8

Synthesis, Principles, and Recommendations

8.1 SYNTHESIS AND FINDINGS

As described in Chapter 1, the IT sector and the IT-intensive industries are key pillars of the U.S. economy, and they continue to remain competitive and be a locus of innovation. They are technologically dynamic, and they have had or been responsible for enormous economic success by any measure. IT is generally regarded as an engine of growth and change across the economy, and there is a growing body of evidence that IT is playing a significant role in improving national productivity, and that any constraints on IT production and support--such as those that might arise from excessive tightness in the IT workforce--may have a pervasive impact on the growth of the economy.

While market adjustment is occurring, the labor market for many IT positions is tight today and likely to remain so for the immediate future, barring dramatic change (Chapter 3). This tightness is not uniformly distributed across all positions, all geographic regions, or all levels.

There are many reasons for tightness in the IT labor market. The fundamental drivers of tightness are technological change and growth in the use of IT applications. To the extent that information technology continues to change rapidly and growth in the demand for IT applications continues to occur, individuals with experience in and/or knowledgeable about the newest technologies will be in relatively short supply. Furthermore, high growth creates conditions such as high wages in the IT sector and in IT-intensive industries that can drive turnover rates higher as workers seek jobs with higher wage offers with other firms--or that can lower turnover if the current employers are willing to match or exceed higher offers from those other firms. Nevertheless, turnover can occur for reasons other than wages as well.

Nevertheless, growth in the use of IT and technological changes would not lead to tightness in the labor force if the available supply of qualified labor were to grow at commensurate rates. Sources of qualified labor include new domestic entrants into the workforce, incumbent workers already in the IT workforce (both those with up-to-date skills and those who can be retrained for new jobs), incumbent workers who might otherwise drop out, workers in other fields who might enter IT work if appropriate training is available, currently unemployed workers, "discouraged" workers who do not count in unemployment statistics, and foreign workers who can either be brought to the United States or work in their home

countries for U.S. companies.Students, workers, and employers have started to respond to tightness in the IT labor market--for example, enrollments are up in computer science degree programs, and employers are taking many of the steps described below to increase supply. But under conditions of sustained growth in demand, it may be difficult for supply to ever "catch up" completely.

Under conditions of a tight labor market, employers must seek workers from the broadest possible pools of talent. On the assumption that the distribution of human talent does not respect ethnic, racial, or national boundaries, this is fundamentally the "enlightened self-interest" rationale for employers seeking out workers from underrepresented groups (e.g., women, minorities, older workers) as well as from the traditional pools, and it is also a major rationale for seeking talent abroad.
From the standpoint of individual employers facing hiring difficulties, one important way to fill vacancies is to increase employee retention--a job that is never vacant takes zero time to fill. Indeed, in analytical terms, the rate of employee turnover is as important a driver of vacancies in the workplace as is company growth, and empirically the data suggest that turnover makes a larger contribution to the vacancy rate than does growt. Many employers are indeed taking steps to reduce turnover by making existing jobs more attractive.

If retention is insufficient, and/or if a company is growing, other sources of qualified workers must be developed and/or expanded (Chapters 6 and 7). Different types of IT work call for different types of IT training. The duration of the necessary training (and/or development of experience) depends on the individual's prior background and the desired level of proficiency in the new area of work. For some types of IT work, an individual with substantial background in a related IT area can achieve basic proficiency in a matter of days or weeks (e.g., someone with training in Pascal can probably learn C well enough in a few weeks to do many things). For other types of IT work, even an individual with substantial background will require years of preparation (e.g., an individual with many years of experience in Pascal or C may take 6 months to a year or more to understand and program effectively in object-oriented languages such as C++ or Java, while an individual with an undergraduate degree in computer science will take several years to obtain a Ph.D. in computer science that enables him or her to do cutting-edge IT research).

Formal education has a role to play in training for IT work, but it is by no means limited to baccalaureate work in computer science. It is certainly true that certain Category 1 work (e.g., IT development) increasingly requires substantial amounts of formal training--more so than has been true in the past. But the requirements of some such jobs may be met by individuals with substantial exposure to formal computer science education (whether through IT minors rather than majors, areas of concentration in IT, or even an array of several IT courses) that can be offered by colleges, universities, and community colleges. And various forms of continuing education (e.g., short courses) can provide some job opportunities--especially in areas for which business understanding and knowledge are more essential than detailed IT knowledge--to those without degrees in IT.

Finally, for education and training to be most beneficial to workers, they must be integrated in appropriately situated real-work contexts. Cognitive theory and workplace experience both suggest that such integration is necessary for workers to use their learned skills most effectively. Employers, understanding this phenomenon, value job applicants who have a proven track record of such experience.

For many of the job areas in which there is tightness today, training sufficient numbers of individuals on a time scale that responds to changes in the market remains a daunting task. Thus, while individual firms may be able to raise wages and compensation high enough to recruit workers doing comparable work from other firms, for the industry as a whole, the short-term elasticity of supply in the overall IT labor force is quite low.

Short-term supply inelasticity in the overall IT labor force is exacerbated by the fact that the U.S. economy today is experiencing unemployment levels that are very low by all historical precedents. Because there is record low unemployment across the board, workers have many options--and thus workers in other fields are less likely to turn to IT than they might be if overall unemployment levels were higher. However, if and when overall unemployment rises significantly, a sector that continues to experience low unemployment

(perhaps the IT sector) will become considerably more attractive to workers in other fields, thus making available a larger supply of potential willing new IT workers.

Finally, the committee has heard many allegations of age discrimination in the IT industry (Chapter 4). It would be naïve to assert that no age discrimination exists. Some employers, managers, and hiring teams do operate from inaccurate assumptions and stereotypes about older people that may cause age discrimination to occur in individual cases. At the same time, workers who lose their jobs or are not hired for whatever reason (company mergers or acquisitions, downsizing, end of life of a product or service, obsolete skills, poor performance, and so on) may inaccurately attribute the cause of this action to age discrimination.

Based on the available empirical data and a variety of anecdotal testimony, it appears that, on average, older IT workers have different experiences with displacement and possibly with post-displacement income than do younger workers. However, these data do not allow the committee to determine whether the differences indicate age discrimination on the part of employers, legal conduct by employers that may be perceived as discriminatory, personal choices made by individual employees, or the ramifications of a rapidly changing industry. To the extent that discriminatory treatment of older workers does exist, policymakers should address this issue--not because the elimination of all such discrimination would have a significant impact on tightness in the labor market, but rather because IT employers, and the nation as a whole, would, by underutilizing valuable human resources, be depriving the economy of a valuable source of talent.

The following observations and findings elaborate the basic picture painted above.

8.1.1 On the Available Data

The best available data sets are for the most part inadequate to provide a definitive description of workforce needs in information technology.

--Definitions of occupations--which are necessarily relatively stable over time--do not necessarily reflect the IT job titles of today because new types of jobs emerge quickly. In particular, occupational categories are generally too coarse and do not reflect important distinctions among IT jobs.

--Some data are not timely enough. Data that are 2 years old are unlikely to reflect accurately today's state of affairs in the rapidly changing IT sector or in IT-related jobs in other parts of the economy.

--Government data on IT workers in H-1B or other visa categories have been severely lacking, with only limited information available on country of origin, occupational category, degrees and experience, total compensation, age, nature of employer (industry, number of employees, revenues), change in employment, previous immigration status, adjustment to permanent status, and so on.

> Thus, policy recommendations from all parties--including this committee--are inevitably based on amix of judgment and interpretation of whatever trends are visible in the existing data, however sketchy andincomplete those trends are.

8.1.2 On the Nature of Business in the IT Sector (Chapter 3)

If past trends continue, the IT sector and the use of IT in IT-intensive industries will likely growsignificantly in the long run. However, it is certain that such growth will be interrupted or at leastcurbedduring certain periods (e.g., economic recessions) that no one can predict. Such periods are likely torelieve then-current tightness in the IT labor market (though they may discourage new entrants fromgoing into IT work shortly thereafter).

Because of the competitive premiums on speed within IT, employers want to be able to respond quickly to workforce needs that change as fast as new technology and/or applications emerge.

The universe of IT employers is highly heterogeneous, involving firms or organizations ranging from finance, manufacturing, and government to IT firms that sell IT products, services, and applications. However, stereotypes of IT work as involving workaholics, dot-com millionaires, and very long work hours and pressure appear to drive many public perceptions of such work, even though they likely reflect only a small segment of all firms employing IT workers.

The development side of the IT sector and of IT-intensive industries is particularly dependent on human talent, with the consequence that capital cannot easily be substituted for labor to increase productivity. Research continues on technology-based tools for improving the productivity of IT workers (and indeed, a number of such tools that have increased productivity are now in wide use--e.g., integrated development environments for software engineering) and on different types of organization and management for software engineering that improve productivity. However, due in part to growth in demand for IT products and services, it is unlikely that the use of tools or management techniques for increasing productivity will have a significant impact on tightness in the IT labor market in the current decade.

For the development of business-specific or company-specific IT applications, knowledge specific to the business dimensions of the application is as necessary as IT-specific skills.

8.1.3 On the Assessment of Talent (Chapter 6)

For an industry that is so dependent on human talent, reliable identification of the most qualified and productive individuals is critically important. However, many of the techniques used today to identify these individuals are poorly matched to determining an individual's qualifications for the relevant jobs.

Systematic efforts to determine the duties, responsibilities, and requirements of a job are most successful when the job in question is relatively stable and well-defined. Because the IT industry is changing so rapidly, it is very difficult to apply these traditional methods. Even recognizing this rapid change, however, existing methods for job analysis are not sufficiently detailed to describe such work attributes as abstract analytical work, skill in the use of information technology, teamwork competencies, and interpersonal skills.

Assessment tools almost always involve tradeoffs between speed/simplicity and thoroughness/accuracy. Some structured assessment methods (i.e., procedures used to evaluate a job applicant that are administered in a standardized and uniform manner, scored in a consistent manner, and validated against indicators of job success) have a solid empirical basis in identifying the most productive workers, enjoy a long and consistent record of validity and cost-effectiveness, and have proven to be fair and practical. On the other hand, structured assessments are often more expensive and time-consuming than unstructured methods, and they often depend on the quality of the information available about the content and requirements of the job.

The unstructured assessment methods commonly used to select IT employees today (such as unstructured group interviews) can raise suspicion of discrimination on the basis of age, race, and gender. In general, job applicants tend to view certain structured assessment methods as more fair and less arbitrary than unstructured methods, even if the use of unstructured methods is legally defensible.

8.1.4 On Education and Training (Chapter 7)

A factor currently limiting domestic production by 4-year colleges and community colleges of individuals with degrees in computer science is the availability of qualified faculty and facilities.Today, there is more student interest in such courses of study than can be accommodated. However, elimination of this limiting factor would increase production only if student interest in such careers matched the number that could be taught with newly available resources.

Many of the most promising students--at various levels from high school to graduate student--are drawn away from academic study to pursue the lure of riches offered by the IT sector. While these individuals themselves may benefit if their ventures are successful, the potential long-term loss to the IT academic research and education enterprise is severe.

Skills are needed, but formal training is not enough. Employers want to know that someone can actually complete a project applying the skills learned in a training course, and educational or training programsthat incorporate real-world internships are more likely to lead to job placements. Thus, any retrainingprogram intended to bring workers into the IT workforce, or to keep the skills of today's IT workerscurrent and relevant to new technologies, must provide work experience as well as training to succeed.

Professional societies have played an important role in supporting education and training through modelcurricula, accreditation programs for undergraduate computer science degree programs, and technicaljournals and conferences.

8.1.5 On Age Discrimination (Chapter 4)

A perception among certain parts of the IT worker community is that discrimination against older workers is rampant. A complaint coming from older workers is that they believe they are more likely to be laid off than younger workers and then, once without a job, they will find it much harder to obtain new employment.

Actions motivated by legitimate business reasons that also have disproportionate adverse effects on older workers do not necessarily constitute illegal age discrimination. Such business reasons may include the desire to reduce labor costs, to increase operating flexibility, or to seek workers with experience in new technologies.

There is evidence that the experiences of older workers in IT may be different from those of younger workers. The available data indicate that:

--The IT workforce is younger than that in other occupations with workers of comparable educational attainment;

--Older IT workers (those 40 years and older) are more likely to lose their jobs than younger IT workers;

--Older IT workers are just as likely as younger IT workers to find new jobs; similarly, the length of time it takes for them to find new jobs is similar to that for younger IT workers. However, older IT workers may compromise more on new jobs than do younger workers.

However, these differences--by themselves--do not allow the committee to determine whether they are the result of age discrimination on the part of employers, other employer behavior and conduct that, while legal, may create perceptions of age discrimination, personal choices by employees, or the ramifications of a rapidly changing industry. Thus, the committee cannot determine whether illegal age discrimination exists to a greater or lesser extent among employers of Category 1 IT workers as compared to employers of other professional occupations.

Difficulties that older IT workers perceive in finding suitable employment exist largely apart from theavailability of H-1B visas, as discussed in Chapter 4. Moreover, elimination of all potential agediscrimination in the IT workforce would not likely have a significant impact on tightness in the ITworkforce in the long term, although it could have a small, but important, one-time effect.

8.1.6 On the Use of Foreign Labor (Chapter 5)

The IT sector and IT-intensive industries are fundamentally global, both with respect to markets andtalent.Foreign-born workers can make an important contribution to the U.S. IT workforce. Furthermore,foreign entepreneurs, scientists, and engineers--like domestic ones--create jobs. Entepreneurs createbusinesses that hire others, while scientists and engineers--through the science and engineering thatunderlie new technologies--create jobs for other scientists and engineers working with thosetechnologies.

U.S. IT companies (and those engaged in the advanced use of information technology) can and do move work overseas for a variety of reasons. Sometimes they do so because labor costs are significantly lower, or because local markets require a local presence, or because they wish to tap a local talent pool with specialized expertise, or because a clean separation from the parent company can allow different "cultural" environments to flourish.

Given the assumption of continued growth in the use of IT, pressures will increase to locate development work abroad that would otherwise be performed in the United States. Such pressures areto some extent independent of the availability of foreign workers (either temporary or permanent) in the United States. Instead, these pressures are driven by a variety of other factors, including the significant cost advantages of relocating work to countries that have substantially lower wage structures than the United States, the need to tailor products to the requirements of foreign markets, and better access to foreign markets. This is not to deny the many difficulties and inefficiencies of coordinating offshore work with work performed in the United States, but many of these difficulties and inefficiencies are likely to be ameliorated by future generations of technologies to facilitate cooperative work.

Growth in the IT industries abroad and the accompanying competition for talent from nations such as India may restrict the supply of foreign workers to the United States. Of course, because the trajectory of future demand for foreign IT workers here and abroad is unknown, as is that of production rates of qualified foreign IT workers, this outcome is by no means a certainty.

It is the committee's judgment that the use of foreign workers will continue to be necessary for the immediate future, and that foreign workers will continue to make important contributions, but policy governing the use of foreign workers must consider not only the benefits of admitting foreign IT workers but also potential negative effects on the domestic workforce and take steps to ameliorate those negative effects.

8.1.7 On the Use of Temporary Foreign Nonimmigrant Labor (Chapter 5)

From the employer's perspective, the critical element of the H-1B program is that it enables employers to engage nonimmigrant foreign labor in useful work on a time scale of several weeks to a few months rather than years, a fact that makes obtaining foreign labor through the H-1B program convenient, given the time scales of change in information technology.

The committee estimates that temporary nonimmigrant workers (mostly with H-1B visas) constitute about 10 percent of the Category 1 IT workforce, though this figure likely represents an upper bound. While H-1B visa holders are far from the dominant influence on the IT workforce, their number is large enough that without these workers there would likely be a slowdown in the rate of growth in the IT sector.

Economic theory implies that an increase in the supply of IT workers, including temporary nonimmigrant workers, will cause the corresponding IT wage rates to be lower than they otherwise would have been. Theory alone does not imply any particular numerical magnitude of this effect. It is the committee's judgment that the current size of the H-1B workforce relative to the overall Category 1 IT workforce is large enough to exert a nonnegligible moderating force that keeps wages from rising as fast as might be expected in a tight labor market.

8.1.8 On Workforce Needs in Biotechnology as a Point of Contrast and Comparison

Product innovation and development in biotechnology are based on advances in the quality and amount of scientific information. Consequently, the paths to biotechnology careers--including those for technicians--require substantial formal training in a number of highly specialized scientific disciplines, including molecular and cell biology. This contrasts with IT, for which individuals can enter through a wide range of educational paths.

Barriers to the entry of new biotechnology products into the marketplace--especially drug products--are significantly higher than the barriers for IT products. Among the reasons for such high barriers are the large investment required in product discovery, the high rate of product failure in the preclinical and clinical trial phases, the need for the investment in product development to be protected by a strong proprietary position, and the high cost of product development (a large part of which can be ascribed to the need for extended (often worldwide) clinical trials).

Despite an abundance of individuals with Ph.D.s in the life sciences, the biotechnology industry is currently finding it difficult to find Ph.D.-level specialists in analytical chemistry, instrumentation, organic synthesis, clinical biostatistics, bioinformatics, production quality assurance, and regulatory affairs. Training in these science disciplines is sufficiently specialized that it is a nontrivial matter for a holder of a graduate degree in a branch of the sciences not mentioned above to shift into the kinds of work required.

8.2 PRINCIPLES FOR ACTION

As noted above, issues related to the IT workforce are multidimensional. Many employers do experience real difficulties and problems in hiring, but these problems are complex enough to defy simple solutions. Indeed, one of the major confounding factors in the public debate over the IT workforce is a plethora of simple solutions that address the problems from a single perspective. The committee believes that actions to address tightness in the IT labor market and the consequences for individual employers should be governed by a number of principles:

There is no single solution to relieving the tightness in the IT labor market, and multiple approaches will be necessary.

All stakeholders have a role in helping to address problems resulting from tightness in the IT labor market. These stakeholders include government policymakers, the IT sector, IT-enabled firms, educational institutions, and individuals. A corollary is that U.S. IT-sector employers have a long-term role (though not the exclusive or even primary role) in training, developing, and maintaining the IT sector's workforce.

Effective approaches to addressing tightness in the IT labor market must be responsive on the time scale of significant change in information technology. Employers must be able to hire workers on a business time scale (i.e., weeks or months), while policy actions taken to relieve tightness in the IT labor market must be reversible or capable of being moderated if and when such tightness no longer obtains.

All approaches to deal with tightness in the labor market have costs and benefits. For example, subsidies provided to increase employer-provided worker training in IT would increase the levels of training that workers receive, but might also result in subsidies being paid to employers to do what they would do anyway.

8.3 RECOMMENDATIONS

In the long run, a systematic effort to nurture an adequate IT workforce depends on several premises for action:

A broad base of citizens with basic fluency with information technology must be developed. Even if most of these citizens do not go on to be IT workers, future IT workers are inevitably drawn from this pool. In addition, educational efforts at the K-12 level must be conducted in such a way that postsecondary study of IT-related subjects is not precluded.

Awareness of IT careers must be promoted, and the reward (financial and otherwise) of pursuing such careers must be widely understood.

Educational institutions at all levels must provide (and be given) the resources for IT-related programs to the extent warranted by student demand. When changes in student demand for IT-related study require nontraditional approaches to education, changes from the status quo should be supported.

Especially in a tight labor market, employers must draw on and develop all sources of talent, both domestic and foreign. As a matter of enlightened self-interest, employers should be loath to overlook possible sources of good IT workers--even if those workers may require some training to make them productive.

The data to support informed decisions must be available. Such data should be collected more frequently, be made available more rapidly, and have a much higher specificity that accurately reflects the nature of the IT-related jobs.

All actions taken to relieve tightness in the IT labor market by increasing the supply of IT workers will take time to show results. Some actions will result in relief in the short term, and others will result in relief in the long term, and actions with a long-term time horizon (such as those described in Chapter 7) are especially important in the event that the tightness of the IT labor market increases.1 But these actions have costs as well as benefits that should be explored before they are pursued. And policies with short-term benefits may have an unintended negative effect on the viability of policies for the longer term. These tradeoffs must be balanced against the economic consequences for both production and IT employment, as well as for the nation as a whole with respect to issues related to overall national productivity.

This section on recommendations is organized by the parties on whom responsibility falls for taking action: IT employers, educational institutions, IT workers, and government. A final section describes actions that should most likely be taken in partnership among the parties.

The number of new recommendations described below is small, and many are already being followed by the actors in question. However, the rationale for some of these recommendations may be different, even if the recommendations themselves are not original to this committee.2 The committee offers its recommendations to encourage what is already being done, and to inspire to action those who are not already taking steps such as these. The committee also calls attention to the very important fact that the manner in which these recommendations are implemented has a great deal to do with their success. Thus, even if some of the recommendations "merely" reflect common sense, the unfortunate reality is that common sense is not always honored in practice. To the extent that some of the recommended actions are being implemented successfully by various individual stakeholders, the description here can be regarded as a description of "best practices" that others may wish to emulate.

8.3.1 For Employers of IT Workers

Change recruiting practices.

Today, IT employers spend considerable recruiting effort on college campuses in the search for top technical talent to meet their immediate needs for IT professionals. However, employers have also pointed

to difficulties in finding good managerial talent for their IT projects. Because management requires a maturity and perspective not often found in recent college graduates, recruiting efforts directed at older workers with necessary technical skills and managerial experience might yield a rich return on effort invested.

Build deeper relationships with universities and other sources of talent.

While most employers do recognize the value of active recruiting at colleges and universities, it stands to reason--and is confirmed by experience--that the larger and more substantive the campus presence of an employer, the greater will be student awareness of that employer. An employer that sets up an employment booth at a job fair once or twice a year will naturally have less visibility than one that meets regularly with the IT faculty, gives seminars to the computer science department, provides financial support and co-op opportunities for students, and works to develop relevant curricula.

Make more use of structured assessment methods.

Unstructured assessment methods, such as informal interviews, are easy to use. They take little time to develop and less time to administer than more structured methods. But employers would increase the likelihood of identifying good performers if they used more structured assessment methods, such as structured interviews in which assessors pose the same questions to every applicant and score the results in a uniform manner.

One method of structured assessment that may be especially valuable for IT employers is the work sample or simulation. An employer could ask an applicant for a programming job to develop an algorithm to solve a particular problem--or even to write a program to solve it, either in a language that the employer uses or in pseudo-code. An applicant for a position as network administrator or manager can be asked to solve a real networking problem, much as some vendor certification programs require candidates for certification to do. Because an individual's formal knowledge becomes useful to the employer only when that individual can apply the knowledge to a business problem, a work sample or simulation is likely to be a better predictor of future job performance than other, decontextualized assessment methods.

Work sample and simulation methods can also be used to identify individuals who will perform well in a team setting. Since much of IT work is a team effort, team skills are essential. One method that has been used to assess persuasiveness, self-confidence, oral communication, and interpersonal skills is the leaderless group discussion. In addition, new methods of assessing teamwork skills could be developed specifically for IT work.

Avoid discriminatory behavior.

Employees who participate in hiring in any way must avoid hiring practices proscribed by law. It is well-understood that hiring managers should be educated in this manner, but it seems less well-understood that the rules on proscribed behavior apply to members of project teams who interview applicants, as well as the managers that make the final decisions. Furthermore, more structured methods of assessing and selecting job candidates are in general less susceptible to sustainable charges of discrimination.

To the extent it is possible to use them, blinded assessments can help to reduce unconscious bias. Just as candidates for symphony orchestra jobs often audition behind screens (so that judges can hear but not see them play), programmers--for example--can submit coding samples without ever having been seen. And they can sometimes answer questions without needing to interact face to face. Under some circumstances, blinding is not possible (e.g., when evaluating teamwork exercises that are part of an interview, or when extended dialogue is necessary to probe more deeply into an applicant's work sample). Nevertheless, the use of blinding when appropriate can be helpful for institutions wishing to reduce their vulnerability to charges of discrimination.

Improve worker quality of life.

Because many IT workers rate nonpecuniary factors as highly as--or more highly than--wages or compensation in their decisions to accept or stay with a given job with a given employer, employers have a great deal of latitude in customizing their environments to better meet the nonpecuniary needs of their employees. For example, telecommuting or other alternative work arrangements can reduce the pressures that result from commuting in areas with high traffic volume. (A further benefit of policies that allow telecommuting is that an employer can begin to use IT workers who are far removed from employer work sites--thus enabling the employer to draw on a national rather than a local talent pool.3) Policies that help to support better work-life integration (e.g., onsite or employer-provided day care for workers with children or elderly parents) can also play an important role in employee recruitment--and especially in employee retention. Policies that allow more time off the job, whether in the form of compensatory time following peak work periods, vacation time, or a moderate work pace throughout the year, might well aid retention.

Practices that improve the quality of life for workers may also help to avoid or reduce the impression of discrimination against older workers; such practices can include recruiting more widely or providing greater flexibility in working conditions.

Promote training.

Human capital theory predicts that employees who receive training become more marketable to other employers and thus become less likely to stay with the original employer. But as noted in Chapter 7, some recent empirical and theoretical research has called this assumption into question. For example, providing training has in some instances been an effective tool in helping to reduce turnover because it increases employee loyalty. And employees who receive training may not find it easy to transfer their training to other firms.

With this perspective in mind, training and continuous learning become realistic and reasonable options. Thus, more employers should:

Consider explicitly the wait time involved in identifying and hiring an appropriate candidate against the time it would take to train (retrain) someone to perform the job for which the employer is hiring. In instances in which the training time is less than the time needed to find an appropriate worker, it generally makes more sense to provide such training.

Collaborate with other employers to provide opportunities for generic training (i.e., regional training consortia that can be used to train workers for a wide range of employers). An important part of such collaboration would be to provide internships or other opportunities for integrating work and learning for those being trained. Such actions help to build the local workforce, to the benefit of all employers in the region.

Consider assigning employees to projects and tasks that broaden and update their skills, rather than assigning them to the tasks for which their skills are greatest. Although assigning people in ways that enhance their skills may reduce productivity in the short term, it could yield greater organizational productivity over the long term by increasing retention of company-experienced personnel. Such in situ training would enable employees to better situate their learning in a real-world experience, and would provide better work-learning integration.

Provide internships for unemployed workers who have been retrained but who need on-the-job experience to hone and contextualize their skills. Of course, pay scales for such internships would be discounted to account for reduced productivity during the period of the internship, but whether or not the intern remains with the company providing the internship, the worker will obtain valuable experience that will be helpful in obtaining his or her next job.

Provide management training to IT workers who recruit, hire, train, and supervise. Such training is likely to be especially helpful in those instances in which younger managers supervise older workers. Note that there are well-understood and tested "best practices" for managing the software development process.4

Provide resources that will allow workers to stay current (e.g., financial support for conferences, journal subscriptions, courses).

Define and/or select courses and subjects of training that employees can benefit most from. Some evidence suggests that employers are better trainers than schools and better able to select effective school-based programs for workers than are the workers themselves.5 It is thus appropriate that employers provide some guidance for workers who wish to retrain, even if the employer does not pay for training at all.

Evaluate managers at least partially on the basis of the training their subordinates receive. It is well known that the behavior of individuals in an organization is shaped by the dimensions along which they are evaluated, and so manager support of training can be encouraged by such evaluation.

Finally, given the difficulties that institutions of higher education have in finding qualified faculty to teach IT-related subjects, employer encouragement of software developers to take adjunct teaching positions in colleges and universities could provide a mutually beneficial arrangement (as discussed below). Although companies are understandably hesitant to lose the services of talented developers, it is sometimes possible to offer as an employment benefit the opportunity to engage in occasional teaching.6

Organize work for productivity.

As discussed in Chapter 3, organizational changes can sometimes make a significant difference to productivity and to personnel requirements. For example, IT employers should consider up-front investments in product design to reduce personnel needs later in the development cycle--and such investments should be explicitly noted in the funding plan. IT employers may also wish to consider the use of applications service providers and industry/enterprise-wide software to reduce personnel requirements, and thus possibly lower the need for IT workers nationally.

8.3.2 For Educational Institutions

Improve secondary mathematics education.

The conclusion that mathematics education needs reform is hardly original with this committee. For example, there is a broad consensus among experts in mathematics education on the need to make the mathematics curriculum for all students richer, more challenging, and more focused. In response, the National Council of Teachers of Mathematics has developed challenging standards for mathematics education that embody the elements outlined above. Curricula based on these standards tend to be problem-centered, stress problem-solving and reasoning skills, and address the motivational issues by connecting skills to problems that students might encounter in real life. Often, students in these mathematics programs work in groups and pairs, as well as individually, just as IT work often involves project teams or groups. And finally, these new curricula attempt to integrate information technology into the instruction.

Promote IT fluency in K-12 and in colleges to a greater degree.

A familiarity and comfort with IT would seem to be a necessary prerequisite for individuals who will become IT workers. Indeed, educational specialization for IT work can build on a basic level of fluency with IT that is accessible to all. The committee endorses the sentiment contained in the 1999 CSTB report

Being Fluent with Information Technology,7 which puts forward the proposition that some degree of fluency with the concepts, skills, and intellectual abilities associated with information technology is appropriate (and increasingly necessary) at the college level, and certainly accessible to lower grades in K-12.

Further, a variety of education reform efforts seek to improve mathematics and science education in K-12. The underlying philosophy of these efforts is to present all students with a robust and intellectually challenging curriculum. If the assumption on which these efforts are founded is valid--that students are in general much more capable of absorbing mathematical and scientific content that was previously thought to be accessible only to a select few--these efforts at reform are likely to produce a much larger pool of individuals who are suited to pursue and are interested in pursuing further education in IT.

The committee recognizes that most K-16 educational institutions are undertaking efforts in this area--but it underscores the importance of creating the widest possible pool of individuals comfortable with using information technology from which IT workers will ultimately be drawn.

Better align educational programs in IT with employer needs.

For a dynamic field such as IT, which exhibits close coupling between the industrial and the academic worlds, it is quite sensible and appropriate to take advantage of possible synergies between the two.

One of the most important points of coupling is providing the opportunity for students to participate in co-op arrangements and internship programs in industry. The committee heard repeated testimony, which incidentally corroborated its own members' experience, that formal knowledge obtained in the classroom is placed into context best in real work environments. Thus, educational programs in IT should offer real-world work exposure and experience as a part of such training, e.g., through co-op arrangements and internships. These comments are especially true for educational and training programs for older workers, which should provide work experience as well as certification. Indeed, it is not unreasonable for an employer to want to know that a potential new worker can actually complete a project using the skills for which he or she is certified.

A second point of coupling is the fact that many of the IT problems faced by industry are worth studying in academia, especially in professional-level academic programs. The potential practical benefits are large, and in addition they often provide challenging intellectual problems that are as worthy of research as much more theoretical problems even though they appear in an applied context. A corollary is that it is not unreasonable for academicians to seek employer input in formulating curricula, especially in advanced subjects. Indeed, seeing how IT workers steeped in their business problems approach the intellectual content of a computer science curriculum is bound to have salutary effects on students.

An offshoot of the above point is that a concentration on technical knowledge to the exclusion of soft but enduring skills (see Chapter 2) such as communication, teamwork, and management does not serve students well. Traditional education in software engineering has often emphasized "hard" but perishable skills, e.g., knowledge of specific languages such as FORTRAN, C, and Java. However, because soft but enduring skills such as project management and people skills do not become obsolete as technology changes and are themselves critical in the marketplace, they warrant explicit attention in formal curricula (though it is especially important that these be integrated into some work experience).

These comments are not meant to denigrate "hard" skills that endure. For example, system design and architecture are increasingly important, and even a relatively small number of well-trained systems architects could contribute greatly toward the successful development of enterprise-wide software. Techniques for implementing the "ilities" (e.g., security, reliability, trustworthiness, manageability, quality of service, modifiability, scalability, and flexibility) in large systems are also important, and likely to be enduring. Curricula better aligned with business needs would increase emphasis in both these areas.

Employers often say that they want graduates who are able to "hit the ground running" and are then able to

stay current with rapidly changing demands of the marketplace. That view argues for a stronger integration of marketplace requirements into traditional computer science training. To the extent that educational institutions can work with professional societies and employers to identify and promote core knowledge and skills that could be addressed by an IT minor or area of concentration, a pool of skilled individuals larger than those of computer science (CS) graduates alone would be available to employers.

Finally, educational institutions can better facilitate the education-to-work transition. Of course, an important part of this transition is teaching skills that can be used in work and providing venues in which those skills can be practiced and enhanced in worklike environments. But equally important is educating workers-to-be about the realities of a changing workplace. Indeed, many of the difficulties encountered by workers in the workplace stem from a mismatch between their expectations and today's marketplace realities.

Another way to facilitate the education-to-work transition is through placement services. Most universities and colleges have placement offices, but an effective job placement operation entails much more effort than is implied by a placement office that does not interact with content-providing departments. Colleges and universities can improve their placement efforts by promoting close and ongoing dialogue between senior academic leaders and local IT employers and by making special efforts to talk up the benefits of hiring nontraditional students.

Expand faculty recruitment pools.

Universities and colleges are seeking to increase permanent faculty in CS undergraduate and graduate programs. However, while research support for faculty seems likely to increase in the future (largely as the result of various new government initiatives to support IT research and development), university dministrators are unlikely to allow growth in these programs at the same rate at which demand for IT workers is increasing (especially since they fear that over the long term, traditional tenured appointments in CS may not be justifiable given ups and downs in the demand cycle and may upset the balance among academic departments). And qualified faculty are increasingly difficult to find.

Given such difficulties at all levels, educational institutions will have to consider other options such as the following for faculty recruitment:

Make greater use of adjunct faculty drawn from industry. Students benefit intellectually from contact with teachers with intimate knowledge of business needs (as described above), and often faculty members from industry are prime channels through which students (their own or others) can be placed and/or recruited.

Upgrade the skills of existing faculty. For example, some colleges are training electronics teachers in computer science, drafting instructors (including computer-aided-drafting instructors) in digital media, and art teachers in Web design.

Use faculty in other departments to assume some of the teaching load. Such an approach is particularly effective for faculty members in related disciplines (e.g., engineering) or in institutions that offer IT minors or concentrations (see below).

In addition, educational institutions can spread existing faculty expertise across more students by offering courses online, hiring teaching assistants, and increasing the work-based component of the curriculum.

Finally, in order to create an environment in which IT-supported intellectual inquiry can flourish across the entire curriculum, faculty in all disciplines should be supported and encouraged to acquire some basic level of fluency with information technology. Only with such fluency will they be able to expose students appropriately to IT in its many pedagogical applications.

Promote formal IT education for students who concentrate in non-IT-related disciplines.

While a formal computer science background is increasingly necessary for many IT occupations, that background is not necessarily or only supplied by a bachelor's degree in computer science. Individuals who concentrate (or have concentrated) their major study efforts in some business domain or some other field should also be able to take computer science or IT minors or concentrations that provide significant exposure to the formal content of computer science curricula. Such individuals are likely to bring special value to employers in those primary areas of study, because they should be able to more effectively apply their IT expertise to problem domains of interest to their employers. Both 4-year colleges and universities as well as community colleges have important roles to play in this regard.

However, such minors or concentrations are not likely to succeed absent close interaction between the faculties in IT and those in the "other" department. Faculty members in the other department should be sufficiently conversant with the basic concepts and fundamentals of computer science to be able to convey those ideas in an appropriate context. And faculty members in IT should be open and sensitive to the field-specific issues that arise in any such collaboration.

The benefits of providing IT-based areas of concentration in other departments should not be lost to those departments. In particular, departments whose enrollments are declining may well be able to boost those enrollments by offering courses that help to prepare students for IT work.

Use professional societies and groups to support educational efforts.

Professional groups should offer more training courses (via distance learning or otherwise), workshops, and publications aimed at keeping the skills of readers current. They can also encourage more young people to enter IT occupations by establishing a curricula "family" that encourages entrance to the IT field through multiple disciplines. Finally, professional societies can provide high schools, parents, and guidance counselors with information about IT career paths, IT occupations, and the skills required for those occupations.

8.3.3 For Individual Workers

Given the realities of today's workplace and likely trends toward high-mobility employment, individual workers are likely to have to assume more responsibility for maintaining the currency of their technical skills in the face of rapidly changing technologies.

IT workers should seek to negotiate release time for training and professional development where possible and employer financial support for training and professional development. Likewise, they should seek placement into jobs that will develop and enhance skills with current technologies. Such placements are likely to be more accessible when the individual is already employed in a company and is seeking other work inside the company.

When using formal education to learn new skills, IT workers should seek a project or internship in order to obtain experience applying the new skills. Employers are often reluctant to hire those with classroom training but without actual work experience.

IT workers should take advantage of training opportunities offered by their employers.

IT workers should seek to stay current with advances in technology and underlying science through participation in professional societies that publish technical journals and sponsor technical conferences and tutorials. Note also that membership in professional societies can help to inform members about the nature of the employment market as well as provide information relevant to their technical skills.

IT workers should take advantage of self-study programs, community college and university courses, vendor certification programs, and other resources for updating their skills in programming tools and languages.

8.3.4 For Government Policymakers

Provide incentives for employers to increase training.

Coupled with the speed at which IT changes, the trend toward high-mobility employment is largely incompatible with significant amounts of training provided by employers, large amounts spent by many IT employers notwithstanding. Yet if workers are to remain competitive in the IT labor market, mechanisms must be found to ensure that they receive the training they need to stay current. However, these same trends that drive the requirement for continuous learning also encourage high worker turnover and discourage employers from investing in worker training.

If one reason that the employment experience of older workers differs from that of younger workers is that older workers lack the up-to-date skills required in this rapidly changing field (a possibility requiring further study), then policymakers may want to consider the access that older workers have to training opportunities. Because of the impediments to training that are described in Chapter 7, government assistance may be necessary to provide that access.

According to neoclassical economics, if training is valuable to firms and workers, they should undertake the necessary amount without inducement from the government.8 However, there are several reasons why the market may not provide the "right" amount of training, providing both a justification for government intervention and a road map for policy:9

Lack of access to capital. Both firms and workers may not be able to borrow the money needed to pay for training. Because human capital resides in the workers and cannot be used as collateral, firms and workers may not be able to borrow against the asset or may have to pay a prohibitively high interest rate.

Imperfect information. Although the economic benefit of higher education has increased dramatically in recent years, workers and firms may not be aware of the magnitude of the increase, or they may not know how long the current high benefits will persist.

Greater social than private benefits to education. It is possible that the value placed on training by society as a whole exceeds the value to individual workers and firms because of "externalities." (For example, increases in training may increase income and therefore reduce dependence on public assistance programs.) As a result, without government subsidization, firms and workers will underinvest in training, relative to the level of investment desired by society as a whole, since they will not reap the full social benefits (only the private benefits).

Training for IT workers can be undertaken by both workers (as described above) and firms. But because firms are hesitant to invest in their workers' general skills given that the workers might leave before the firm can recoup its investment, the committee focused on approaches that have been used or proposed for government to compensate the employer for part of the costs that result from training an employee.10 Potential government incentives include the following:11

Tax credits. If firms were permitted to take tax credits for qualified training activities, the cost of training to firms would be reduced, and they would likely expand their use of training. Tax incentives have been used in the United States to encourage expanding employment, hiring workers with particular characteristics, expanding investment, and expanding research and development. Evaluations of these activities have shown mixed results, so the design must be carefully crafted to achieve the desired results and preclude windfalls.

Subsidized loans. The federal government already offers subsidized loans for education, disaster relief, and establishing or operating small businesses. For several years, the U.S. Department of Labor has been exploring the feasibility of a loan program to encourage more employer training.

Direct grants to employers for training. Several states have operated training grant programs for a number of years. States that operate such programs generally require detailed applications from employers to ensure that the training is targeted to the types of training the states wish to encourage.

Levy/grant or mandatory training programs. Under a levy/grant program, employers are required to make payments based on some measure of their ability to pay or their perceived need to train; the funds are then rebated to contributing employers based on their expenditures on training. In contrast, mandatory training programs require employers to spend a specified share of their payroll on training, or they forfeit the unspent funds to the government. Both of these approaches have been used in Europe and Asia to promote training.

The committee is explicitly silent on which, if any, of these mechanisms have proven successful or would be appropriate for the IT sector or IT-intensive industries, and on how strong the incentives should be. However, experience does seem to indicate that employer contributions to training programs (e.g., on a partially matching basis) are needed to obtain employer buy-in--without such contributions, employers have no real incentives to make the program work. With this caveat, the committee encourages all levels of government to consider expanding the use of various training incentive policies.

A final point is that the source of funds for training subsidies is unclear. An argument could be made for the use of general tax revenues, on the grounds that the IT sector is one of strategic importance to the nation. Alternatively, the use of H-1B fees to support training subsidies that are directly linked to the fields in which H-1B workers work is certainly within the spirit of the legislation specifying the disposition of such fees. Again, the committee is silent on which of these sources of funds (or perhaps others) is most appropriate.

Support regional training consortia.

Regional training consortia are useful because they help develop the regional workforce. When employers help to define the training program, its effectiveness and relevance to their needs are likely to be increased. Universities and colleges and community colleges, too, have a role in providing pedagogical expertise and access to intellectual resources that are not usually available in commercial firms. Government support is useful for catalyzing such efforts.

When training consortia succeed, they do so because they provide a mechanism to overcome some of the disincentives to training described above. For example, lack of capital for training can be overcome if larger firms, with more capital, share training costs with smaller firms. More importantly, regional training efforts can overcome the "free rider" problem that results when some firms (often the larger firms) invest in education and training, while other firms steal the trained employees. Regional training consortia also allow member companies to pool both expertise in training and trainees, in order to achieve economies of scale.

Many employers of IT workers already participate in trade associations. However, as discussed in Chapter 6, training and retraining initiatives organized by trade associations are not always successful in helping trainees obtain IT jobs, and they sometimes falter when public funds run out. With stable funding from member firms, regional training consortia would be better able to develop and refine training and employment initiatives. Employers who were financially committed to a regional training consortium might be more likely to provide the internships and structured on-the-job training opportunities that are likely to lead to employment.

Collect better data.

The committee believes that in a highly dynamic field such as IT, better data are required to help policymakers, employers, workers, and students make appropriate decisions. To enable better understanding of the workings of the IT labor market and intelligent policy decisions, both stock (point in time) and flow (changes over time) data are required. Specifically, data are needed on the size of the IT labor force by detailed occupation, industry, and firm characteristics (such as size and type of IT work) and should cover all forms of compensation, including bonuses and stock options. Data that trace work histories are also needed to characterize where IT workers come from (e.g., country of origin, post-secondary ducation, previous occupation) and the qualifications they bring to the job, as well as exit rates and the occupational destinations of workers who leave IT work. These data must be available more quickly, in more detail, and for larger samples than the government typically collects through surveys such as the Current Population Survey and the Occupational Employment Survey program. Finally, the Immigration and Naturalization Service and the Department of Labor must improve the data they collect and publish on the role of foreign workers in the IT labor force, including--in addition to the categories mentioned above--data on the previous and subsequent immigration status of H-1B workers.

Taking special note of the inadequacy of the available data to address questions of age discrimination, the committee recommends the collection of high-quality data to directly address such questions, such as the data provided by well-designed and properly executed audit studies. The committee recognizes that no single study can establish the existence and/or extent of discrimination, because almost every study has one limitation or another. Rather, a finding of widespread discrimination must be based on an array of evidence and data. As some courts have found, audit studies can be one important element of such an array. While not every audit study is of high quality, the methodological intent of an audit study is to focus on the experiences of individuals whose characteristics and qualifications are comparable in all ways except for the protected characteristic (e.g., age, race). As a result, they suffer from fewer of the problems that plague studies that rely on survey and administrative data alone, as discussed in Chapter 4. As such, timely and properly performed audit studies provide important evidence relevant to the existence or nonexistence of discrimination.

Though some improvements in the federal data-gathering process may result in more and/or better data becoming available in the next few years, the committee recognizes that federal funds for data gathering are limited. Moreover, private efforts to gather such data have sometimes been viewed skeptically because of potential conflicts of interest. The committee therefore suggests that the IT sector and IT-intensive industries work jointly with the government to improve the data collection system for the IT workforce and that the IT sector and IT-intensive industries consider sponsoring specific data collection activities by the Bureau of Labor Statistics and other government statistical agencies.

An important corollary of the recommendation to collect better data is that when more adequate data do become available, policymakers should once again examine the issues that motivated this study in the first place. Many of the questions that the committee would have liked to answer definitively were simply impossible to address given the paucity and poor quality of data available. In the absence of definitive evidence, the committee chose to focus its best efforts on explicating the relevant issues, in the hope that a future analytical effort drawing on data to be available in the future will be able to shed further light on questions of interest to policymakers.

Change funding formulas for state-supported educational institutions.

Today, state and local governments often allocate funding to public educational institutions on the basis of their full time equivalent (FTE) student enrollment. Such formulas make it difficult for these institutions to respond quickly to changes in "hot" areas, such as IT is today. Changes in funding formulas--such as the allocation of discretionary funds for "hot" programs--would help to increase program flexibility and responsiveness, and allow public institutions to bid more effectively on the open market for talent.

Support research.

The federal government has an important role to play in identifying and supporting areas of research that may help to relieve tightness in the IT labor market in the long term. Some of these areas of research include:

Work organization, situated learning, and productivity. By and large, little is known about the kinds of work organization that lead to increased learning and greater productivity among IT workers. In particular, the best approaches to organizing work and training workers who develop or create IT products or applications-based services (Category 1 work, as described in Chapter 2) are not yet clear. It is unlikely that one type of work organization is inevitably superior to others under all circumstances, so a key component of this research would be to identify the circumstances under which one type of organization is better than another. Further, such research should aim at providing managers and corporate executives with actionable guidelines to help them make appropriate decisions before projects are started.

Assessment tools for IT jobs. As noted in Chapter 6, one of the impediments to the use of structured assessment methods in IT is that their administration is resource-intensive. This is a particularly serious issue for undertaking initial screening. One possibility is to explore the notion of an online assessment tool that can be used to identify highly skilled individuals in a nondiscriminatory manner.

Software engineering.12 A better understanding of the "ilities" (e.g., flexibility, security, reliability, manageability, quality of service, modifiability, and scalability) and how to incorporate them into large systems would be useful in identifying bottlenecks in the software development process. Likewise, software reuse is poorly understood, with outstanding issues about where and under what circumstances software reuse is beneficial in software development, what the benefits are, and how software reuse could be implemented on a wide scale to make a significant improvement in software development productivity.

Better integration of the above areas (work organization, assessment, and software engineering). Because many IT managers were once IT workers themselves, it is important to understand how IT workers can develop key managerial skills. A better understanding of career paths from IT worker to IT manager--and of how the individuals successful in such transitions integrate technical and managerial knowledge--is likely to enhance the quality of IT management in the future.

More generally, support of high-risk, high-payoff research would help to retain and attract top researchers in and to academia. As noted in Chapter 6, it is hard for the nonprofit academic sector to compete with the commercial sector on the open market for top IT talent. Indeed, those who choose to remain in academia are usually motivated for reasons other than financial ones--reasons such as the desire to teach and to engage in high-risk research that does not necessarily have immediately foreseeable commercial payoff. But the hassles of being an IT academic faculty member are increasing--larger class sizes, increasing difficulty in obtaining research grants, decaying infrastructure, and so on.13

A number of reports14 have called on the U.S. government to increase levels of support for IT research and to support a larger proportion of high-risk, high-payoff research. The committee adds its voice to these reports calling for such action, because of the impact they will have--if successful--in reducing the difficulties involved in conducting university-based research.

Ensure that foreign workers are as free as domestic workers to change jobs, and streamline the green-card process.

Comprehensive and effective reform of law and policy regulating the use of foreign workers in the United States depends on a statutory and regulatory apparatus that does not introduce excessive delay in the processing of individual workers. As noted earlier, employers turn to the H-1B visa program because it provides a route through which foreign labor can be legally hired in the United States in a timely manner.

Whereas it can take 5 to 8 years to obtain a green card for an individual worker, an H-1B visa can usually be obtained in a matter of months. Much of the controversy over the H-1B program is rooted in the belief that the use of H-1B workers places U.S. workers at a disadvantage, because of H-1B workers' lack of mobility and their status as "temporary" in the labor force. Based on these problems with the program, the committee makes the following recommendations:

H-1B visas should be more portable than they are today, thus allowing H-1B workers to change jobs more easily.15

Today, H-1B workers cannot change jobs unless and until a new employer files an H-1B petition accompanied by a new labor certification application. In addition, if an H-1B worker who wishes to obtain permanent residency changes employers, is promoted such that his or her job duties change, or relocates with the same employer, he or she may have to start the green-card process all over again, may lose his or her original priority date,16 and may not complete the process prior to the expiration of his or her H-1B status. In short, many H-1B workers are bound to their employers for immigration-related reasons.

The green-card process should be reformed and significantly streamlined, thus reducing the time needed to obtain green cards.

The current green-card process for certain categories of employment-based visas is based on legislation dating from 1952 and consists of two components: a labor certification administered by DOL, and an INS review of the foreign worker's proposed employment and credentials, as well as his or her personal history, culminating in issuance of a green card. Both components are in need of reform. One problem with the labor certification process is that it requires a labor market test for certain categories of employment-based immigration that does not reflect innovations in recruitment practices, such as recruiting at professional meetings or advertising positions on the Internet. More generally, it is widely acknowledged that the current process is delay-ridden, cumbersome, and overly complex. As a result, a labor certification that takes from 6 months to 4 years to obtain may be entirely overtaken by changes in the labor market by the time the certification is granted. Another problem that delays issuance of green cards is that the INS allocates immigrant visas based, in part, on country of origin, resulting in per-country limits on the number of green cards that can be issued each year. Because the limits are reached in several countries where there is high demand for visas (such as China and India), substantial backlogs occur, making the green-card process particularly slow for nationals of those countries.

Recognizing these problems with the current green-card process, the committee recommends that it be reformed according to the following policy principles:

1. The green-card process must be streamlined in a way that significantly reduces labor certification processing and limits total processing times to a time scale of a year or so, rather than the current total of 5 to 8 years. In principle, this is an implementation issue, but policy decisions are likely to be necessary to achieve such changes in implementation. The Department of Labor should develop rules enabling labor certification applicants to change job duties as a result of promotion, change their place of employment, or change employers more easily without invalidating their green-card processing, and Congress should consider changing the "per-country" limits to reflect current immigration patterns. More generally, where possible, steps in the green-card process should be conducted in parallel rather than serially. For example, as noted in Chapter 5, the INS portion of the green-card process involves two distinct steps that currently must be conducted sequentially. INS should consider conducting these steps simultaneously.

2. Any streamlining changes to the green-card process should exist as a matter of regulation or statute, and be administered uniformly throughout the nation. A program based on regulatory or statutory authority is subject to public comment and has a degree of legitimacy not enjoyed by programs based on directives. It is therefore more likely to be administered consistently throughout the nation. Similarly, employers need clear rules and requirements that allow them to know when they are in compliance and what applications will be approved.

3. Labor certification requirements should reflect innovations (such as the use of the Internet) in recruitment and should also reflect that recruiting practices may vary by industry and occupation (professional employees in some occupations, for example, are recruited at professional meetings).

The DOL has acknowledged a need to reform the labor certification process.17 In addition, DOL has already undertaken some efforts at reform, e.g., its "reduction in recruitment" (RIR) process. However, while these reforms are a step in the right direction, they do not go "far enough" and likely violate one or more of the committee's articulated policy principles. For example, the RIR process is intended to take into account recruitment practices normal to industry today, and thus to reduce the time needed to process labor certifications. However, the basis for RIR is a DOL administrative letter, which has not been uniformly implemented throughout the nation; different regions vary in both procedures and processing times--from 3 months to 2 years.

In addition, while the committee recognizes that an important controversy regarding the H-1B visa program is its size, it has found no analytical basis on which to set the "proper" level of H-1B visas, and thus decisions to reduce or increase the cap on H-1B visas are fundamentally political. Furthermore, since the H-1B program is used to supply skilled labor in many fields other than IT, an IT-centric analysis is clearly inadequate. At the same time, the current situation, in which the H-1B cap is reached early in the fiscal year, resulting in INS freezing H-1B approvals until the following October and using H-1B numbers from the next year's allotment to satisfy pent-up demand from the prior year, is unacceptable. In order to alleviate this problem, it may be worth considering approaches that either distribute allocation of the visas throughout the year or that move away from the notion of a fixed numerical cap.18

Finally, the committee urges policymakers to look ahead several years and consider the effect of having increased the numbers of H-1B visas without having significantly streamlined the labor certification rocess or having reevaluated the numerical limits on immigrant visas available in the U.S. current employment-based immigration program (i.e., the number of permanent visas available to foreign workers based on their job skills and country of origin). The committee believes that it would be a mistake to adopt "stopgap" measures related to this group of nonimmigrant workers and miss the opportunity for a considered debate on the nation's policies regarding employment-based immigrants, given the fact that our economy is rapidly becoming more global.19 Some of the issues for the national debate include the nature of the appropriate criteria for different classes of immigration (e.g., employment-related skills, family ties, political status), the allocation of visas of different types among occupations and nationality, the number of visas available in each category, and the appropriate balance of indigenous and foreign labor in the United States.

8.3.5 For the Federal Government as a Major User of IT

The government depends heavily on IT systems to conduct business and, more importantly, to provide for the security and welfare of the nation. In many cases, these operations are handled by contractors who develop and operate IT systems for the government. But the government employs many IT professionals directly. One reason is that government systems may contain sensitive data to which contractor access would be inappropriate. A second important reason is that government needs considerable IT expertise to exercise appropriate management oversight for its many IT-related contracts. As described in Chapter 3, the federal government faces a number of specific challenges when seeking to recruit and retain IT workers, including an inability to match private sector compensation, an impending retirement bulge, and a statutory inability to tap foreign workers for certain sensitive positions.

In addition to some of the actions (mentioned above) that all large employers of IT workers can undertake, the federal government should take the following steps.

Emphasize the fulfillment that comes from working in responsible positions serving the nation.

In the past, IT and other technical workers have often had great responsibility for implementing and managing complex and important systems. In many cases, government employees have had far more responsibility than they would normally have in private industry. As the amount of contracting out increases, government workers will assume the responsibility for managing large teams of contractors. This can be very fulfilling work. At the same time, IT operations that must remain within the government because of the sensitive nature of their processing can also provide technically challenging work that is of national significance.

A deliberate effort to publicize accomplishments of IT professionals in government would be consistent with such an emphasis. For example, well-publicized award ceremonies, write-ups in trade journals, and some high-level attention to successes working in challenging areas (such as those posed by large federal systems) could well be part of such an effort.

Be more flexible in remuneration and recruiting methods.

The government can take several steps to achieve greater flexibility in remuneration and recruiting:

Make government compensation systems more competitive with the private sector. The present system cannot react rapidly enough to the rapidly changing IT workplace. Temporary relief is needed to the Civil Service Title 5 rules for as long as the IT labor market remains tight and dynamic. Congress has sometimes provided waivers for demonstration projects, for example, to retain key technical people in Department of Defense (DOD) laboratories. Such programs can provide more flexibility, such as signing bonuses, entry at higher than normal civil service positions, substantial bonuses to outstanding workers, and rapid promotion.20

Update the occupational structure of IT work done in federal service. The current structure does not match the occupations recognized in the IT industry today. Advances in technology mean that IT jobs change rapidly. Broadening the occupational structure of IT work will allow greater flexibility for managers to react to changes in the nature of the work.

Eliminate the restrictions on the remuneration of retired federal employees. Retired federal workers (military and civilian) are an important potential source of IT skills and experience. However, laws on dual compensation prohibit civilian retirees from getting the full combined value of their salary and annuity upon reemployment in the federal service. Recent legislation removed this restriction for retired military personnel. Rehired civilian annuitants, however, only get the difference between their retirement pay and what would have been their salary. This restriction discourages civilian retirees, who therefore take jobs in the private sector.

Emphasize the special advantages of working in government as an employer for those from nontraditional labor pools: women, minorities, persons with disabilities, and unemployed and underemployed mid-career technical professionals. These advantages include the defined hours, the family-friendly work environment, the stability of employment, and the health and pension benefits.

Make greater use of intern programs, possibly augmenting them with stipends for course work and term papers that are directly applicable to government problems. Internships are popular in the private sector, and DOD, for example, has had a fairly successful program in the past.

Improve working conditions.

The government should make much greater use of telecommuting and other practices to improve IT working conditions. Telecommuting, flex time, and flex place are standard practice at many companies. Some of these programs are implemented ad hoc in the federal government, but more systemic utilization of new business work models could motivate workers to join or remain in government service.

Make more resources available for training.

The federal government should raise its investment in IT training to the best levels in the private sector in order to maintain the skill levels of its employees and to help with staff retention. For many years the military has provided substantial education and training to its employees. This has been an important factor in retention. Some of these same principles (e.g., tuition reimbursement) can be applied in federal civil agencies.

Use contractors more effectively.

The government should provide contractors with more flexibility in staffing projects. In some cases contracting officers have set unrealistically high educational and experience requirements and compensation rates that are too low. They have also set severe restrictions on the extent to which training can be billed to government contracts. Such measures exacerbate the tightness in the IT labor market that the government feels. For example, requiring a 4-year degree eliminates many highly qualified people from working on government contracts. Loosening these restrictions will increase the pool of qualified workers available to work on government contracts and help companies to maintain the skills of their employees.21

The government should continue to innovate in the area of contracting as it has over the past few years and should continue to make greater use of off-the-shelf hardware and software, rather than more expensive and inflexible custom programming. Agencies should take advantage of contracting vehicles that have become much more flexible, allowing government managers to reward good contractor performance and not make awards to contractors with bad records, even though their bid price may be low. Local managers should be given more authority but should be held accountable for the systems that their contractor teams implement This kind of flexibility will be even more important as the demands for e-government increase in order to be more responsive to citizen needs.

Support a next generation of (federal) IT workers.

Analogous to U.S. government programs that support the education of physicians in return for a number of years of service to medically underserved areas, the government should consider establishing a federal "cyber service" program. For many talented high school students the high cost of college education is a barrier to continued education. An IT scholarship and intern program would provide the financial means for these students to gain a college-level education in IT. The government would pay for a student's undergraduate and/or graduate IT education in return for the student's commitment to government service.

Another aspect of promoting federal service in IT relates to the cultivation of future federal leaders in IT, giving them greater responsibility early in their careers and regular job rotation. For example, the CIO Council has recommended that the Office of Personnel Management prepare a program to develop better managers and supervisors for new IT workers who may have many nontraditional work preferences. Such measures are a helpful step that will nurture a next generation of IT workers.

8.3.6 For Joint Action

While federal and state governments, companies, and academia can do more individually to relieve the tightness in the IT labor market, cooperation among these groups is also necessary on a national and regional basis. These constituencies need leadership and motivation to work together, and this can best be provided by the federal and state governments. Examples of actions that can be taken are described below.

Promote awareness of and interest in IT careers.

Stimulating awareness of and interest in IT careers should engage both the public and private sectors. For example, the Department of Commerce noted in mid-1999 the need for greater awareness of opportunities, reporting on an apparent need to improve the image of IT jobs to attract young people22 and launching an initiative to promote better image-making through the mass and entertainment media as well as renewing emphasis on K-12 education as the time and place to stimulate interest in IT careers. Stimulating youth interest in IT careers has, of course, long been the province of relevant professional societies, and concern about labor market tightness has further stimulated such efforts. The Association for Computing Machinery and the Computer Society of the Institute of Electrical and Electronics Engineers, which represent both Category 1 and Category 2 IT workers, as well as other organizations more focused on Category 2 IT workers, have long been involved in planning for education, mentoring, and youth outreach, including programs for disadvantaged youth as well as youth generally. Professional societies aggregate information about IT careers, education, and training at the national (or international) level and publish it; many outreach activities are developed and undertaken at local levels and in communities. These efforts may provide a useful platform or social network on which to build.

Expand opportunities for groups underrepresented in IT.

As noted in Chapter 6, the full utilization of all sources of labor is necessary to cope with a tight labor market. Considerations of fairness, equity, and civic engagement in a democratic society also imply the same course of action. The discussion of structured assessment in Chapter 6 suggests that expanding the pool from which qualified workers can be identified is not inconsistent with meritocratic hiring principles. However, to the extent that groups underrepresented in IT are underrepresented because they have not been attracted to IT work and/or had the appropriate educational and training experiences, government, employers, and educational institutions all have particular roles to play. The following list of actions to be taken by some or all of these parties is derived largely from a paper originally intended to address the issues of women in IT careers;23 however, the list is applicable with minimal modification to members of all underrepresented groups.

1. Collect better data on the status of underrepresented groups in CS and in IT. Little is known about what encourages youth and adults to pursue IT, what helps to retain them in the field, and what enables them to succeed. Research also needs to be sensitive to the differences between demographic groups (Native Americans may have needs and issues very different from those of African Americans) as well as to the differences within groups (Hispanic Americans have many different countries of origin, as well as backgrounds in different social classes, and also have many individual differences). Thus, research should address how the patterns of access, experience, and attitudes differ across various groups underrepresented in computing
fields.

2. Provide role models for all age levels so members of underrepresented groups can imagine themselves as IT professionals. Members of underrepresented groups have entered IT careers in the past despite having few or no role models, but pioneers can pay a high price for their success. To make a substantial increase in the numbers of people from underrepresented groups who select IT careers, it is important to have visible role models who by their presence convey the message that IT is open to all.

3. Provide mentoring for all age levels so that members of underrepresented groups can receive the support they need to scale the professional ladder. Mentors can be from the same demographic group or from a different group; they can be teachers, supervisors, more experienced workers, or others; they can be volunteers or people who mentor as part of their job. Research shows that personal relationships and mentoring are important components of career success.

4. Recruit additional members of underrepresented groups into CS faculty positions at universities and key IT positions in industry. This recommendation speaks to both role modeling and mentoring at the level of higher education, but it also does more. Diverse faculty can help to shape the field of CS in important ways, and help to educate a new and more diverse generation of IT professionals.

5. Encourage industry to produce products aimed at the interests of underrepresented groups. IT products themselves can by their nature send a message to users about whether or not IT includes them and serves their interest. Even computer games, if sensitively designed, could help to attract to IT careers those who might not otherwise have thought to pursue them.

6. Enhance the public image of computer scientists and engineers. The belief that, for example, one must be a "nerd" to be successful in IT can be a significant barrier. Also, the false perception of IT careers as requiring an 80-hour work week may be particularly discouraging to some groups. IT employers and professional societies would be particularly appropriate stakeholders to pursue an effort such as this.

7. Encourage programs that provide a friendly atmosphere for members of underrepresented groups in academe and industry. Reports of harassment, of "chilly classrooms," and of cultural mismatches for underrepresented groups are frequent in some industrial and educational settings. These problems are not unique to IT, but a tight labor market and declining participation by female students make these issues urgent to address. Also potentially helpful could be an examination of the degree of "social relevance" of educational curricula, as this might be a factor in attracting and retaining underrepresented groups.

8. Provide programs that allow members of underrepresented groups to enter the IT field through alternative programs such as reentry programs. A member of an underrepresented group who chose an alternative career path because he or she was not encouraged to pursue IT should have access to alternative points of entry. Reentry programs, mid-career programs, and the like can help to create alternative paths to a successful career in IT.

Notes

1 Even if tightness in the IT labor market does not increase, education and training measures for workers would still be
helpful in an economy that is increasingly based on knowledge and information.

Computer Science and Telecommunications Board, National Research Council, Making IT Better: Expanding
Information Technology Research to Meet Society's Needs, 2000; Scaling Up: A Research Agenda in Software
Engineering, 1989; More than Screen Deep, 1997; Computers at Risk, 1991; and Trust in Cyberspace, 1999 (Washington, D.C.: National Academy Press).

Council on Competitiveness. 1998. Going Global: The New Shape of American Innovation, September. With regard
to software, the report observes, "Although software companies invest heavily in R&D, their focus is more toward
the 'D' side. This emphasis tends to create a gap in fundamental research, particularly in software productivity. As
demand for information technology explodes and information networks grow more complex, the need for automating
the software process will be critical."

President's Information Technology Advisory Committee (PITAC). 1999. Information Technology Research:
Investing in Our Future. Report to the President, February. Available online at <http://www.ccic.gov/ac/report>.
The PITAC report stresses: "We have become dangerously dependent on large software systems whose behavior is
not well understood and which often fail in unpredicted ways. Therefore, increases in research on software should
be given a high priority."

Information Technology for the Twenty-first Century: A Bold Investment in America's Future (<http://www.ccic.gov/it2/initiative.pdf>, January 24, 1999) is the President's response to and endorsement of the
PITAC recommendations.

2 Some of the other reports that have made some similar recommendations include:

3 Workers located abroad could also be accommodated in this manner. But for some of the reasons discussed in Chapter 5,
it is probably easier to use domestic workers--who share common cultural and linguistic referents--than foreign workers.

4 See, for example, McConnell, Steve. 1997. Software Project Survival Guide: How to Be Sure Your First Important Project
Isn't Your Last. Redmond, Wash.: Microsoft Press. Available online at <http://www.spmn.com/>.

5 See Bishop, John H. 1997. "What We Know About Employer-Provided Training: A Review of the Literature," Research in
Labor Economics 16:19-87. An implication is thus that if employers do not themselves support and pay for worker training,
they must at the very least provide guidance to workers about courses of training that would be most helpful.

6 Roberts, Eric, with the endorsement of the ACM Education Board, "Computing Education and the Information Technology
Workforce," white paper provided to the Committee on Workforce Needs in Information Technology, 2000.

7 Computer Science and Telecommunications Board, National Research Council. 1999. Being Fluent with Information
Technology. Washington, D.C.: National Academy Press.

8 A competing view argues that limited public resources would be better invested in promoting early childhood
development and achievement rather than in providing subsidies for training. See Heckman, James J. 2000. "Policies to
Foster Human Capital," Research in Economics 54(1):3-56.

9 List based on Barnow, Burt S., Demetra Smith Nightingale, and John Trutko. 1996. Building the Capital Market for
Employer-Funded Training and Education: Background Paper. Washington, D.C.: The Urban Institute.

10 Such actions may also help to relieve perceptions of age discrimination on the part of certain older workers. Because
companies may be reluctant to hire individuals who have retrained themselves in new technologies but lack experience in
working with them in an on-the-job setting, recent college graduates who have had internship opportunities to obtain work
experience that supplements classroom training have an advantage over older workers who would rarely have such
opportunities.

11 See Barnow, Burt S., Amy B. Chasanov, and Abhay Pande. 1990. Financial Incentives for Employer-Provided Worker

Training: A Review of Relevant Experience in the U.S. and Abroad. Washington, D.C.: The Urban Institute, March.

12 For example, a recent NRC report (Computer Science and Telecommunications Board, National Research Council. 2000. Making IT Better: Expanding Information Technology Research to Meet Society's Needs. Washington, D.C.: National Academy Press) makes recommendations for increased fundamental research on improving productivity in the design and implementation of IT systems.

13 One study undertaken by the National Science Foundation (Curtis, Kent. 1983. Computer Manpower: Is There a Crisis? Washington, D.C.: National Science Foundation. Available online at <http://www.acm.org/sigcse/papers/curtis83/>) found that most faculty who left academia for industry did not cite economic motivation as the primary reason for the shift. Instead, those faculty identified a range of concerns about the academic work environment--huge class sizes, heavy teaching loads, inadequate research support, the uncertainty of tenure, and bureaucratic hassles--that the NSF study refers to collectively as "institutional disincentives." As enrollments in computing courses rose, these institutional disincentives increased in severity, to the point that faculty became overwhelmed and sought other opportunities elsewhere. While dated, the lessons of this study characterize a substantial fraction of faculty sentiment today.

14 Computer Science and Telecommunications Board (CSTB), National Research Council, Funding a Revolution, 1998; Trust in Cyberspace, 1999; and Making IT Better: Expanding Information Technology Research to Meet Society's Needs, 2000 (Washington, D.C.: National Academy Press). President's Information Technology Advisory Committee (PITAC). 1999. Information Technology Research: Investing in Our Future. Report to the President, February. Available online at <http://www.ccic.gov/ac/report>.

15 Note that if H-1B visas are allowed to be more portable, a set of circumstances is eliminated in which employers can take advantage of an employee's dependence on remaining in the same job for immigration-related issues; thus, the labor market should become more competitive. In addition, many employers would benefit since it would allow them to reassign employees to new positions more easily; if DOL also developed a more flexible approach to employment changes during labor certification, as recommended below, then H-1B portability would also allow employers to reassign prospective permanent residents to new positions without interfering with their green-card processing.

16 Recall that the "priority date" is the date that establishes an individual's place in the queue for permanent residency. The priority date is highly relevant because of the per-country numerical yearly quotas for permanent residency.

17 For example, the DOL recently published in the Federal Register general principles that will "guide the development of

proposed regulations to effectuate the redesign [of the labor certification process]" in ways that will "streamline the
process, save resources, improve the effectiveness of the program, and better serve the Department of Labor's customers."
(See Federal Register (20 CFR Part 656, RIN 1205-AB), August 25, 2000, p. 51777.)

18 Some of the approaches discussed with the committee include auctions of H-1B visa-sponsoring privileges to employers
(perhaps periodically to distribute the visas throughout the year); a floating cap that varies with some statistical indicator
such as occupational unemployment rates or vacancy rates, with floors and/or ceilings on the cap; and prequalification of
an employer to use H-1B workers up to some percentage of its workforce (perhaps depending on size), based on
attestations and certifications about that employer's hiring and recruitment practices. Because of a lack of time and
necessary expertise, the committee did not conduct an analysis of these alternatives, and thus is explicitly silent on
expressing a preference among these approaches. These approaches are mentioned simply to demonstrate that a fixed
numerical cap is not the only way to approach the issue.

19 As noted above and in Chapter 5, H-1B workers seeking green cards may be subject to years of processing delays due to
visa backlogs (either because the quota for employment-based immigration is inadequate to handle the growing number of
cases or the per-country limitations are inadequate to avoid backlogs for the large number of H-1B workers born in countries
such as China and India). Unless Congress also addresses these backlog issues, many of these green-card applicants may
not finish their processing prior to the expiration of their H-1B status, forcing them to terminate employment, leave the
United States, and wait abroad until an immigrant visa becomes available.

20 A first step is to understand the differences in compensation systematically. The federal CIO Council's IT Workforce
Committee has partnered with the National Academy of Public Administration (NAPA) and the Office of Personnel
Management (OPM) to sponsor a study to document the compensation differences between the federal government and
private sector.

21 On May 2, 2000, the House passed a bill (HR 3582) that calls on federal agencies to ease educational requirements for IT
workers on government contracts.

22 Meares, Carol Ann, and John F. Sargent, Jr. 1999. The Digital Work Force: Building Infotech Skills at the Speed of
Innovation. Washington, D.C.: U.S. Department of Commerce, June.

23 Gurer, Denise, 3Com Corporation, Association for Computing Machinery Committee on Women in Computing (ACM-W),
white paper provided to the Committee on Workforce Needs in Information Technology, 1999.