the north of NYC, they are Westchester, Rockland, and Putnam Counties, i.e., the remainder of the eight-county "NY PMSA."

Within the categories with smaller numbers of firms, the largest numbers are in data processing and preparation. This category saw significant growth in the mid-1980s but went into dormancy until 1994, when it started to grow rapidly, increasing by more than 50 percent from 1994 to 1997. (See Chart B-2.)

Chart B-2. *No. of Firms, Software Industry, NYC Suburbs, 1980-1997*



Source: NYS Department of Labor. See notes to Chart B-1.

The total number of firms in the NYC suburbs in the software industry rose at an annual average of 11.8 percent from 1980 to 1997. However, after 1992 the annual average growth in total number of firms reduced to 9.3 percent. Computer programming services, prepackaged software, computer integrated system design, and computer related services grew at much slower rates during 1992 to 1997 compared with 1980 to 1992 period. On the other hand, the number of firms in data processing and preparation and information retrieval services firms grew much faster after 1992 than before 1992. (See Table B-1.)

Table B-1. *Average Annual Change in Number of Software Firms, NYC Suburbs, 1980-1997, Ranked by No. of Firms in 1997*

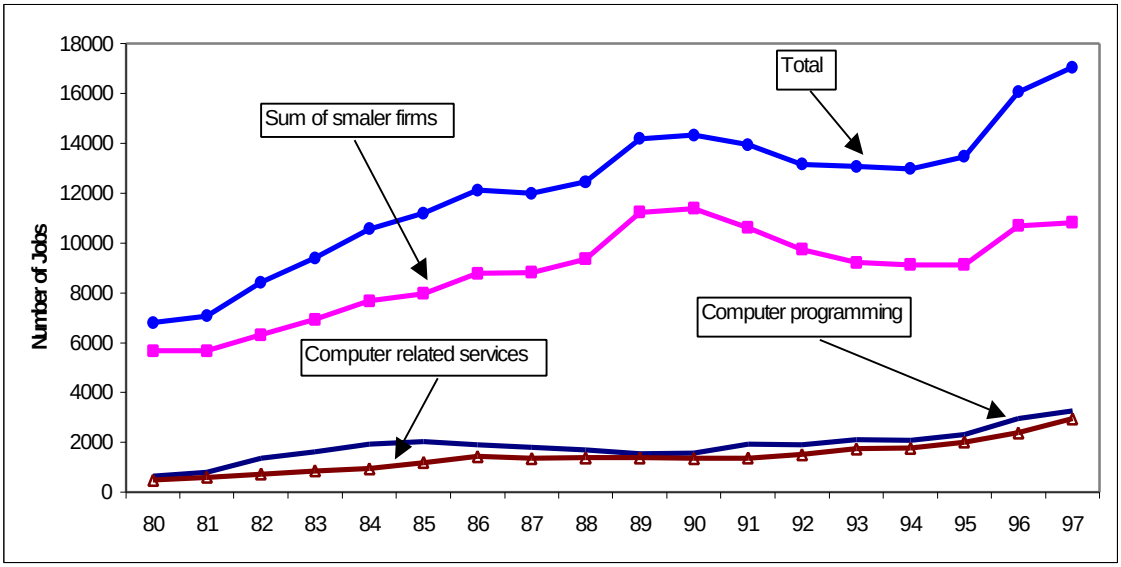
Rank		**Number of Firms**			**Average Annual Change in Number of Firms, Percent**		
		1980	1992	1997	1980-1997	1980-1992	1998-1997
1	Computer-Related Services	99	566	1081	15.1 %	15.6 %	13.8 %
2	Computer Programming Services	75	496	645	13.5 %	17.0 %	5.4 %
3	Data Processing & Preparation	123	189	305	5.5 %	3.6 %	10.0 %
4	Computer Integrated System Design	12	114	120	14.5 %	20.6 %	1.0 %
5	Prepackaged Software	14	83	113	13.1 %	16.0 %	6.4 %
6	Information-Retrieval Services	21	29	45	4.6 %	2.7 %	9.2 %
7	Computer-Facilities Management	22	34	41	3.7 %	3.7 %	3.8 %
	Total	**366**	**1511**	**2350**	**11.6 %**	**12.5 %**	**9.2 %**

Source: NYS Department of Labor.

2. Number of Employees

Overall, the number of software employees in suburban NYC increased in the 1980s, decreased in 1990-1994 (in a delayed reaction to the NYC recession), then picked up again in 1995-1997. (See Chart B-3.)

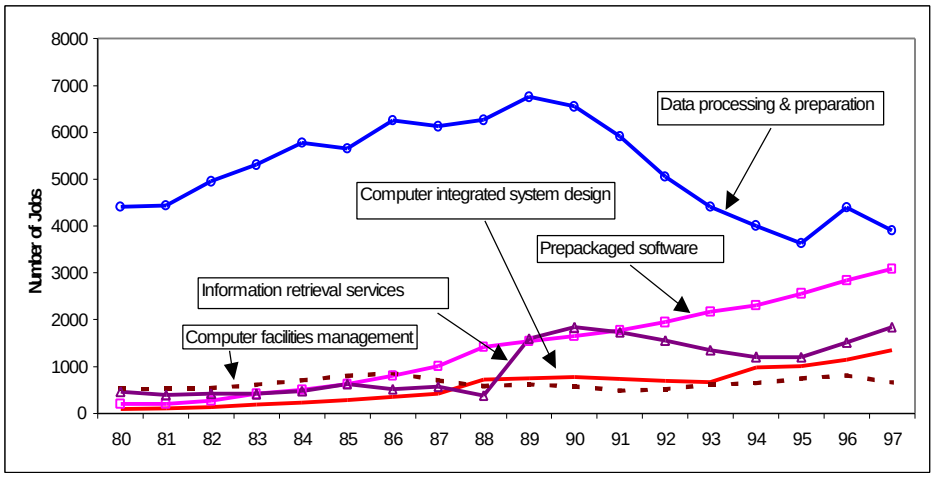
Chart B-3. *No. of Jobs, Software Industry, NYC Suburbs, 1980-1997*



Source: NYS Department of Labor. See notes to Chart B-1.

The number of employees in data processing and preparation fell significantly, from nearly 7,000 in 1990 to 4,000 in 1997, at the same time as the number of firms was growing from fewer than 200 to more than 300. This implies that the number of employees per firm dropped from more than 30 to about 13, which suggests a significant improvement in productivity, or a change in the kind of work that data processing firms do in 1997 compared with 1991. (See Chart B-4.)

Chart B-4. *No. of Jobs, Software Industry, NYC Suburbs, 1980-1997*



Source: NYS Department of Labor.

Software jobs in the NYC suburban counties grew at an overall average annual rate of 5.8 percent between 1980 to 1997. The growth rate in 1992-1997 was 5.6 percent, slightly lower than 5.9 percent in 1980-1992. Jobs in most of the software-industry categories rose more slowly in 1992-1997 compared with 1980-1992. The data processing and preparation category lost jobs in 1992-1997. (See Table B-2.)

Table B-2. *Number of Software Employees and Average Annual Change, NYC Suburban Counties, 1980-1997, Ranked by No. of Employees in 1997*

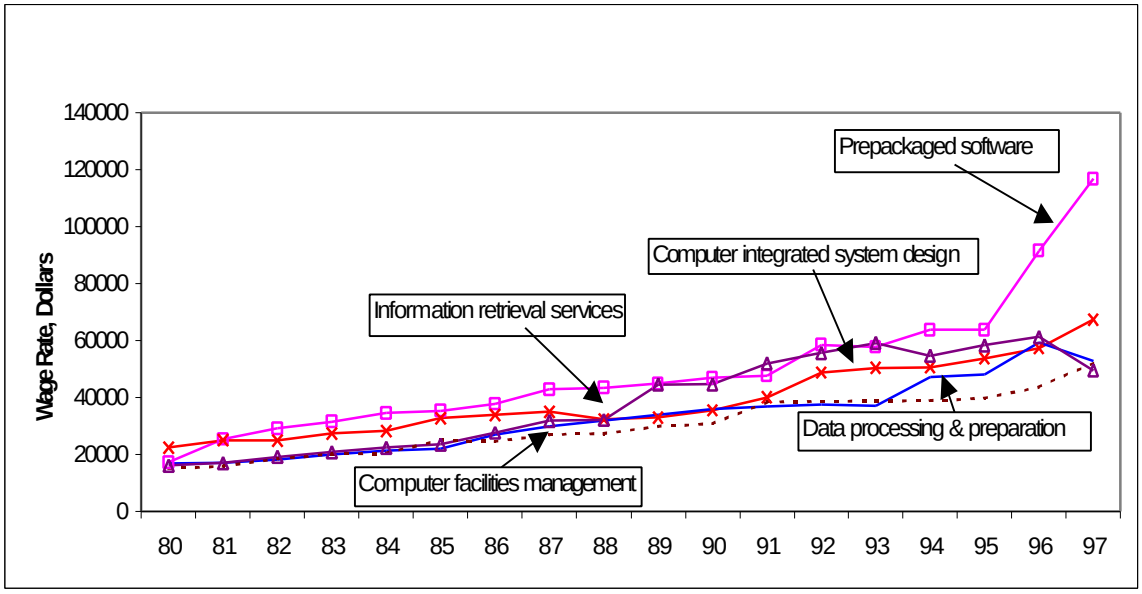
Rank		**Number of Employees**			**Average Annual Change in Number**		
		1980	1992	1997	1980-1997	1980-1992	1992-1997
1	Data Processing & Preparation	4,412	5,053	3,903	-0.7 %	1.1 %	-5.0 %
2	Computer Programming Services	640	1,902	3,280	10.1 %	9.5 %	11.5 %
3	Prepackaged Software	200	1,942	3,086	17.5 %	20.9 %	9.7 %
4	Computer-Related Services	485	1,516	2,947	11.2 %	10.0 %	14.2 %
5	Information-Retrieval Services	457	1,551	1,839	8.5 %	10.7 %	3.5 %
6	Computer Integrated System Design	89	689	1,345	17.3 %	18.6 %	14.3 %
7	Computer-Facilities Management	522	508	656	1.4 %	-0.2 %	5.2 %
	Total	6,805	13,161	17,056	5.6 %	5.7 %	5.3 %

Source: NYS Department of Labor.

3. Average Wage

Average annual wage rates for all the categories in the software industry rose consistently from 1980 to 1995, then spiked upward in 1995-1997, led by the categories with fewer firms. (See Chart B-5.)

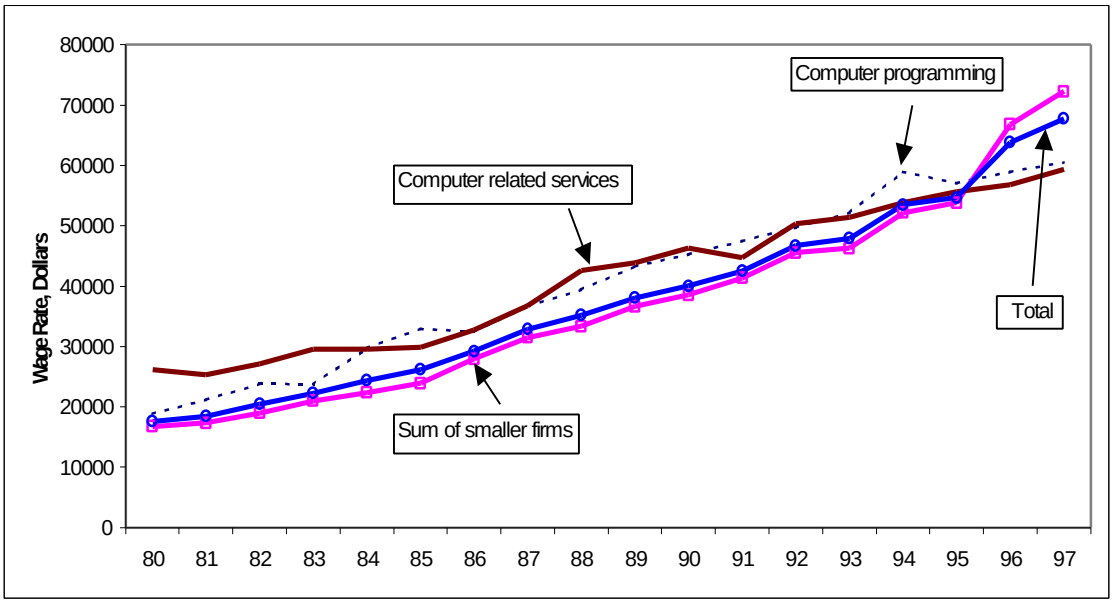
Chart B-5. *Average Annual Wage Rate, Software Industry, NYC Suburbs, 1980-1997*



Source: NYS Department of Labor.

The driving force behind the higher salaries was the prepackaged software category, which saw its average wage rate double from $60,000 to $120,000. (See Chart B-6.)

Chart B-6. *Average Annual Wage Rate, Software Industry, NYC Suburbs, 1980-1997*



Source: NYS Department of Labor.

Wage rates continue to rise at a steady pace, regardless of the change in the number of firms or the number of employees. The annual growth rate of wages was an average of 8.5 percent between 1980 to 1992, then fell slightly to a still-healthy growth rate of 7.9 percent from 1992 to 1997. (See Table B-3.)

Table B-3. *Ave. Annual Change in Software Wage, NYC Suburban Counties, 1980-1997, Ranked by Wage Rate in 1997*

Rank		**Wage Rates**			**Ave. Annual Change in Rates, Percent**		
		1980	1992	1997	1980-1997	1980-1992	1992-1997
1	Prepackaged Software	$17,311	$58,510	$116,746	11.9 %	10.7 %	14.8 %
2	Computer Integ. System Design	$22,410	$48,691	$67,325	6.7 %	6.7 %	6.7 %
3	Computer Programming Services	$18,896	$49,713	$60,511	7.1 %	8.4 %	4.0 %
4	Computer-Related Services	$26,128	$50,366	$59,322	4.9 %	5.6 %	3.3 %
5	Data Processing & Preparation	$16,850	$37,676	$52,903	7.0 %	6.9 %	7.0 %
6	Computer-Facilities Management	$15,053	$38,634	$52,107	7.6 %	8.2 %	6.2 %
7	Information-Retrieval Services	$16,182	$55,644	$49,547	6.8 %	10.8 %	-2.3 %
	Total	**$17,607**	**$46,683**	**$67,771**	**8.3 %**	**8.5 %**	**7.7 %**

Source: NYS Department of Labor.