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An Information Technology Labor Shortage? Legislation in the 106th Congress

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Linda Levine
Specialist in Labor Economics
Domestic Social Policy Division

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Summary

Concern about an information technology (IT) labor shortage prompted Congress, in Title IV of P.L. 105-277, to raise for 3 years the ceiling on H-1B visas for skilled temporary alien workers. The law also called on the National Science Foundation to assess employers' future requirements for workers with computer-related skills, the future education/training needs of U.S. students to ensure an adequate supply of workers at requisite skill levels, and the potential costs/benefits to the U.S. economy from admission of foreign workers with science and engineering skills. The study requirement suggested that disagreement persisted about the existence of an IT labor shortage. The imposition of a user fee on employers who file H-1B visa petitions to largely go toward funding technical skills training and math, engineering or science education similarly implied ambivalence over the preferred solution to the perceived shortfall of IT workers.

While many (including the National Research Council in its congressionally mandated report released in October 2000) would agree that the IT labor market became tight in the late 1990s, the paucity of good data made it difficult to unambiguously determine that an IT labor shortage existed. For example, although employment increased rapidly for IT jobs overall during the 1990s and is projected to continue to do so through 2008, job growth rates varied between individual IT occupations. In addition, while the decline in bachelor's degrees conferred in computer/information sciences was used to demonstrate that firms faced a dwindling supply of workers, bachelor's degree holders in other disciplines commonly work in IT jobs and other sources (e.g., community colleges) prepare persons for IT positions. Although estimates of job vacancies were pointed to as proof of a labor shortage, they are an insufficient indicator — especially those made without reference to the duration of job openings or the wage levels associated with them. Moreover, an occupation could have both a high unemployment rate (which suggests excess supply) and a high vacancy rate (which suggests excess demand) if firms search in the labor market for experienced workers who already possess the hottest IT skills and simultaneously layoff, rather than retrain, their own IT employees. (A subtext of the IT worker debate was whether demand exceeded supply for all workers; for workers already trained in the latest skills; or for young workers to whom firms could pay relatively low, entry-level wages.) Surveys also presented a mixed picture of IT pay which, under shortage conditions, should increase much faster than wages for jobs with a more abundant supply of labor.

Proposals were introduced in the 106th Congress to promote education and training in math, science and engineering skills among U.S. residents. Other bills returned to immigration policy as a way to lessen tightness in the IT labor market while often also raising P.L. 105-277's user fee and changing its allocation formula. The legislation that the 106th Congress passed to address this issue continued the two-pronged approach initiated by the 105th Congress, namely, further raising the limit on H-1B visas as well as increasing the user fee for education/training purposes and altering its allocation formula. With the IT sector experiencing reduced product demand and employee layoffs in 2001, interest in this issue has waned.

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Concern about an information technology (IT) labor shortage culminated during the congressional debate over raising the ceiling on H-1B visas for skilled temporary alien workers.[1] The 105th Congress chose to raise the cap for 3 years on the admission of nonimmigrant professionals who work in specialty occupations[2] in Title IV (the American Competitiveness and Workforce Investment Act, ACWIA) of P.L. 105-277 (the FY1999 Omnibus Consolidated and Emergency Supplemental Appropriations Act).

ACWIA also called on the National Science Foundation (NSF) to, among other things, study and report on employers' requirements over the next 10 years for workers with computer-related skills, the future education/training needs of U.S. students to ensure an adequate supply of workers at requisite skill levels and the potential costs/benefits to the U.S. economy (i.e., to employers, workers and consumers) from admission of foreign workers with science and engineering skills. The study requirement suggested that disagreement persisted about the existence of an across-the-board IT labor shortage. And, the imposition of a filing fee on employers of $500 per H-1B visa petition to be used largely to fund technical skills training and math, engineering or science education suggested ambivalence about the preferred solution to the perceived shortfall of workers with computer-related skills.

This report presents information on the demand for and supply of IT workers during the 1990s. It analyzes the adequacy of measures that arguably demonstrated the presence of an IT labor shortage around the turn of the century. The ACWIA provisions that the 105th Congress intended to expand the supply of appropriately educated or trained U.S. workers as a means of fulfilling employers' demand for IT personnel are next set forth, along with subsequent changes to ACWIA made by the 106th Congress. The report closes with a description of legislation introduced during

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[1] U.S. Congress. Senate. Committee on the Judiciary. Subcommittee on Immigration. Hearings on the High Tech Worker Shortage and U.S. Immigration. 105th Cong., 2d Sess., February 25, 1998. (Hereafter cited as Senate Committee on the Judiciary, *High Tech Worker Shortage*); and U.S. Congress. House. Committee on the Judiciary. Subcommittee on Immigration and Claims. Hearings on Immigration and America's Workforce. 105th Cong., 2d Sess., April 21, 1998. For a summary of the hearings and of P.L. 105-277, Title IV see CRS Report 98-531, *Immigration: Nonimmigrant H-1B Specialty Worker Issues and Legislation*, by Ruth Ellen Wasem.

[2] In addition to computer-related jobs, employers have obtained H-1B visas for such occupations as physical, occupational, and speech therapists; electrical engineers; auditors and accountants; university faculty; and physicians and surgeons.

the 106th Congress that was meant to further increase the number of domestically available workers with computer-related skills.

The Demand for and Supply of IT Workers

The U.S. statistical system does not include a direct measure of occupational imbalances in the supply of and demand for workers.

The Demand Side

The U.S. Bureau of Labor Statistics (BLS) collects data on current employment and estimates future employment by occupation. These statistics represent only the demand side of the labor market. They understate the real demand for labor to the extent supply limitations constrain employment growth.

Table 1. Employment in Selected IT Occupations, 1989-1999
(numbers in thousands)

Year	Computer systems analysts, engineers and scientists	Computer programmers	Total, computer-related occupations
1989	566	561	1,127
1990	605	594	1,199
1991	675	546	1,221
1992	693	550	1,243
1993	769	578	1,347
1994	916	549	1,465
1995	933	553	1,486
1996	1,093	561	1,654
1997	1,236	626	1,862
1998	1,471	613	2,084
1999	1,549	685	2,234

Source: U.S. Bureau of Labor Statistics. *Employment and Earnings*, January issues.

Note: The data are derived from a survey of households, the Current Population Survey, and use the Census Bureau's occupational classification system.

Over 2.2 million persons worked in IT jobs as computer systems analysts, computer engineers, computer scientists and computer programmers in 1999 —

twice the number in 1989, the last peak in the business cycle. As shown above in **Table 1**, the ranks of computer systems analysts, engineers and scientists expanded to a much greater extent (174% or 983,000 workers) than those of computer programmers (22% or 124,000 workers). In contrast, total U.S. employment rose by slightly less than 20% between 1989 and 1999.

Employment gains among computer programmers, who are classified in the technicians and related support occupational division, did not exceed the average across all occupations until the latter half of the period. The much flatter growth trajectory of programmers vis-a-vis professional computer-related occupations (e.g., computer systems analysts) may be partly related to technological considerations, such as "consolidation of systems and applications, developments in packaged software, advanced programming language and tools, and the growing number of users who design, write, and implement more of their own programs."[3] In addition, computer programmer is a narrowly defined group; BLS assigns new, emerging IT occupations to the computer systems analysts, engineers and scientists group within the professional specialty occupational division.

Table 2. Employment, 1998 (Actual) and 2008 (Projected)

(numbers in thousands)

Occupation	Number		Projected change	
	1998	2008	Number	Percent
Total, all occupations	140,514	160,795	20,281	14
Total, IT occupations	2,177	3,891	1,712	79
Computer engineers	299	622	323	108
Computer support specialists	429	869	439	102
Database administrators	87	155	67	77
All other computer scientists	97	212	115	118
Systems analysts	617	1,194	577	94
Computer programmers	648	839	191	30

Source: Braddock, Douglas. Occupational Employment Projections to 2008. *Monthly Labor Review*, November 1999.

Note: The base year data are derived from a survey of firms, the Occupational Employment Statistics (OES) survey, and use the OES rather than the Census Bureau's occupational classification system.

[3] Veneri, Carolyn M. Here Today, Jobs of Tomorrow: Opportunities in Information Technology Occupations. *Occupational Outlook Quarterly*, fall 1998. (Hereafter cited as Veneri, *Here Today, Jobs of Tomorrow*.)

BLS projects that IT employment could increase to almost 3.9 million workers by 2008. (See **Table 2** above.) As has been the case, the professional IT occupations are expected to grow much more than the technical IT occupation of computer programmers. Nonetheless, employment of programmers is projected to expand by much more than the average occupation, 30% versus 14%, respectively.

These demand-side data are somewhat wanting in detail, however. The figures do not indicate the level — entry or experienced — at which firms want to hire IT workers. A subtext of the IT worker debate was whether demand exceeded supply for all workers; for workers already trained in the latest, sophisticated skills; or for young workers to whom firms could pay relatively low, entry-level wages. (See Appendix for data on average salaries for all workers by IT occupation and on average *starting* salaries offered to bachelor's degree recipients with IT majors or for IT jobs.) ACWIA called upon the National Academy of Sciences to assess and report on the status of older workers in the IT field. (See section below on Selected Results from the ACWIA-Mandated Studies.)

The Supply Side

The supply-side data are even more problematic than the demand-side data with regard to providing insights about conditions in the IT labor market. Because there rarely is just one source of workers for a given job, it is very difficult to estimate the supply of labor to a particular occupation and hence, whether an imbalance exists between supply and demand.

A common assumption is that individuals with bachelor's degrees in computer/information sciences are the major source of IT workers. This supposition underlies the notion that the decline in bachelor's degrees conferred in computer/information sciences through the early 1990s means that, in a period of rising demand, employers have faced a dwindling supply of new qualified workers. However, as shown in **Table 3**, roughly one-half of computer programmers, systems analysts, engineers and scientists in 1999 had completed bachelor's degrees regardless of field of study. Moreover, as already was shown in **Table 1**, the employment of IT professionals doubled in the 1990s despite the downward trend in computer/information sciences bachelor's degree recipients early in the period.[4] A Commerce Department report that declared the existence of an IT labor shortage was faulted for failing to adequately take into account sources of supply other than college

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[4] The National Center for Education Statistics collects data on degrees awarded in computer/information sciences separately from data on degrees awarded in engineering (e.g., computer engineering). Degrees awarded in engineering exhibit the same declining trend as degrees awarded in computer/information sciences. While a substantial share of bachelor's degree holders employed as computer engineers in 1995 had majored in engineering, large proportions had majored in related or in unrelated fields. More specifically, among bachelor's degree recipients employed as computer software engineers, 35% had graduated with engineering majors; 31% with computer/information sciences majors; 13% with mathematical sciences majors; 11% with life, physical, social and related sciences majors; and 10% as nonsciences/nonengineering majors. Veneri, *Here Today, Jobs of Tomorrow*.

graduates who had majored in computer/information sciences.[5] And, the number of bachelor's degrees awarded in computer sciences reversed direction in the last few years, increasing modestly between the early 1990s (24,200) and late 1990s (24,768).[6]

Table 3. Percent Distribution of Workers in Selected Occupations by Highest Level of Education Completed, 1999

Educational level	Computer systems analysts, engineers and scientists	All professional specialty occupations	Computer programmers	All technicians and related support occupations
Total	100.0	100.0	100.0	100.0
High school graduate or equivalent[a]	6.3	7.3	10.0	21.6
Some college, no degree	14.9	9.3	19.5	26.7
Associate's degree	8.2	8.6	12.3	21.1
Bachelor's degree	51.5	38.7	44.5	25.8
Master's degree	16.5	21.6	12.0	4.0
Professional degree or PhD	2.7	14.6	1.7	0.9

Source: U.S. Bureau of Labor Statistics. Unpublished Current Population Survey data.

[a]Includes a small number of workers without a diploma who completed less than 12 years of schooling.

Not only are persons with bachelor's degrees in computer/information sciences employed in non-IT jobs, but also persons with bachelor's degrees in related and unrelated fields of study work in IT occupations. For example, about 48% of

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[5] U.S. Department of Commerce. Office of Technology Policy. *America's New Deficit: The Shortage of Information Technology Workers*. Washington. September 29, 1997; and U.S. General Accounting Office. *Information Technology: Assessment of the Department of Commerce's Report on Workforce Demand and Supply*. GAO/HEHS-98-106R. Washington, March 20, 1998. (Hereafter cited as GAO, *Information Technology: Assessment of the Department of Commerce's Report on Workforce Demand and Supply*.)

[6] National Center for Education Statistics. *Digest of Education Statistics*, 1999. NCES 2000-031. Washington, D.C., May 2000. (Hereafter cited as NCES, *Digest of Education Statistics*.)

bachelor's degree recipients in 1992-1993 who majored in computer/information sciences worked in non-computer occupations in April 1994. The same was true for some 36% of bachelor's degree recipients who majored in computer programming. Alternatively, bachelor's degree recipients who majored in the related fields of engineering and mathematical sciences accounted for 19% of college graduates employed as computer systems analysts in 1995, while bachelor's degree recipients who majored in nonsciences and nonengineering fields accounted for 28% of the total. Similarly, bachelor's degree recipients in related fields of study accounted for 26% of college graduates employed as computer programmers, while bachelor's degree recipients in unrelated fields accounted for 9% of the total.[7]

Community colleges and private vocational institutions also prepare students for IT jobs, as do company and military training programs. For example, associate's degrees accounted for 23.5% of the postsecondary degrees in computer/information sciences conferred in 1996-1997.[8] In addition, as shown in **Table 3**, 23.1% of computer systems analysts, engineers and scientists as well as 31.8% of computer programmers had completed postsecondary education below the bachelor's degree level in 1999. And, unlike the previously mentioned downward trend in bachelor's degrees awarded in computer science/information and computer engineering, the number of associate (as well as masters and doctoral) degrees in IT and related disciplines has been on the rise since the 1980s.[9]

Measures of Labor Market Conditions

Because neither demand nor supply can be measured directly, "the determination of labor market imbalances must rely upon *indicators* ... The best-known example of such an indicator is the unemployment rate ... Using only one indicator, however — even one as relevant as the unemployment rate — can still lead to an incorrect conclusion" about the existence of a labor shortage.[10] Indicators in addition to those previously discussed (i.e., the trend in employment and projected employment change) include the occupational unemployment rate and the trend in wages. Vacancy information also is an indicator, but such estimates are not currently part of the government's statistical system. BLS intends to reestablish a job openings/labor turnover survey, but it will not yield measures of job vacancies by occupation.

BLS cautions that available labor market indicators should be combined with information on the supply of labor to one or more related occupations (e.g.,

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[7] Veneri, *Here Today, Jobs of Tomorrow*. Note: The remaining major field of study (i.e., life, physical, social and related sciences) accounted for 16% of systems analysts and 18% of computer programmers with bachelor's degrees.

[8] NCES, *Digest of Education Statistics*.

[9] U.S. Department of Commerce. Office of Technology Policy. *The Digital Work Force: Building Infotech Skills at the Speed of Innovation*. Washington. June 1999. (Hereafter cited as DOC, *The Digital Work Force*.)

[10] Cohen, Malcolm S. *Labor Shortages as America Approaches the Twenty-first Century*. Ann Arbor, Michigan, University of Michigan Press, 1995. p. 25. (Hereafter cited as Cohen, *Labor Shortages*.)

educational attainment by field of study vis-a-vis skill requirements of employers) and with "knowledge of the workings of the labor market" (e.g., whether there are lags between rising demand and a supply response) in order to analyze existing or potential labor shortages. "Conclusions about shortages should not be based on general labor market statistics alone or anecdotal evidence alone."[11]

The Unemployment Rate. While most observers would acknowledge that the comparatively low jobless rates of IT occupations reflect a tight labor market, fewer would agree that it proves a shortage. As shown in **Table 4**, the unemployment rate in 1999 for computer programmers, at 2.3%, was identical to that of all technicians. The jobless rate in 1999 for professional IT workers was 1.7%, just 0.2 percentage points below the rate for all professional workers. The unemployment rates of IT workers in 1999 was virtually the same as in 1989 (see table note), the last time there was concern about labor shortages generally.

Table 4. Unemployment Rates in Selected Occupations, 1989 and 1999

Occupation	1989	1999
All professional specialty occupations	1.7	1.9
Computer systems analysts, engineers & scientists	1.4	1.7
All technicians and related support occupations	2.4	2.3
Computer programmers	1.6	2.3

Source: U.S. Bureau of Labor Statistics. Unpublished data from the Current Population Survey.

Note: Because of the fairly small number of workers in computer-related occupations, year-to-year changes in their unemployment rates must be several tenths of a percentage point (0.6-0.9) to be considered statistically significant.

An occupation's unemployment rate is a tenuous measure of shortages because it is based on only those in the labor force who report that their current or last job was in that occupation.[12] The jobless rate of computer programmers, for example, does not pick up workers with programming degrees who either currently are employed in other occupations or who are newly entering or reentering the labor force but have not yet gotten a job, all of whom represent potential sources of supply. The jobless rate of programmers also does not reflect individuals who may be qualified for such work (e.g., math majors) but are now employed in another occupational group. In

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[11] Veneri, Carolyn M. Can Occupational Labor Market Shortages be Identified Using Available Data? *Monthly Labor Review*, March 1999. p. 21.

[12] *Ibid*. Note: The occupational unemployment rate is the number of workers without a job in a given occupation as a percent of the labor force in that occupation. The labor force in a given occupation is the number of workers currently employed in the occupation and the number of unemployed workers whose last job was in the given occupation.

addition, it does not capture qualified workers who are out of the labor force (e.g., retirees with IT skills) who might reenter under the right circumstances. Thus, the multiple paths to employment in many occupations not only make it difficult to determine the supply of labor to particular jobs but also complicate the unemployment rate's usefulness as a conclusive indicator of an occupational labor shortage.

Vacancy Data. Two surveys conducted for the Information Technology Association of America (ITAA) and from which IT vacancies were estimated were heavily relied on to substantiate the existence of a labor shortage in the late 1990s. ITAA surveyed 2,000 medium and large companies, of which 271 responded. (Firm size was measured by number of employees or sales volume.) It was estimated from this sample that roughly 190,000 IT positions were unfilled at all medium and large firms in the United States, and that the vacancies represented about 10% of all IT positions at these private sector firms.[13] The Virginia Polytechnic Institute and State University, in collaboration with the ITAA, surveyed 1,500 companies having at least 100 employees, and 532 responded to this survey. It was estimated that 346,000 positions for computer programmers, systems analysts and computer engineers/scientists were unfilled at all U.S. companies with 100 or more employees on their payrolls.[14] The accuracy of either of these estimates is questionable, however, because of the surveys' low response rates (14% and 36%, respectively).[15]

A subsequent ITAA-commissioned survey used a much broader definition of IT occupations.[16] Firms (excluding non-profit organizations and government) reportedly needed an additional 1.6 million IT workers in 2000, and a little over than one-half (843,328) of the required positions would go unfilled due to a shortfall of qualified IT workers. (The shortage measure was based on the proportion of applicants that a nationally representative sample of 700 hiring managers at IT and non-IT for-profit firms with at least 50 employees considered to be qualified for specific IT job

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[13] Information Technology Association of America. *Help Wanted: The IT Workforce Gap at the Dawn of a New Century*, 1997.

[14] ITAA and the Virginia Polytechnic Institute. *Help Wanted: A Call for Collaborative for the New Millennium*, 1998.

[15] GAO, *Information Technology: Assessment of the Department of Commerce's Report on Workforce Demand and Supply*.

[16] In the two previous ITAA-sponsored studies, the following standard occupational categories were used to define the IT workforce: computer programmers, systems analysts, engineers, and scientists. In the latest report, a broader definition consisted of the following eight job categories derived from skill standards of the NorthWest Center for Emerging Technologies (NWCET) and an "other" category: programmer/software developer; database administrator/developer; web administrator/developer; network systems specialist; enterprise information systems integrator; interactive digital media specialist; technical writer; and computer systems ("tech") support representative. (The NWCET was established in 1995 with an NSF grant and had as one of its goals the development of voluntary skill standards that reflect the expectations of IT firms.)

categories.) Based on an estimated IT workforce of 10 million, a vacancy rate of 8.4% was calculated.[17]

Vacancies in general are an insufficient measure of labor shortage. An occupation could have both a high unemployment rate — which suggests excess supply — and a high vacancy rate — which suggests excess demand — if employers and workers find it difficult to make matches due to imperfect information or due to the different locations of job openings and qualified workers.[18] The same situation also could indicate a skills mismatch rather than a shortage *per se* if employers want to fill vacancies with persons who already possess and have experience applying the latest specialized skills (e.g., C++ expertise) rather than retraining their mid-career IT employees who lack the currently hot skills. Evidence exists that companies, because of short product-life and product-development cycles in IT-intensive industries, have been pursuing a "buy" (from the external labor market) rather than a "make" (by training employees within the firm) employment strategy.[19]

Moreover, data that cover one point in time do not indicate whether the current level of IT vacancies is consistent with or differs from past conditions. A firm could regularly have a high proportion of vacancies if it experiences high turnover or is growing rapidly, or if vacancies take a long time to be filled.[20] In addition to information being absent on the duration of IT vacancies today and over time, information also is lacking on the salaries associated with the vacancies. Such data could help to demonstrate whether there is a shortage of qualified workers *per se* or whether employers have not been raising wages sufficiently to attract enough workers (e.g., from other occupations or from outside the labor force).

Wage Increases. If occupational demand is nearing or outstripping supply, economic theory suggests that employers will bid up wages to attract workers. "Thus, rapidly rising wages are consistent with a labor shortage."[21] The picture of pay trends in the IT labor market is unclear, however. Private surveys show larger gains than government surveys primarily due to differences in sample size and methodology. The government sources are more likely to be accurate.[22]

Based on a source that compares hundreds of occupations over time, the relative earnings trends of IT workers have varied by occupational group and by year. As shown above in **Table 5**, the median weekly earnings of computer systems analysts, engineers and scientists employed full-time in the private and public sectors rose by 42% between 1989 and 1999 — 4 percentage points more than the all occupations'

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[17] ITAA. *Bridging the Gap: Information Technology Skills for a New Millennium*. April 2000. (Hereafter cited as ITAA, *Bridging the Gap*.)

[18] Cohen, *Labor Shortages*.

[19] DOC, *The Digital Work Force*.

[20] Testimony of Robert I. Lerman in Senate Committee on the Judiciary, *High Tech Worker Shortage*.

[21] Cohen, *Labor Shortages*, p. 33.

[22] DOC, *The Digital Work Force*.

average. The differential is wider — at 10 percentage points — in the case of computer programmers whose median earnings per week grew by 48% over the period. After barely rising in 1998, the pay of computer programmers increased at an above average rate in 1999 (6.5% and 5.0%, respectively). The increase in median earnings of computer professionals (5.9%) in 1999 also surpassed the all occupations' average gain (5.0%), but to a much smaller extent.

A compensation survey conducted for the ITAA by William M. Mercer found that the average hourly pay of IT workers rose between 12% (for software development architect) and 20% (for operating systems/software architect/consultant) in one year alone, 1996. In contrast, a *Computerworld* survey found that in the same year compensation changes ranged from -2% (for systems analyst, administration) to 0% (for senior systems programmer) to 5% (for chief information officer (CIO), CIO/vice president of IT or information systems). Substantial salary increases did not occur until 1997, according to this source, when CIOs averaged a 28% gain and at the opposite end of the spectrum, senior systems programmers' compensation grew by 9%.[23]

Table 5. Median Weekly Earnings of Full-Time Wage and Salary Workers in Selected IT Occupations, 1989-1999

Year	All occupations	Computer systems analysts, engineers and scientists	Computer programmers
1989	399	711	606
1990	415	744	654
1991	430	792	662
1992	445	810	685
1993	463	821	747
1994	467	846	738
1995	479	872	743
1996	490	891	772
1997	503	918	840
1998	523	952	843
1999	549	1008	898
Change, 1989-1999	38%	42%	48%

Source: U.S. Bureau of Labor Statistics. *Employment and Earnings*, January issues.

[23] Melymuka, Kathleen. We're in the Money. *Computerworld*, 11th Annual Salary Survey, September 1, 1997. [http://www.computerworld.com].

According to data collected quarterly by the National Association of Colleges and Employers (NACE), average starting salaries offered to graduates with bachelor's degrees in computer science rose by 54% between the September 1994 and 2000 surveys. Much of that increase occurred in one year alone, 1998, when the entry-level wage offer for new graduates with bachelor's degrees in computer science spiked by 12.7%.[24] (For starting salary offers in other IT fields see Appendix.)

There was some evidence that pay raises in IT occupations may have slowed somewhat in the waning years of the 1990s. *Computerworld*'s annual salary survey found that the typical increase in IT salaries was between 4% and 5% in both 1998 and 1999. In 1997, it had been 11%. But, some IT jobs did continue to command large pay raises (e.g., 20% for the average CIO and 11% for the average IT director in 1999). The more subdued growth rate in IT pay partly may have been due to having fewer workers tied up with Y2K-compliance efforts. In addition, firms reportedly were expanding their (re)training of existing employees and thereby internally growing the pool of IT workers.[25] From a more long-term supply perspective, enrollment in computer-related programs at 4-year colleges began to trend upward.[26]

Selected Results from the ACWIA-Mandated Studies [27]

The National Research Council released a report in October 2000 which complied with P.L. 105-277's requirement of a study by the NSF concerning IT shortages and by the National Academy of Sciences concerning older IT workers. After analyzing the best available statistics, the Council's Committee on Workforce Needs in Information Technology found them wanting in terms of yielding a definitive determination of whether an IT shortage existed. The committee chose to call the IT labor market a tight one, and it expected the market — especially for IT occupations in which there is a lengthy educational process — to remain tight for the foreseeable future. With regard to older workers, the committee also found the data inadequate to conclude whether employers of IT workers illegally engaged in age discrimination.

The report acknowledged that without H-1B workers to fill IT positions, the sector would likely have experienced slower growth and that reliance on "foreign

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[24] Starting salary offers to new computer science graduates (bachelor's degree level) averaged $31,783 in September 1994, $33,712 in September 1995, $35,222 in September 1996, $37,216 in September 1997, $41,949 in September 1998, $44,649 in September 1999 and $49,055 in September 2000. NACE, *Salary Survey*, various issues.

[25] Fryer, Bronwyn. Return to Sanity. *Computerworld*, 13th Annual Salary Survey. September 6, 1999 and Goff, Leslie. The E-lusive Staff. *Computerworld*, 4th Annual Hiring Forecast Survey. Note: For information on IT hiring managers' views about the relative effectiveness of different sources of skill development (e.g., on-the-job employer-provided training) see ITAA, *Bridging the Gap*.

[26] Bachelor's degree enrollments in the fields of computer science/computer engineering have risen over 108% between 1996 and 1998. DOC, *The Digital Work Force*.

[27] National Research Council. *Building a Workforce for the Information Economy*. Executive Summary from a prepublication copy dated October 21, 2000.

workers will continue to be necessary for the immediate future." The relatively large number of H-1B visa holders in IT jobs put "nonnegligible" downward pressure on wages, according to the committee. In other words, the availability of H-1B workers kept the pay of IT workers from increasing as much as it otherwise would have in a tight labor market.

Although the committee could not find an analytical basis upon which to determine the "proper" level of H-1B visas, it offered several recommendations (e.g., the provision of training incentives to employers as well as the collection of more timely, disaggregated data on the IT labor force in the United States). Other recommendations dealt specifically with employment-based immigration policy and with the federal government as an employer of IT workers.

Legislation and Education/Training Programs

The 105th Congress

In addition to temporarily importing more already qualified workers to alleviate the tight IT job market, some Members of the 105th Congress wanted to promote a home-grown remedy to the perceived shortfall of computer-related workers. Consequently, P.L. 105-277 included a provision that requires firms filing petitions to bring into the country, to extend the stay of, or to hire from another U.S. employer nonimmigrant professionals on or after December 1, 1998, but before October 1, 2000, to pay a $500 user fee per petition.

Under P.L. 105-277, the fees deposited in the H-1B Nonimmigrant Petitioner Account initially were allocated as follows:

- The U.S. Department of Labor (DOL) is to issue grants amounting to 56.3% of the fees for demonstration programs under the Job Training Partnership Act (JTPA, Section 452(c)) or its successor, the Workforce Investment Act of 1998 (WIA, Section 171(b)), to establish demonstration programs and projects that provide training in technical skills to employed and unemployed workers. The National Science Foundation (NSF) is to use 28.2% of the fees for scholarships to low-income students enrolled in programs that confer associate, undergraduate, or graduate degrees in mathematics, engineering or computer science.
- The NSF is to expend 4% of the total fees to award merit-reviewed grants under the National Science Foundation Act of 1950 (Section 3(a)(1)) for programs that provide opportunities for enrollment in year-round K-12 academic enrichment courses in mathematics, engineering or science; and 4% to carry out systemic reform activities in K-12 under Section 3(a)(1) of the 1950 Act. The remaining fees are to go to the Attorney General to reduce the processing time of H-1B petitions and to improve the enumeration of nonimmigrant workers, including the submission of periodic reports to the House and Senate Committees on the Judiciary

(1.5%), and to the DOL to reduce the processing time of visa applications and for enforcement (6%).

(See the section below on the 106th Congress for information about how it changed the user fee's level and allocation formula.)

DOL's 56.3%. In the August 16, 1999 *Federal Register* (p. 44543-44554), the Employment and Training Administration (ETA) announced the availability of grant funds from ACWIA's user fee to private industry councils (PIC) under the JTPA, local workforce investment boards under the WIA, and regional consortia of PICs or local boards for technical skills training programs in high-demand occupations (e.g., those for which employers have submitted H-1B applications)[28] targeted at employed and unemployed persons. There is a 50% non-federal matching requirement. Although the federal grant must be used only for training services, applicants can count non-federal resources for supportive services (e.g., transportation or child care) toward the matching requirement.

In February 2000, the ETA announced the first-round awards of $12.4 million in nine grants for the provision of training to some 3,000 workers. The typical grant award was $1.5 million.[29] The second-round grant solicitation appeared in the March 29, 2000 *Federal Register* (p. 16658-16670). In July, a total of $29.1 million was awarded in 12 grants to serve approximately 5,000 workers. The awards ranged from a little more than $900,000 to $3.0 million. The third-round grant solicitation was issued August 1, 2000 (see *Federal Register*, p. 46958-46969). Some $54 million was awarded in October 2000 to fund 22 grants that ranged from almost $1 million to about $2.8 million.

NSF's 28.2%. ACWIA authorized the Computer Science, Engineering, and Mathematics Scholarships (CSEMS) program which is to award funds to accredited institutions of higher education. They, in turn, are to select students for a 2-year CSEM scholarship of up to $2,500 per year per student. Low-income,[30] academically talented students must be in associate, bachelors or graduate degree programs in computer science, computer technology, engineering, engineering technology, or mathematics to be eligible for scholarships. They must be pursuing their studies on a full-time basis and be U.S. citizens, U.S. nationals, refugee aliens or permanent resident aliens.

About 280 proposals from public and private schools were submitted by the August 30, 1999 deadline for first-round award applications. The NSF subsequently announced the provision of $22.49 million to 114 institutions which will enable each to offer about 40 scholarships annually over a 2-year period. The institutions' total

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[28] Appendix A of the solicitation lists selected H-1B professional, technical and managerial occupations (and fashion models) by number of job openings certified by the DOL.

[29] More information on grant awards can be found at the following internet website: [http://www.wdsc.org/sga/awards/].

[30] Determination of financial eligibility relies on U.S. Department of Education criteria for Pell grants and for Graduate Assistance in Areas of National Need.

awards include funds for administrative and other expenses.[31] Applications for second-round grants were due to the NSF by August 3, 2000 and awards were made during Spring 2000. About $24 million went to 110 institutions.[32]

P.L. 105-220. Subtitle C of WIA created The Twenty-First Century Workforce Commission to study the skills needed to obtain IT jobs, explore ways to increase the supply of IT workers, and compare the success of U.S. and foreign programs at training individuals for IT employment. The Commission's report was released in June 2000. Among other things, it endorsed not only preparing more U.S. students and upgrading the skills of incumbent workers to fill IT jobs, but also raising the H-1B visa cap as a response to skill shortages in conjunction with increasing the fee for employers who file H-1B petitions. As it turned out, this was the path ultimately chosen by the 106th Congress.

The 106th Congress

Bills introduced during the 106th Congress to alleviate the tightness in the IT labor market took several tacks, which are described below. The one ultimately settled on saw the Congress returning to immigration policy as a remedy. This approach was prompted, in large part, by an announcement from the Immigration and Naturalization Service (INS) that the 115,000 limit on H-1B visas for all of FY2000 effectively had been reached in March 2000. In FY1999, the 115,000 cap had not been hit until June 1999.

Bills Amending ACWIA's User Fee Level and Allocation Formula. Several bills were offered that included raising the user fee and altering its allocation formula. Both the House and Senate ultimately passed S. 2045 (the American Competitiveness in the Twenty-First Century Act of 2000) and the President signed it in October 2000. Among other things, P.L. 106-313 raised the cap on H-1B visas to 195,000 annually between FY2001 and FY2003 while making additional visas available for FY1999 and FY2000. It exempted from the cap aliens employed by institutions of higher education, nonprofit research organizations or governmental research organizations. P.L. 106-311, enacted on October 17, 2000, raised the user fee from $500 to $1,000 for those petitions filed 2 months on or after the date of enactment. (For more information on other changes specific to immigration policy

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[31] The total grant award includes up to 5% of the total scholarship amount for student-support infrastructure (e.g., recruitment of students from groups underrepresented in CSEM fields including women, racial/ethnic minorities, and persons with disabilities; retention of CSEMS recipients to degree completion; and support in employment placement) and up to 5% for project management and administration (e.g., confirmation of scholarship applicant's eligibility and evaluation of program outcomes). **Note:** For information on the underrepresentation of certain groups in the IT labor force, see Freeman, Peter and William Aspray. *The Supply of Information Technology Workers in the United States*. Washington, D.C., Computing Research Association, 1999; National Science and Technology Council. *Ensuring a Strong U.S. Scientific, Technical, and Engineering Workforce in the 21st Century*. April 2000; and National Science Foundation. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 1998*. NSF 99-87, February 1999.

[32] For more information see: [http://www.ehr.nsf.gov/ehr/due/programs/csems/].

see CRS Report RL30498, *Immigration: Legislative Issues on Nonimmigrant Professional Specialty (H-1B) Workers*.)

P.L. 106-313 amended the allocation of funds in the Nonimmigrant Petitioner Account in the following ways:

- The DOL's share for training fell from 56.3% to 55.0%.
- The NSF's share for the previously described CSEMS program fell from 28.2% to 23.5%. The level of scholarship awards rose from $2,500 to $3,125 (the Pell Grant amount), with scholarships renewable for up to 4 years.
- An additional 15% went to the NSF to carry out a direct or matching grant program to support private-public partnerships in K-12 education in lieu of the 8% for K-12 activities enumerated in ACWIA. (Funds for the systemic K-12 reform activities referenced in ACWIA were subsumed in the new, broader NSF program.)
- The Attorney General continued to get 1.5% to reduce the processing time of H-1B petitions and to improve the enumeration of nonimmigrant workers, while the DOL's share for reducing the processing time of H-1B applications dropped from 6% to 5%.

As in ACWIA, the legislation directed the DOL to use its 55.0% share to create demonstration programs to provide technical skills training for both employed and unemployed workers. P.L. 106-313 specified that the training need not develop skills commensurate with a 4-year college degree and that it should prepare workers for a range of occupations along a career ladder. Further,

> Consideration shall be given to the use of grant funds to demonstrate a significant ability to expand a training program or project through such means as training more workers or offering more courses, and training programs or projects resulting from collaborations, especially with more than one small business or with a labor-management training program or project.

P.L. 106-313 directed the Secretary of Labor, in consultation with the Secretary of Commerce, to award

- 75% of the grants to WIA's local workforce investment boards or consortia of such boards in a region. These grants require a 50% non-federal match. (Under ACWIA, 100% of the DOL grants had to go to workforce investment boards or consortia.)
- 25% of the grants to partnerships consisting of at least two businesses or a business-related nonprofit organization that represents more than one business. These grants require a 100% non-federal match.

Further, at least 80% of all DOL grants from the user fee must be awarded for skills training in high technology, information technology and biotechnology (e.g., skills required for "software and communications services, telecommunications, systems installation and integration, computers and communications hardware, advanced manufacturing, health care technology, biotechnology and biomedical

research and manufacturing, and innovation services"). And, no more than 20% of the grants shall go toward training persons for skills in a single specialty occupation (as defined in Section 214(i) of the Immigration Nationality Act).

P.L. 106-313 also required the DOL and NSF to track and monitor the performance of programs funded from the Nonimmigrant Petitioner Account. The two agencies are to submit a report on the programs' performance to the House and Senate 1 year after the date of enactment.

Using Tax Incentives. Companion bills H.R. 838 and S. 456 would have amended the Internal Revenue Code (IRC) to allow an employer an income tax credit for expenses that he paid or incurred in connection with the provision of technology training. The IT training credit would have been equal to 20% of the employer's annual IT training program expenses. If the IT program were operated in certain areas (e.g., an urban or rural empowerment zone/enterprise community, a school district where at least one-half of the students are eligible for subsidized lunches, or a disaster area) or by a small employer (i.e., 200 or fewer employees on the payroll), the rate would have been 5 percentage points higher. The maximum amount of IT program expenses employers could have taken into account when calculating the credit was $6,000 per individual for the taxable year. IT program expenses were defined as a program that trains computer programmers, systems analysts, and computer scientists or engineers; involves a partnership between employers and state training programs, school districts, universities or certified commercial IT training providers; and that entails the employer paying or incurring at least 50% of the costs. The IT training credit would have been part of the general business credit under the Code.

H.R. 5004 (Technology Education and Training Act of 2000) also would have amended the IRC to provide a credit for 100% of the expenses paid or incurred by taxpayers in connection with IT training programs. Although the maximum amount of IT program expenses per individual generally would have been $1,500, it could have gone up to $2,000 if the training programs were operated in empowerment zones/enterprise communities, school districts in which at least one-half of the students are eligible for subsidized lunches, disaster areas, rural enterprise communities, rural economic area partnership zones, or if the programs were operated by small employers (i.e., those who had 200 or fewer employees daily in each of 20 or more calendar weeks in the current or preceding calendar year). The amount of the credit would have been reduced for employees whose employers paid or incurred qualified training expenses. IT training program expenses were those that lead to an industry-accepted IT training certification for the participant. The NSF, through a newly created advisory group, would have developed a list annually of the latest industry certifications that could qualify for the credit.

Other Bills Unrelated to ACWIA's User Fee and Education/Training Provisions. H.R. 709 (The Technology Education Capital Investment Act of 1999) would have authorized the appropriation of funds to involve the NSF, Secretary of Education, Secretary of Commerce, and a Technology Workforce Commission in an effort to alleviate the perceived shortage of IT workers. Under the legislation, the NSF would have expanded its informal science and math education programs (i.e., science education provided outside a formal school setting) as well as its national

advanced scientific and technical education program under Section 3(a) of the Scientific and Advanced Technology Act of 1992. The Secretary of Education would have made grants to states for the purpose of awarding scholarships to students in programs leading to a postsecondary degree in science, math, engineering or a related field. The Secretary of Commerce would have made grants to institutions of higher education so that they could develop industry-sponsored internship programs which give undergraduate engineering students the opportunity for hands-on training at local businesses. The Technology Workforce Commission would have examined the causes of and possible solutions for the IT labor shortage as well as the comparative efficacy of programs in the United States and other countries to increase the supply of IT workers, especially those programs that offer secondary or postsecondary education other than a 4-year bachelor's degree. It would have issued a report to the President and the Congress.

H.R. 1265 (The Mathematics and Science Proficiency Act of 1999) would have authorized a demonstration project through the NSF to encourage interest in the fields of math, science and IT. Under the bill, the Director of NSF would have awarded grants to local educational agencies in five urban and five rural areas so that they could develop an IT program which builds upon or expands math, science and IT curricula; purchase necessary equipment for such a program; and provide teacher training in the IT, math and science fields. Maximum grant awards could not have exceeded $300,000. Grant applications would have had to include assurances of agreements with private sector representatives for such things as donation of computer hardware and software, establishment of internship and mentoring opportunities for students who participate in the IT program, and donation of scholarship funds for students who have participated in the IT program. The Director would have been required to assess the effectiveness of the activities carried out under this legislation and to conduct a longitudinal study of students who received scholarships including the number of students who graduated from institutions of higher education with degrees in math, science or IT and the number of graduates who took jobs in these fields. The bill authorized to be appropriated to the NSF $3,000,000 to carry out the Act.

Appendix: The Older Worker Issue

As previously mentioned, the debate over whether there was an IT labor shortage around the turn of the century is related to the kind of workers employers wanted versus those who were available. Some asserted that firms wanted younger workers who were well-schooled in the latest IT skills, who were more willing to put in very long hours allegedly because they have not yet taken on non-work responsibilities (e.g., raising a family) and who could be paid less than more senior IT workers. IT-intensive firms countered that for reasons of competitiveness they could not take the time, nor did they have the staff available, to train mid-career IT employees in currently hot IT skills. Moreover, given the tightness of the labor market, companies argued that the employees to whom they provided training might well then take jobs with other firms.

The first table below shows the earnings of all workers, regardless of age or experience, in selected IT occupations. The second table relates to starting salaries offered (1) to students graduating from bachelor's degree programs in IT-related disciplines regardless of the occupation they are entering, and (2) to students graduating from bachelor's degree programs, regardless of the field of study, who are being hired into IT-related jobs. A comparison of the data in the two tables not unexpectedly reveals that the starting salaries of presumably inexperienced, young workers typically are below those of all workers on average.

Appendix Table 1. Average Wages in Selected IT Occupations, 1999

Occupational group	Hourly wage	Annual wage
Computer hardware engineers	32.19	66,960
Computer & information scientists, research	32.30	67,180
Computer programmers	26.42	54,960
Computer software engineers, applications	31.62	65,780
Computer software engineers, systems software	31.84	66,230
Computer support specialists	18.95	39,410
Computer systems analysts	27.85	57,920
Database administrators	25.26	52,550
Network & computer systems administrators	24.08	50,090
Network systems & data communications analysts	26.78	55,710

Source: BLS' Occupational Employment Statistics survey database.

Note: Data for 1999 reflect the redesigned Standard Occupational Classification system and are not comparable with figures for prior years.

Appendix Table 2. Average Salary Offers to Bachelor's Degree Candidates, by Major Field of Study and by Job Function

Major field of study[a]	September 1999	September 2000
Computer engineering	45,666	50,182
Computer science	44,649	49,055
Computer programming	40,839	43,058
Information sciences	38,902	43,737
Systems analysis	38,879	37,343
Job function[b]		
Software design & development	45,590	50,373
Hardware design & development	45,892	49,596
Computer programming	40,935	45,962
Information systems	41,596	45,387
Systems analysis & design	41,083	46,462

Source: National Association of Colleges and Employers (NACE). *Salary Survey*, various fall issues.

Note: The September 2000 salary survey, for example, reports on information the NACE received September 1, 1999 and August 7, 2000 about starting salary offers made to students graduating with bachelor's degrees between September 1, 1999 and August 31, 2000. The offers are a representative sample of actual job offers made to new college graduates during the recruiting year. The survey is published four times a year.

[a] Graduates may have entered any occupation.
[b] Graduates may have had any major field of study.