

Assessing the Demand for Information Technology Workers

Data on the Information Technology Workforce

The purpose of the IT Workforce Data Project is to identify and disseminate trustworthy statistics on information technology workers in the United States. This is our fourth and final report. Earlier papers in the series, all released in 1999, provide a general overview of the IT workforce, review the supply of persons with appropriate academic degrees, and furnish data on the employment of foreign-origin workers in IT jobs.

In addition to printed reports, results from this project are available at the United Engineering Foundation's web site at www.uefoundation.org.

Queries about the IT Workforce Data Project are welcome. Contact Richard Ellis: (717) 532-3966 or email to ellis@cvns.net.

Sponsors

The United Engineering Foundation
The Alfred P. Sloan Foundation

Principal Investigators

Richard Ellis, Ellis Research Services,
Shippensburg, Pennsylvania

B. Lindsay Lowell, Institute for the Study
of International Migration (ISIM),
Georgetown University

Review Panel

Tapan Mukherjee, National Science
Foundation (chair of the panel)

Frank Blecher, past chair, board of trustees,
United Engineering Foundation

Michael Finn, Oak Ridge Associated Universities

Vin O'Neill, IEEE-USA

Robert Weatherall, Office of
Career Services, MIT (retired)

Acknowledgments

Our thanks and appreciation to Lawrence Burton of the National Science Foundation's Division of Science Resources Studies and Mary Collins of WESTAT, Inc., for the generation of statistics from NSF's SESTAT data base; and to Mary Bowler, economist with BLS' Division of Labor Force Statistics, for time series data on employment and unemployment in core IT occupations.

November, 1999

According to much of what one hears in media reports and policy debates in the Congress, the United States never seems to have enough high tech workers. Warnings of shortages of engineers, scientists, and now information technology specialists have appeared regularly since the 1950's. Such concerns are understandable; technological strength is seen as a crucial ingredient of American economic prosperity. Other factors add to the continual pressure to maximize the country's supply of technical talent. Large labor pools help employers contain their payroll costs and improve the odds for a steady supply of occasional brilliant performers, the technical wizards whose contributions have been shown to be crucial. Training all of these specialists keeps academics busy; large academic establishments also contribute to American research and development capabilities, fueling the emergent technologies that keep this system going. For many, questioning this state of affairs is tantamount to arguing with success.

However, there is a problem: in all these years, there is no evidence that any serious shortages of technical professionals — engineers in the past, information technology specialists now — have ever occurred. To be sure, there have been ups and downs in supply and demand as normal business cycles of boom and recession affected general levels of employment, and as demographic trends influenced supplies of newly trained workers. In the early 1970's and again in the early 1990's, there were serious problems of *weak* demand for technical people. There have been obvious cases of "spot" shortages: scrambles for people with especially hot specialties, experience in particular industry sectors, or favored geographic locations. But on the national level, data on trends that reflect supply and demand for technical professionals have been mainly notable for their stability. This applies with special force to measures of pay, the best indicators of actual shortages of workers. If shortages exist, compensation should rise sharply as employers bid for scarce talent, but when adjustments are made for inflation, technical pay has remained remarkably consistent since the 1950's, even with allowances for such factors as bonuses and stock options. As this paper shows, this general picture of high tech employment trends seems to apply to information technology today just as it has to other kinds of technical professions in the past: spot shortages may exist, and strong demand can be seen for some kinds of people, but on the whole there is no compelling evidence to suggest a national shortage of IT workers, either now or in the near future.

To assess the nation's need for technical talent, it helps to start by understanding where we already are. The number of engineers, scientists, and other technical professionals in the United States has been growing rapidly for 60 years. At present, information technology includes the fastest growing occupations in the country.¹ Even the "Baby Bust" of the 1960's and 1970's, when annual numbers of live births dropped 25 percent, did not stop growth in the technology sector's share of all U.S. jobs, although the rate of growth did slow down. Now the numbers of college-age youth are rising again, which will fuel further increases in the share of the U.S. labor force that is composed of information technology workers and other high tech specialists. In short: the USA has a rapidly growing technical workforce, and that growth is going to accelerate. Thus the question is not whether the supply of high tech people is growing; rather, the issue is whether existing growth is sufficient to meet national interests. Industry says those interests are threatened by inadequate supplies of IT specialists.² Others dispute this claim.³

¹ See the first report in this series, *Core Occupations of the U.S. Information Technology Workforce* (January, 1999).

² See *Help Wanted: The IT Workforce Gap at the Dawn of a New Century and Help Wanted 1998: A Call for Collaborative Action for the New Millennium*, both from the Information Technology Association of America (ITAA; Arlington, Virginia; 1997 and 1998). A third ITAA report in this series is anticipated but has not been released at this writing.

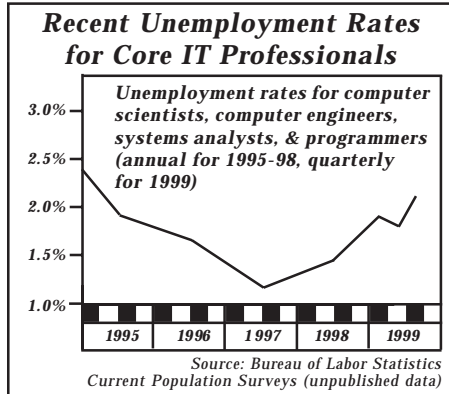
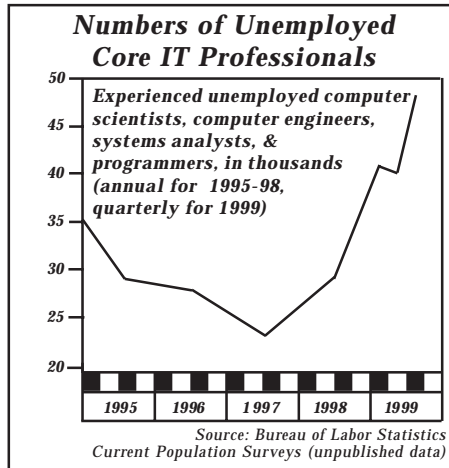
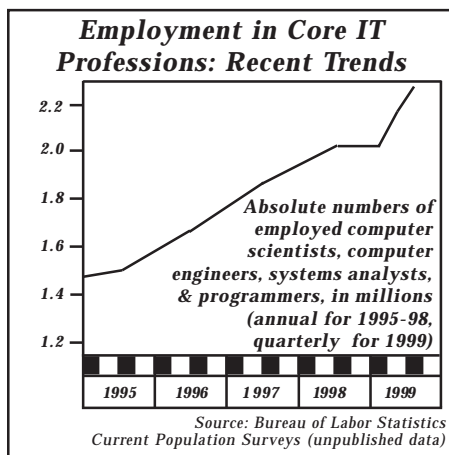
³ See Norman Matloff, *Debunking the Myth of a Desperate Software Labor Shortage*, based on testimony April 21, 1998 to the U.S. House Judiciary Committee Subcommittee on Immigration, at <http://heather.cs.ucdavis.edu/itaa.html>. Also see his *High-Tech Trojan Horse: H1-B Visas and the Computer Industry* (Washington: Center for Immigration Studies, 1999).

Indicators of Demand

In early 1998, Burt Barnow of the Institute for Policy Studies at Johns Hopkins University, John Trutko of James Bell Associates, and Robert Lerman of the Urban Institute released a paper, *Skill Mismatches and Worker Shortages: The Problem and Appropriate Responses*, which is both an outline of factors that need to be considered in assessing the demand for specific occupational specialists, and a case study of the labor market for IT workers.⁴ Barnow *et al.* identify a set of "general indicators of potential labor shortages within specific occupations":

Trends in Employment Levels. Increasing levels of employment suggest increases

⁴ Final report to the Office of the Assistant Secretary for Policy, U.S. Department of Labor (Washington: The Urban Institute, 1998).



in demand. Our first report showed that the higher-level core IT occupations — computer scientists, computer engineers, and systems analysts — grew from less than 300,000 workers in 1983 to over 1.5 million workers by the end of 1998. Growth for programmers was less rapid, but the numbers of those workers also increased during this 15-year period, from about 450,000 to over 600,000. This trend of growth has continued in the first three quarters of 1999.

Trends in Unemployment Rates. Increased levels of unemployment suggest weak demand. Unemployment among experienced IT workers has been rising since 1997. The levels of unemployment are still not especially high, at 2.1 percent in the most recent quarter. Even so, the increases in joblessness undermine any conclusion that the overall growth in all IT employment, noted above, might be a signal of serious shortages.

Trends in Earnings. Barnow *et al.* state "The rate of wage growth within an occupation relative to other occupations is often the clearest indicator of the existence of a shortage (at least over the short term). Rapidly rising wages within an occupation suggest that at least a temporary imbalance exists between the labor supply and the demand."⁵

Using data from the Bureau of Labor Statistics' Current Population Survey, Barnow and his colleagues found that during the ten years from 1988 through 1997, changes in the earnings of core IT workers were similar to those for all professionals and only marginally higher than those for the entire civilian labor force. If arguments are to rest solely on these CPS data (a widely trusted source of such statistics), then this is "striking evidence against a shortage of IT workers," as Barnow *et al.* observe.⁶

However, the CPS wage data do not agree with some other sources. Barnow *et al.* take note of several surveys that indicate both higher levels and greater growth in compensation, including studies from Wm. M. Mercer, Coopers and Lybrand, DeLoitte & Touche, and *Computerworld's* annual surveys. None of these sources is as respected as the federal Current Population Survey, but the consistency of their results does give one pause.⁷

⁵ *Ibid.*, p. 65.

⁶ *Ibid.*, p. 66.

⁷ *Ibid.*, pp. 68-70. The authors note that "It is not clear whether these surveys are broadly indicative of wage changes in the field of IT workers. In some instances, the wage surveys are conducted for groups that represent or advocate for a particular constituency (e.g., employers of IT workers, labor unions, or trade associations)." Another serious problem with many non-federal sources of salary data is that often they present only final results for particular detailed job titles (such as "senior software engineer"), geographic areas (e.g., the Southwest U.S.), or both, and do not provide information on the numbers of cases on which their results are based, so that it is not possible to aggregate data into meaningful national estimates for the IT industry as a whole.

The U.S. branch of the Institute of Electrical and Electronics Engineers (IEEE-USA) has conducted biennial compensation surveys of its members for over a quarter of a century. The 1995, 1997, and 1999 editions of these surveys also show higher wage rates and stronger salary growth for IT specialists than does the CPS.⁸ Such differences are to be expected, since members of IEEE with specialties in computer software or hardware are an elite subset of IT workers.

IEEE's data include information on the effects of irregular contributions to income such as bonuses and stock options, two sources of gains in compensation that are often missed by traditional salary studies. Bonuses are one of the components of the primary incomes tracked by IEEE. Since 1994, their importance as contributors to the total income of IEEE's electrical and computer engineers has risen slightly, from 3.8 to 6.4 percent of overall earnings for those employed full time in their areas of professional competence. These increases are not large enough to make bonuses a major component of overall pay. Similar findings apply to the effects of income from profit sharing plans, which rose from 2.8 to 4.4 percent of total earnings.

Data on the impact of stock options are less easily assessed, since the value of options fluctuates from day to day, but IEEE does obtain estimates of the present value of options received during the previous calendar year. Both the share of IEEE members who reported options and the estimated value of those awards did rise between 1996, when 16.1 percent of these engineers and computer scientists reported options with a median value of \$7,100, and 1998, when 27.5 percent reported options with a median value of \$10,000. These values were highly skewed; about 10 percent of those who got options accounted for more than 80 percent of the aggregated value of all these rewards. Another ten percent viewed their options as worthless, estimating present values of zero. As IEEE's latest report puts it, "The median value of options [for all persons covered by its survey]... is zero, since over 70 percent got nothing at all from this source."⁹

Given that members of IEEE are among the most highly trained and valuable of all IT professionals, these results can be taken as a generous estimate of the effects of bonuses and stock options on the com-

⁸ IEEE U.S. Membership Salary & Fringe Benefit Survey 1995; IEEE U.S. Membership Salary & Fringe Benefit Survey 1997; IEEE-USA Salary & Fringe Benefit Survey, 1999-2000 Edition (Washington: IEEE-USA, 1995, 1997, 1999). The deficiencies of presentation and methodology noted previously do not apply to these biennial compensation surveys. As a technical society, IEEE may be an advocate, but its salary studies meet academic standards for completeness and rigor. For example, complete national summary data are provided, and statistics include full reporting for both numbers of cases and any nonresponses.

⁹ IEEE, 1999, *op. cit.*, p. 3-3.

pensation of IT workers in general. While not insignificant, these effects are not large. They have risen, but not by so much as to suggest major shortages of labor. The skewed distribution of the stock options suggests that their main function is to provide incentives for small numbers of people at the top.

Although both IEEE's statistics and other non-federal sources of data on the compensation of IT specialists have indicated strong demand, at least for those with exceptional skills, any trend of significant increases in pay may have slowed down even for the elite workers. *Computerworld's* latest survey, done during the summer of 1999, states that "The typical increase in information technology salaries has hovered between 4% and 5% for the second year in a row. Indeed, salaries for all but a few IT positions in 1998 and 1999 have remained remarkably flat."¹⁰ This outcome is consistent with IEEE's results, for that society's latest data reflect changes for 1997 as well as 1998—and *Computerworld* says that the largest increases came in 1997.

Other data also suggest that the period from 1995 through 1997 was a time of exceptionally strong demand in which IT compensation did improve. New information from the National Science Foundation's SESTAT database on scientists and engineers shows electrical engineering and computer science graduates with the lowest unemployment and underemployment rates and above average salary growth for this period, and electrical and computer engineers with the highest overall salaries.¹¹ However, the SESTAT statistics shed no light on any further developments after 1997.

Another factor that could obscure real increases in pay is shifts in the age structure of the IT workforce. Its rapid growth has been fueled by intensive recruitment of new graduates, both those with IT degrees and others. The more the IT labor force is comprised of relatively youthful workers, the lower its average pay.

To summarize: federal and non-federal sources of data on trends in pay do not yield consistent indicators of the demand for IT specialists in the recent past. It may have been very strong, but the only measure of *current* trends, *Computerworld's* 1999 survey, suggests that demand has moderated since 1997. One must give particular consideration to the CPS data used by Barnow *et al.*, because of all the different sources, only this one is known to cover all IT workers. Other surveys, such as those done by IEEE-USA, are more likely to apply to elites in the industry, where levels of compensation are higher and competition much fiercer than is the case for average IT workers in the nation as a whole.

Vacancies. Barnow *et al.* note that an alternative model of occupational short-

ages developed by Kenneth J. Arrow and William W. Capron "concludes that shortages will be characterized by vacancies."¹² Both reports on the IT workforce issued to date by the Information Technology Association of America (ITAA)¹³ cite vacancy rates to justify industry requests for increases in the use of temporary foreign labor and other interventions to boost supplies of qualified personnel.

ITAA's first report estimated a total of 191,000 vacancies, presumably for 1996 (the report is undated but was released in the Spring of 1997). Total core IT employment in 1996 was 1,654,000, so the ITAA data imply that one in every ten positions was vacant. A problem is that ITAA's findings were based on a sample survey of employers with a return rate of only 13.6 percent, rendering results suspect due to potential response bias.

The second ITAA study was similar. Response rates improved to 35.6 percent of the sampled employers, but weighted extrapolations of the data led to an estimate of well over 3.3 million core IT workers in the United States, nearly double the number counted by BLS at the time. Such results cast doubt on the credibility of other findings in this report, including the estimated number of vacancies (as in the first study, approximately one in ten).

Commenting on ITAA's first report, Barnow *et al.* note that a lack of any information about normal vacancy rates in the industry and the length of time that positions have been unfilled makes it difficult "to judge how serious this number of vacancies would be..." and they conclude that "the evidence presented is insufficient to judge whether an actual shortage exists."¹⁴ There are always *some* vacant positions, due to normal turnover of employees and the fact that newly created openings are initially vacant. It is also important to remember that IT is already the fastest growing employment sector in the United States. Since 1995, the number of core IT jobs (which precisely match the positions defined by ITAA) has grown 10 percent a year—that is, exactly at the level that industry vacancy figures suggest should be met. Where then is the problem?

¹² *Op. cit.*, p. 10.

¹³ *Op. cit.*

¹⁴ *Op. cit.*, pp. 41-43.

Decreases in the Supply of Labor. Another indicator of possible shortages cited by Barnow *et al.*, ITAA's first report raised this factor, pointing to declines between 1986 and 1994 in the production of new computer science graduates. But only a minority of IT professionals have CS degrees; business, math, natural and social science, and engineering majors are also commonly employed in IT jobs.¹⁵ Second, the drop in computer science enrollments has ended. The Taulbee surveys, conducted by the Computing Research Association, show that during 1996 and 1997 the number of computer science majors "effectively doubled,"¹⁶ and the trend continues, reinforced by the end of the "Baby Bust" effect on university enrollments in general: for the first time in a decade, colleges are seeing rising numbers of high school graduates.

This is not all. There are at least three additional sources of labor supply for the IT industry. In 1998, employers convinced the Congress to expand the numbers of foreign workers admitted each year with temporary H-1B visas for up to six years of professional employment. The revised ceiling of 115,000 new admissions a year is still viewed by some employers as an insufficient response to their needs. Despite the increase, the cap on the number of admissions continues to be reached well before each fiscal year ends, leading to an "annual foreign-worker hiring binge"¹⁷ as IT companies scramble not just for new people but also to catch up backlogs from preceding years. Other industries also make use of H-1B labor, so the number of these workers actually available to work for IT employers is less than the ceiling total. As a result, several members of Congress have announced intentions to introduce legislation to further increase the availability of foreign workers for IT jobs and to attempt to reduce problems of fraud in the program by screening to restrict entrants to people with advanced educations and substantial pay.

¹⁵ *The Production of U.S. Degrees in Information Technology Disciplines* (January, 1999).

¹⁶ P. Freeman & Wm. Aspray, *The Supply of Information Technology Workers in the United States* (Washington: Computing Research Association, 1999), p. 84.

¹⁷ Dan Gillmor, "You can have a say about H-1B visas," *San Jose Mercury News*, September 20, 1999.

Selected Indicators of Recent Trends in IT Wage Rates

Occupational Group	Annual Average Rise in Median Earnings	Source
Computer Scientists & Systems Analysts	3.5%	} Barnow <i>et al.</i> (<i>op. cit.</i>), using CPS data for 1988 to 1997
Computer Programmers	4.0	
All Professional Occupations	3.4	
Entire Civilian Labor Force	3.0	} IEEE-USA Salary & Fringe Benefit Surveys, 1995-1999
Fulltime EE's With Computer Hardware/Software Specialties	6.0	
"All but a few IT Positions"	4.0 - 5.0	
		} Computerworld Salary Surveys, 1998 and 1999

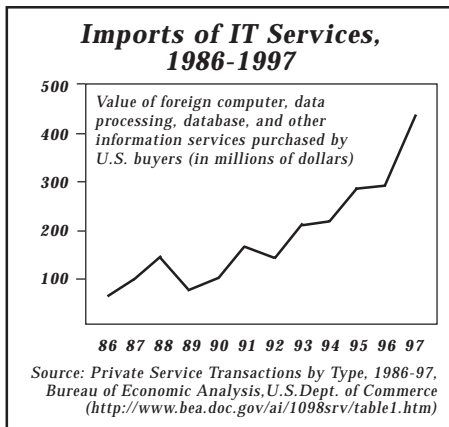
¹⁰ "Return to Sanity," *Computerworld* (September 6, 1999).

¹¹ Personal communication, from Michael Finn of the Oak Ridge Institute for Science & Engineering.

The H-1B program is controversial. Some American IT specialists believe temporary foreign workers displace U.S. citizens, that companies may see H-1B's as indentured servants who must depend on the good will of their employers in order to remain in the United States, and that the practice helps employers hold down prevailing wages. Other observers are convinced that U.S. technology has greatly benefited from contributions of immigrants, that the nation should welcome new talent, and that employers need access to the "best and brightest." All these claims, pro and con, have some basis in fact. Many cases of displacement have been documented, and some employers are known to view foreign talent as cheap labor. At the same time, the contributions of immigrants, both temporary workers and those who have gone on to become citizens, to American technology is unquestionable, and there is little doubt that many H-1B workers are very talented people. After all, most come to the attention of U.S. employers because they are already here, pursuing advanced degrees at American universities.¹⁸

H-1B workers are not the only kind of foreign talent working in the U.S. There are other visa categories for temporary workers, including the "L" program for foreign employees of firms doing business in the United States. Employers do not need to bring foreigners to this country in order to make some use of their skills. Another alternative source of supply for IT specialists is outsourcing of work to shops in India, Russia, and elsewhere. A measure of the magnitude of growth in outsourcing IT work to foreign job shops is provided by import statistics from the Department of Commerce. The dollar value of American purchases of offshore computer, data processing, database, and other information services increased nearly eightfold in the eleven year period between 1986 and 1997, to \$434 million. This level of work is especially impressive when one notes that the cost of using the services of people with Ph.D's in electrical engineering in India is about a tenth of this cost in the USA.

¹⁸ For more information, see the third paper in this series, *Foreign-Origin Persons in the U.S. Information Technology Workforce* (March, 1999).



Like the use of foreign temporary workers, outsourcing is not universally viewed as desirable. Some observers are concerned that outsourcing may undermine U.S. capacities. By offsetting domestic shortages, demand for the internal supply of people is weakened.

A third broad source of additional IT labor consists of underutilized workers in the domestic labor force. As was noted in our first report, over a third of the people trained in IT professions are not employed in these fields. To be sure, some of these persons work in closely allied jobs — e.g., professors of computer science or managers of IT companies (either status is counted outside the IT specialties *per se*). And all professions include graduates who do not put their training to work. Some change careers, some never intended to practice in the first place, and some are simply unsuited for a field or for employment generally. Even so, more than a quarter of a million persons with degrees in IT disciplines were not employed in those fields in 1995.¹⁹ Some of those people might be persuaded to return to the industry.

A problem in discussions of the IT job market is the tendency to treat it as a single monolithic entity when in fact it varies enormously by region, types of firms, and types of job candidates. Companies that *create new hardware and software* are the most glamorous players, concentrated in areas like Seattle, Boston, and the Silicon Valley. This end of the industry is fiercely competitive—the term “carnivores” has been used, with pride²⁰ — and it seeks workers who are the stars of the profession. It is often assumed that conditions in this segment of the industry apply to all, but they do not. For example, Anderson Consulting considers a much wider range of employment candidates than does Microsoft.²¹ Anderson, a very large employer of IT talent, is in the business of *applying hardware and software to solve its clients' problems* — a larger, less visible, more mature segment of the industry.

Conclusions and Some Puzzles

In summary, none of the possible signs of an inadequate supply of IT workers provides unambiguous evidence that there are not enough people in the field, and several indicators — rising numbers of experienced unemployed workers, the “flat” compensation results reported by *Computerworld*, increasing enrollments in computer science — suggest that if anything, pressures of demand on the available supply may have eased somewhat during the past year. Increased use of foreign talent, both in the U.S. and in offshore job shops, reinforces this

¹⁹ *The Production of U.S. Degrees in Information Technology Disciplines* (op. cit.).

²⁰ Gary Rivlin, *The Plot to Get Bill Gates* (New York: Random House, 1999), p. 227.

²¹ Robert K. Weatherall, “Firms and Their Needs” in “The Placement of New Graduates,” *Engineers* Vol. 4, No. 2 (April, 1998), p. 4. Freeman and Aspray, op. cit., also discuss such differences in the industry.

judgment, adding to the range of options available to people who need IT skills.

This does not rule out less general kinds of difficulties in the IT job market, both for employers and for job candidates. It may seem contradictory, but we suggest that (1) there is no general national shortage of workers, (2) many employers still can't find the people they seek, and (3) some persons with IT training and experience have difficulty finding work. How can this be?

One answer may be that there are signs of a strong preference for recent graduates in the IT job market. Young workers have been trained in current technology, are probably more likely than others to be willing to work the long hours and give the total commitment that some IT employers want, and they cost less. The thirst for such people helps to explain the strong industry interest in H-1B's, who account for large shares of the pool of recent graduates, especially at the MS and PhD levels.

Data on age in the second report in this series show that core IT professionals are much younger than those in other technical professions.²² Freeman and Aspray discuss the issue: “There is a common perception that information technology is an occupation for younger workers. We all have the image of the young programmer staying awake on massive doses of caffeine while undertaking a thirty-six hour programming session. There is some truth to this image...”²³

The appeal of youthful workers is explained in part by the short life cycle of information technology. As Freeman and Aspray observe, “This rapid turnover in technology makes it imperative that IT workers adapt to new technologies and new products... they must continuously work at keeping their skills and knowledge up to date or risk becoming obsolete and unemployable.”²⁴ Freeman and Aspray do not explain how to do this while putting in 36-hour days.

When heavy emphasis is placed on training and experience that is both very specific and very recent, those who lack these credentials may encounter serious problems finding work, even if they have amassed lengthy records of success in the past. This raises at least two questions. First, are employers missing an opportunity to make better use of candidates who are not so young? And if it is commonplace for people in IT — including foreign as well as domestic workers — to become dated and therefore less employable in the profession, what steps if any should be taken to deal with this situation? We have no ready answers to these questions, only a belief that they need to be asked. This, and not a more general shortage of talent, is a critical challenge that faces information technology today.

²² *The Production of U.S. Degrees...* (op. cit.).

²³ Op. cit., p. 115.

²⁴ *Ibid.*, p. 40.