The Labor Market for Information Technology Workers

Testimony before the Senate Judiciary Committee, Subcommittee on Immigration

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I am happy to address the committee about the labor market for information technology workers and immigration policy. In my brief time, I shall focus on four questions of relevance to your decisions about whether to expand visas for temporary or permanent immigrants.

1. How do we know a labor shortage in an occupational area when we see one?
2. What is the evidence for and against the claims of a shortage of information technology workers?
3. To the extent temporary or long-term shortages are emerging, how should the private and public sectors respond?
4. Should liberalizing immigration policy play a role in meeting the expanded demand for high tech workers?

The key points of the testimony are these:

- The evidence is far from conclusive about the existence of a serious shortage, especially among some segments of the IT labor market; employment growth has been rapid among computer engineers, data base administrators, and computer support specialists but not among computer programmers; most importantly, the trends in real wages do not indicate the type of rapid growth in compensation that would be indicative of a market attempting to adjust to a labor shortage.
- Workers enter the IT field from many fields; only a modest share of IT workers require computer science degrees; moreover, a very large share of those working in IT fields move to other fields frequently; if the industry managed to persuade a high share of incumbent workers to remain, they would a less difficult task filling positions.
- The expansion of job opportunities in the IT field should stimulate enhanced public-private initiatives to attract workers to the field through expand training, the development of clear career pathways and skill standards, and the expansion of youth apprenticeships and career academies. In addition, the public sector should encourage collaboration between employers of IT workers and community colleges and other post-secondary institutions to create curriculum for use in medium-term and long-term programs that is well-tailored for IT careers.
- Government policy makers should be cautious about short-term efforts to expand the supply of workers, especially by increasing the number of immigrant visas; given the boom and bust cycles often observed in these fields, by the time the government acts to increase supply, the market may have already shifted from an excess demand to excess supply stage. Expanded immigration may have another counterproductive impact. It may deter prospective students from choosing an IT career when they hear that potential immigrants entering the field will gain special access to visas.

Macroeconomic Context of Today's Shortage Discussion

Concerns about the inflationary impact of specific labor shortages caused most economists to believe that the US economy could not achieve unemployment under 5.5% or even 6% without rising inflation. Instead, the supplies of labor materialized with little pressure on unit labor costs or prices. The number of jobs expanded by over 6 million between January 1995 and January 1998, as over 5 million people joined the labor force and over 1 million left the ranks of the unemployed. Moreover, the economy has had to fill jobs involving relatively high skills. About two of three of 17 million full-time jobs added since 1988 were in the professional and managerial occupations. Usually, finding enough workers to fill vacancies in a specific occupation is less of a concern than the problem of an aggregate labor shortage. Nevertheless, it is theoretically possible that serious shortages in particular occupations or regions might act as a bottleneck that could limit our country's ability to continue the economic expansion without inflation.

General Indicators of Labor Shortages

Defining what we mean by a shortage is a good first step. The first element is that the quantity demanded of

workers of a particular type exceeds the quantity supplied at the going market wage. The second element is that the market must adjust slowly or not at all to the imbalance. Generally, free markets alleviate shortages through the price mechanism. When workers are scarce at current salaries, we expect employers to bid up wages, which both attracts workers into the field and deters the use of these more highly paid workers. Thus, in a shortage situation, we should observe rising employment and rising wages or some combination of the two. If the initial shortage is widespread and if additional supplies of qualified workers do not materialize, the effort to fill the job vacancies can stimulate inflation.

When there are many employers, labor market forces will generally raise relative wages enough to attract workers from other fields. In fields involving long lags between the onset of vacancies and the time it takes to train additional workers, rising demand for workers may initially raise wages without bringing additional supplies of workers. However, within a few years, the increased wages draw more workers into the field. A good example is the scientific and engineering occupations. The job market for natural scientists and engineers has fluctuated between large reductions in demand in the mid- 1970s to large increases by the mid-1980s to moderating patterns in the early and mid- 1990s. When demand fell, so did relative wages, and ultimately the number of students choosing to graduate with an engineering or science degree. When salary premiums increased, as in the mid-1980s, the proportion of students entering the field increased. Thus, market forces generally respond to increases in demand, even in professions requiring lengthy training periods.

Shortage of Information Technology (IT) Workers?

The three primary census occupational classifications for IT workers are: computer systems analysts and scientists, computer programmers, and operations and systems researchers.

Included under the first category are: 1) *Computer engineers*, who work with the hardware and software aspects of systems design and development and who often work in teams that design new computing devices or computer-related equipment; 2) *Software engineers*, who design and develop both packaged and systems software; 3) *Database administrators*, who work with database management systems software, who reorganize and restructure data and who also may be responsible for maintaining the efficiency of databases and system security; and 4) *Computer support analysts*, who provide assistance and advice to users, interpreting problems and providing technical support for hardware, software, and systems. They may work within an organization or directly for a computer or software vendor.

Systems analysts implement computer technology to meet the individual needs of an organization. They study business, scientific, or engineering data processing problems and design new solutions using computers. Systems analysts may design entirely new systems, including both hardware and software, or add a single new software application to harness more of the computer's power.

Computer programmers write and maintain the detailed instructions—referred to as "programs" or "software"—that list in a logical order the steps that computers must execute to perform their functions. In many large organizations, programmers follow descriptions prepared by systems analysts who have carefully studied the task that the computer system is going to perform. Programmers code instructions in a conventional programming language, such as C and FORTRAN, or one of the more advanced artificial intelligence or object-oriented languages, such as LISP, Prolog, C++, or Ada. The transition from mainframes to PCS has blurred the once rigid distinction between the programmer and the user, as adept users increasingly take over many of the tasks previously performed by programmers by using spreadsheet and database programs.

Despite the extravagant claims of a shortage of IT workers, the indicators are mixed. *The employment trends shown in Figure 1 reveal rapid growth in the computer systems analysts and scientists, but no growth in the other professions until last year*. Employment in operations research has actually declined since 1988 and the total number of computer programmers remained at about 560,000 workers between 1988 and 1996, a time in which employment of all professionals expanded by nearly 30 percent. Only in 1997 do we observe substantial growth in the employment of computer programmers, as jobs increased by 11.6%. One may speculate that the source of the recent sudden jump in programmer positions is the demand by companies, governments, and other organizations to solve the problems linked to the year 2,000 bug. If so, we can expect additional short- term pressures on the job market for programmers this year and perhaps next year, but perhaps even reductions in demand in future years. Data from occupational employment surveys (OES) taken among employers confirm these trends. Employment of computer programmers barely increased at all, while jobs in the higher level fields rose rapidly.

In spite of weak employment growth in two of the three IT occupations, one might still argue that a shortage of workers prevented employers from hiring in these fields. In addition, shortages might have limited the expansion of jobs in the rapidly growing occupation of computer systems analysts and scientists. But, if serious shortages were taking place in any of these fields, we would expect market pressures to raise salaries for IT workers more rapidly than for other professional workers. *In fact, the weekly wage patterns displayed in Figure 2 show no evidence of a market experiencing a shortage. Except for the 1996-97 period, real wages have been essentially flat since 1988, rising slightly above the slow growth in median wages experienced by professionals as a whole*.

Data from some private surveys indicate higher salary levels and higher rates of growth. A survey conducted for the Information Technology Association of American (ITAA) by William Mercer indicated salary increase of nearly 20% and salary levels of well over $50 per hour (equivalent to about $2,000 per week). The Mercer data are inconsistent with other private surveys as well with public data sources. A survey conducted by Deloitte & Touche Consulting Group revealed that salaries for computer network professionals rose an average

of 7.4% between 1996 and 1997. Coopers and Lybrand found average salary increases at 500 software companies were 7.7% in 1995 and almost 8% in 1996. *Computerworld*'s annual survey found that in 11 of 26 positions tracked, average salaries increased more than 10% from 1996 to 1997. According to this survey, system analysts' salaries increased by 15%, programmer/analysts salaries were up by 11%, and directors of systems development increased by 10%. In 1997, starting salaries for graduate with bachelor's degrees in computer science had increased to an average of $36,666, while experienced programmers received salaries in the range of $45,000 to $75,000. The wage rates and wage growth reported in the Mercer study are far higher not only than the CPS weekly earnings data but also than other private surveys and the BLS employer survey data. The Coopers and Lybrand study estimated that senior software engineers earned $63,000 annually, far below the rates listed in the Mercer study. The BLS occupational compensation survey data show median weekly earnings of under $1,000 per week for jobs at the middle occupational level of computer systems analyst. On an hourly rate, this works out to about $25 per hour, a figure well below the hourly earnings reported by Mercer for middle to high level IT occupations.

If the shortage were severe, we might expect companies to go to considerable effort to retain existing IT workers. While such initiatives certainly take place in some instances, the striking reality is that plenty of workers in IT fields leave their positions for other occupations. For example, of the 484,000 college graduates working in the computer science or data base administrator occupations in 1989, 215,000 were no longer working in any IT occupation in 1993. Nearly 200,000 of the 540,000 people working as computer programmers in 1989 had left the IT area by 1993.

In principle, worker shortages could persist in the absence of wage pressures but only when free competitive markets do not prevail. If one employer dominates the market, then it will typically not bid up wages even when it would willingly hire more workers at prevailing wages. Another possibility is some implicit agreement among employers or some external restriction limiting the growth of wages. However, neither of these situations is a plausible description of the actual labor market for information technology workers.

The empirical basis for the claim by ITAA of a major shortage of IT workers is the recent study conducted by Virginia Polytechnic Institute (Virginia Tech) on behalf of ITAA. This study argues the case for shortages of IT workers on grounds of high numbers of vacancies. The study surveyed 1,493 companies, of whom only 500 responded to the questionnaire. On the basis of these responses, the Virginia Tech authors estimated that: 1) the core IT workforce is 3,354,000 in the programming, systems analysts, and computer engineering fields; and 2) that vacancies amount to 346,000 or approximately 10 percent of positions. In comparison to the data collected by the Census Bureau both from households and from employers, the Virginia Tech study vastly overestimates the size of the core IT workforce. In 1996, employers reported only about 1.5 million employees working in these fields. Households reported a substantially higher figure, about 2 million, in 1997. Neither figure is close to the 3.3 number projected in the Virginia Tech study.

A second problem with the study is its lack of perspective about the presence of vacancies. In any industry with a rising demand and/or high turnover, the presence of vacancies does not necessarily demonstrate a shortage of workers. A vacancy simply means the firm has an open position it has not yet filled. Vacancies as a proportion of employment will depend on the employer's turnover rate, how long it takes to fill a vacancy, and the extent to which the company is growing. Even among employers not expanding at all and in markets where there are no shortages, vacancies can easily reach the rates reported. For example, a company expecting turnover of 30% per year and expecting to take four months to fill a vacancy will have vacancies equal to 10% of employment. If the employer is expanding, vacancies would run at an even higher rate than the 10% figure cited in the Virginia Tech study. For these reasons, the Virginia Tech figure tells us nothing about the presence of a shortage of IT workers, the duration of any shortage, or the reasons for the shortage.

What about future shortages? A potential indication of future shortages is that future demands will outstrip future supplies. In the case of IT workers, the Bureau of Labor Statistics projects rapid rates of employment growth between 1996 and 2006. The projected net job growth figures by occupation are as follows: computer engineers, 235,000; data base administrators and computer support specialists, 240,000; systems analysts, 520,000; and computer programmers, 129,000. In the fields other than computer programming, the growth is estimated at about 1,000,000 new workers over ten years, or about 100,000 per year. Although the numbers constitute very high percentage growth, the absolute number of openings in these fields approximately the same as projected combined openings among registered nurses and therapists. The additional 1 million job openings in the IT fields other than computer programming represents about 12% of the 8.3 million openings projected for professionals and about 8% of 13.5 million openings among professionals and managers.

Diversity of Applicant Pools. Whether the robust demand for computer specialists will outstrip supply depends partly on the ability of the industries employing IT workers to attract new entrants and to retain existing workers. In examining this question, it is important to recognize that the pool of potential applicants extends well beyond individuals with degrees in computer science. In fact, as of 1993, only a modest proportion of IT workers come from people who earn BA or higher degrees in computer science. Among the 1992-93 cohort of college graduates, only one-third with jobs in computer science or programming jobs had degrees in computer science or information science. Nearly as large a share came from majors in business management (28 percent). Students with engineering degrees accounted for 12 percent of new graduates working in IT fields. At the same time, nearly half the computer science graduates entered jobs outside the computer field. The picture is similar for all workers in the computer and information science field. Data from a National Science Foundation study reveals that of the 1.2 million college graduates employed in 1993 in several information technology fields (computer sciences and operations researchers, computer programmers, computer science professors, software engineers, and hardware engineers), only about 31% had degrees in computer science. The largest other majors were business degrees (19%), engineering degrees (10%), math (9%), and a variety

of social science degrees (8%). In the case of computer programmers, about 76,000 or 38% of the 200,000 employed in the field had computer science degrees. Another 13,000 had electrical, electronic, and computer degrees. Still, over half the working programmers with BA degrees earned their degrees in non-computer related fields.

Emerging Training Opportunities. Proprietary schools as well as colleges and universities offer training for IT workers in moderate skill positions. Interviews with officials at three proprietary schools in the Washington, DC area report high growth in enrollments and very high placement rates among those who complete the program. Many of the courses last about 4-5 months and equip workers to take jobs in computer programming in such languages as C++ and JAVA, as computer technicians, and network administrators. The tuition typically ranges from $1,000 to $5,000. The schools are open to students of any background. No prior programming or network experience is necessary. Although the quality of the graduates from these programs is uncertain, there are certification exams in some of the relevant fields. Reporter Mike Allen in Sunday's *Washington Post* describes proposed legislation going through the Virginia House that would provide community colleges with funding to tailor courses to specific industries in the information technology field. Cooperating companies apparently believe that they can fill many of their positions with people trained in the community college system. The story points out how four year universities are also gearing up to meet the demand for IT workers.

While sketchy, the evidence from training programs and emerging post-secondary programs suggests that workers with reasonably good academic skills can gain access to IT professions in a relatively short period of time. On the other hand, these programs are unlikely to serve as the source of workers in the most advanced IT professions.

Overall, I conclude that several IT occupations are expanding rapidly but that the supply networks have proved reasonably successful in absorbing the demand. Moreover, to the extent that wages in the IT fields rise faster than they have in the past, we can expect a major market response to reduce or eliminate any intermediate term shortage. One potential difficulty consistent with the data is a short-term shortage of programmers linked to the effort to resolve the year 2,000 bug.

How Should the Private and Public Sectors Respond? Should Immigration Policies Play a Role in Reducing the Shortage?

Before deciding on strategies for dealing with any shortage, we should recognize that past experience suggests that by the time we take actions to solve a shortage, it is already too late and may exacerbate a surplus. Remember that some professions, such as engineers, have been subject to boom and bust cycles. When demand has been robust, salaries have increased and government subsidies have expanded, thereby stimulating a large increase in the supply of engineers. Unfortunately, often just as new entrants have joined the engineering work force, demand for engineers has declined. The combined impact of the expansion in supply and the reduction in demand has sometimes led to an enormous glut of engineers.

Projected shortages of PhDs in math and natural sciences led to legislation in 1990 that resulted in dramatic increases in the number of visas for university professors, especially in the math and science fields. Permanent visas granted to college and university teachers in the 1992-94 period reached 8 times the average levels granted between 1959 and 1979. The impact may have been to the academic career positions for native scientists and mathematicians. The unemployment rate of math PhDs in the period 1-3 years after their degree rose from 0.7% in 1993 to 4% in 1995; the proportion involuntarily working outside their field also increased from 7.1% to 9.3%. Although the academic market for math and science PhDs differs considerably from the market for IT workers, the experience of the early 1990s should act as a caution against government policies aimed at solving a selected labor market shortage.

One of the benefits of today's tight labor market for all workers and for IT workers is the impetus to private-public efforts to expand and improve training, to attract new workers to fields requiring significant skills, and to retain existing workers. We see employers spending time and money to develop new approaches to recruitment, training, and job stability. It is important that we promote those efforts and avoid policies that reduce the incentives of employers to undertake sensible long-term strategies that can widen access of American workers to good jobs.

To the extent the US is experiencing or may experience an IT shortage, it is almost certainly in the computer engineers and scientist fields and possibly is some specialty programming areas. Only these occupations show rapid past and projected increases in demand. Although the demand for programmers is expected to increase, the supply should respond since training is readily available for those who wish to enter the field and the courses can be completed in well under one year. While no doubt market imperfections exist, the capacity to train mid-level IT workers is expanding rapidly. Certification of job-related knowledge and skills in the IT occupations has already become a major industry. A good example of a collaborative private-public initiative is the Applied Information Management (AIM) Institute in Omaha, Nebraska. AIM has brought industry and higher education together in ways that expand the sources of labor. In addition to promoting continuing education, AIM has developed internships and curriculum and has worked to attract high school students to IT careers.

Shortages could occur in high level IT occupations because of the combination of the rapid expected growth in demand for computer engineers and systems analysts, the long duration of education and training required for entry into these jobs, and the limited number of individuals with the abilities and persistence to attain degrees in the relevant engineering, computer science, mathematics, and other science fields. Some potential entrants might choose not to enter the field because of their uncertainty about whether their hard work will pay off

several years into the future. IT companies can attract more candidates for these positions by not only raising wages but by taking actions to reduce uncertainty. Among them are policies that reduce turnover and that utilize job ladders.

Ironically, the policy of expanding immigrant visas for IT positions is potentially counter-productive because it can increase uncertainty and reduce the incentive to enter the field. Prospective US students may choose not to prepare for the IT field if they see that foreigners will gain easy access to visas simply by entering an IT occupation.

Public and private programs could attract some prospective entrants into the field when they are young enough to make adequate preparation in schools and on the job for advanced work in computer science. Currently, few students in high school are aware of what it is that computer scientists do, what academic skills are required, the challenges and activities on the job, and what the economic rewards are. Companies and even governments as employers could promote internships and apprenticeships for high school and college students to give them a taste for the skills required and the content of the jobs in IT careers as well as allowing students to learn whether they like or dislike the field. Simply making the career ladders transparent and giving students a chance to work and learn at the same time can be very effective. The Autodesk Foundation is spearheading an effort that includes coordinating internships across the entire San Francisco Bay area not only in the IT field but in others as well. Internships provided by the Autodesk Corporation itself achieved benefits that apparently outweighed the costs during the internship period. These internship experiences are likely to spur many young people to obtain the necessary training to enter high level IT positions.

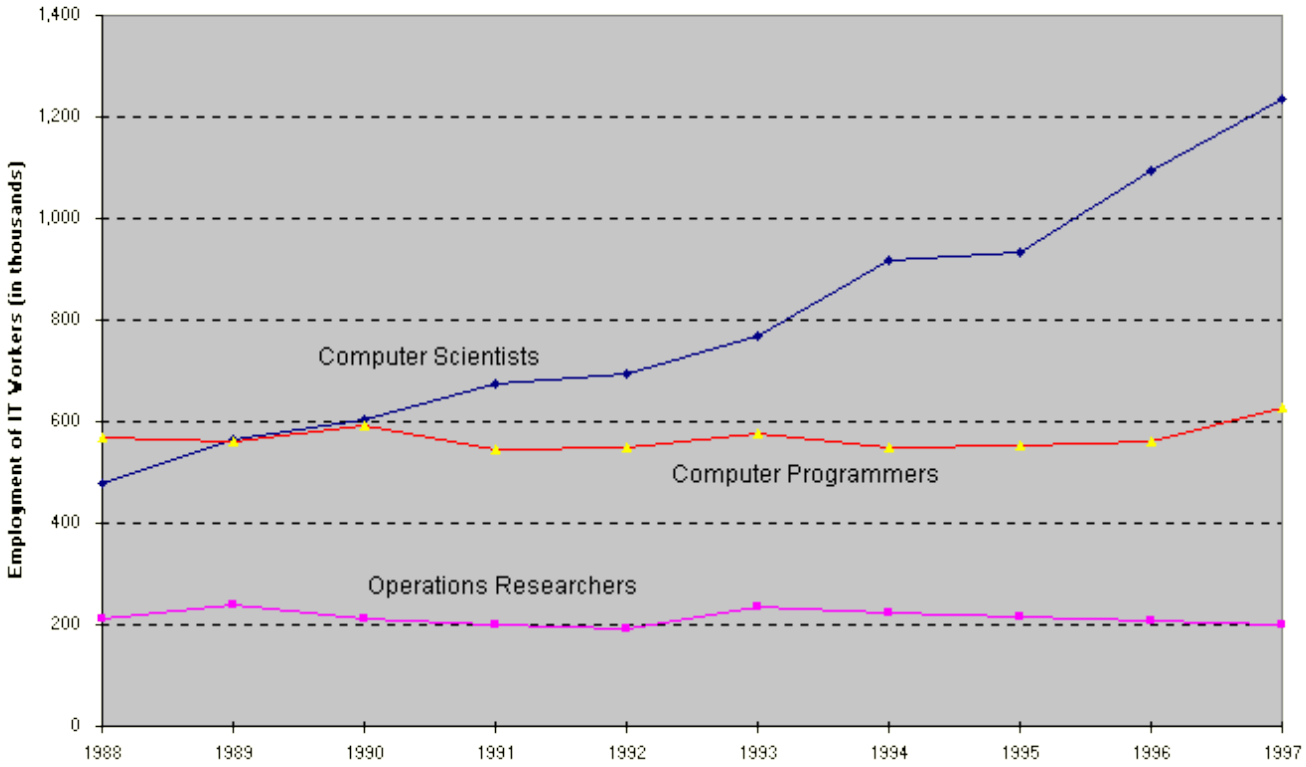
The government could encourage private firms, the school systems, and foundation officials to work together to expand these opportunities. It could also make clear what are the existing career pathways in the IT field. Another school-to-work approach would be to create Career Academies and youth apprenticeships in the computer field. Career Academies are usually schools within schools oriented around a career theme. As students move through their last 2-3 years of high school, they stay with their own teacher, take extra courses in the theme field, learn directly from industry staff, and go on internships. Students in schools that focus on an occupational area often do better than other students and certainly have higher satisfaction with school and work and stimulate students to learn more about the industry and its requirements. Often, such Career Academies have close links with industry. Students would hear industry leaders pointing out the shortage areas and the rewarding careers in the IT field. One example is the Computer Academy within Oakland Tech High School. Students within the school not only learn about computer hardware and software but they gain valuable work experience. As volunteers working with donated equipment, they are able to earn their own computers as well as produce enough computers to use in classrooms throughout the Oakland school district.

Public-private partnerships could disseminate information to employers on the benefits of training and of supplying student internships or apprenticeships. Many skill certifications already exist, but they are often narrow and might well induce workers not have the flexibility to adapt to future trends. Modernizing and coordinating the current certification system would help workers understand what he or she needs to learn contribute to enter the field and would help firms recognize the capabilities of those achieving a certification.

Another approach is to stimulate additional company-sponsored training. There is evidence that company spending on training is going up. However, one deterrent to additional spending is the legitimate fear that spending money on general training for a worker today might yield little benefit if the worker leaves the job market or moves to a competitor. One way to reduce the uncertainty companies face about their ability of companies to recoup training costs would be to have workers sign a pledge to pay back the firm for training expenses in the event the worker moves to another firm. Before implementing a policy on this subject, it is important to determine why such approaches are not used extensively today. What are the barriers that currently face firms attempting to implement such an approach? Is it the potential difficulty collecting from movers? If so, perhaps a third party could assist firms and workers in formulating and finalizing such agreements.

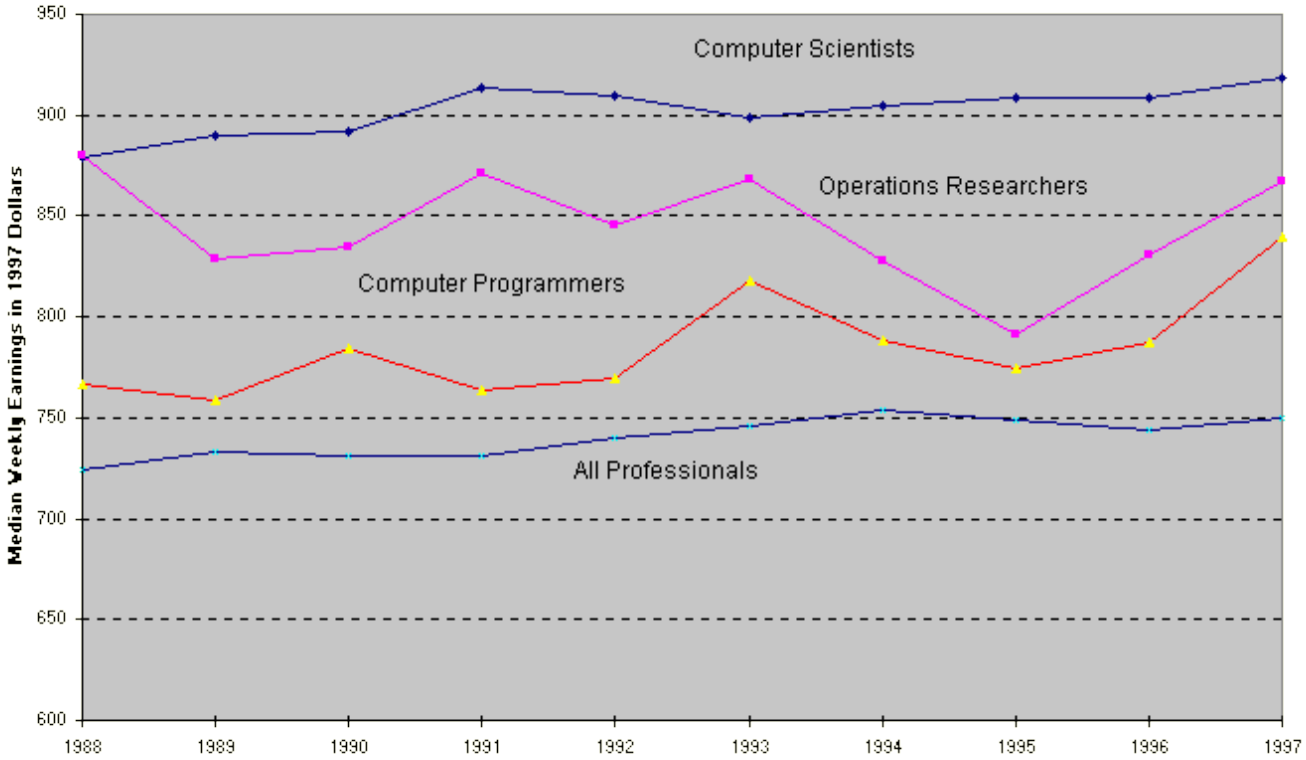
Finally, the government could promote additional research on the causes of the possible shortages in the highest level IT positions and the costs and benefits of alternative strategies for expanding the supply of high level IT workers. How exactly were firms able to expand supply in the 1988-96 period, by upgrading existing workers, by hiring people new entrants, and by using foreign workers? If a major source of high level IT workers was the training and promotion of programmers or systems analysts, then meeting future demands may be especially difficult since fewer experienced programmers or analysts might be available for upgrading. Another important question is: what are the best mechanisms for encouraging young people to learn about the field and to gain the appropriate training and work experience to become successful? The IT field offers the nation a great opportunity—a major source of good jobs for the future. It is now up to our young people and to our institutions to make sure we take advantage of this opportunity.

Figure 1: Employment Trends of Information Technology Occupations: 1988-1997



Source: Employment and Earnings, January 1989-January 1998, US Bureau of Labor Statistics.

Figure 2: Real Median Weekly Earnings of Workers in Information Technology Occupations: 1988-1997



Source: US Bureau of Labor Statistics, Employment and Earnings, January 1989-January 1998. The earnings data are deflated by the GDP implicit price deflator.