GUEST EDITARTICLE

Demographic and Economic Trends: Implications for Education and Industry

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Three hundred years ago, predicting the future was simple: Life 25 years from now will be the same as this year unless an epidemic strikes. In those days, a curriculum for educating young people for the future was obvious. Now that the rate of technological and social change is on the vertical stem of the J curve, anticipating the future has become essential for business but increasingly difficult. Behind this accelerated rate of change is the computer that gets twice as *smart* every 18 months, a fact that Paul Horn, senior vice president of research at IBM, predicts will continue for at least another 15 years (*Life*, 1997).

Educators in vocational, industrial, technology, and engineering education who want to prepare students for the future often find program and curriculum planning to be difficult. Students in these fields have special reason to be anxious about the relevancy of their education since it prepares them for future employment in fields that are changing rapidly. While technological changes are certain, we cannot predict the exact nature and the speed of the changes with any degree of certainty. Yet, a few trends and demographic realities exist, and some authors are bold enough to suggest the most important foci for individuals and businesses in the future. For educators, some of these trends and directions will have an impact on *who* we teach, others on *what* we teach, and yet others on *how* we teach.

My search for trends and social/economic changes was done by examining several sources that report demographic data and trends, and literature in which "world-watcher experts" in economics and certain industrial fields made predictions. Only recent issues of journals, periodic literature, and books were reviewed to obtain the most current data and interpretations. (See Reference section for complete bibliographic information.)

Obviously, there are many more resources that focus on the future. Some writers develop *creative* scenarios of underground cities, skyscrapers several miles high, a workless society, colonies on the moon, life on Mars, and more. While all of these scenarios may come true in time, the resources I selected are, for the most part, quite conservative and based on current trends as opposed to creative speculation. For the record, none of the trends were taken from the *National Inquirer*.

This article is divided into three sections. The first identifies selected current and anticipated demographic and economic trends. The second lists key technologies that are anticipated to be of major importance in the new millennium. The third section explores several implications of these trends for education and industry.

TRENDS

Demographic Changes and Trends

1. Populations shifts: Mitchell (1995) described the two baby booms that have occurred since World War II, and how they will affect the population configuration in the next few years (see Figure 1).

- The population of college-aged young people has hit bottom and will be going up slowly

Figure 1. **Two baby booms and how they grew. (From Mitchell, 1995, p. 27.)**

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from the second baby boom until around 2005 where it will peak (Mitchell, 1995).
- As Figure 2 indicates, the first baby boom will have a "graying" effect on the labor force by 2006.

***Figure 2.* Percent of labor force by age group in 1996 and projected to 2006. (From Bureau of Labor Statistics, 1998, p. 2.)**

- While the proportion of children in poverty during the 1970s fluctuated from 14% to 17%, the poverty rate for children in 1993 had grown to 23%. "Unfortunately, the next boomers are divided into haves and have-nots according to their access to technology and the ability to build important skills early in life....The poorest members of the next baby boom are the least likely to have access to up-to-date technology" (Mitchell, 1995, p. 30).
- The population of people over 85 will increase four times as fast as the total population in the next 40 to 50 years.

Economics/Business

1. We will continue to move from a national economy to an international economy. As noted by the Organization for Economic Cooperation and Development (OECD, 1998), a number of non-OECD countries have become much more active in world trade in the last two decades. As Figure 3 indicates, the emerging economies in Asia, excluding Japan, have grown quickly, especially in manufacturing. Taken as a group, Korea, China, and other Asian emerging market economies had easily exceeded the United States in world merchandise exports by 1996 (OECD, 1998).

***Figure 3.* Shares in world merchandise trade (percent).**

According to Naisbitt (1996), "the modernization of Asia economically, politically and culturally is by far the most important event taking place in the world today" (p. 18).

2. While some Western industrialists are concerned about the added competition reflected by the increases in exports, particularly from the Asian countries, the positive side is that markets in these countries are also opening as shown by the growth in imports by the same countries.

3. In 1988, more than 300,000 Americans worked for Japanese companies; 100,000 Japanese worked for American ventures in Japan, and Japan's Ministry of Trade and Industry predicted that Japanese investment would spawn an additional million American jobs by the year 2000 (Naisbitt & Aburdene, 1990).

These predictions, however, were made before the downturn in the Asian economy, and the prophets of the "Asian Century," anticipating the economic dominance of the Pacific Rim countries in the new millenium, have fallen suddenly silent. However, one is safe in saying that the potential for economic dominance still exists. China, with its 1.1 billion population, was least affected by the economic problems of the region because of its controlled economy, but some economic housekeeping must occur in a number of the other countries before they can continue to progress at the rate shown in Figure 3.

4. Lester Thurow (1992), dean of the Sloan School of Management at MIT, noted that international competition will move increasingly from *niche competition* in which countries excelled in different product areas (e.g., airplanes or computers) to *head-to-head competition*, in which the major players (U.S., European community, and the Pacific Rim) all want to compete for the same markets: microelectronics, biotechnology, the new materials-science industries, telecommunications, civilian aviation, robotics plus machine tools, and computers plus software.

5. Services, from advertising and legal counsel to automotive repair and take-out food, have become the fastest growing part of the economy with 12.3% growth from 1987 to 1992 compared to 1.5% for the retail sector (see Figure 4). One fourth of the service industry is health care, driven in part by use of expensive technology and an aging population (Bureau of Labor Statistics, 1996). Currently, health services coupled with business and professional services account for nearly two thirds of service firms. Services, like the goods-producing industry, will have an edge if they master technological change, develop niche marketing skills, and focus on customer service (Du, Mergenhagen, & Lee, 1995, p. 32).

6. The fastest growing service area is expected to be business services, which is neces-

***Figure 4.* Projected job openings due to growth and replacement needs by major occupational group, 1994-2005 (Bureau of Labor Statistices, 1996, p. 2).**

sitated in part by new technology (i.e., hardware and software), but also involves consultants and accounting and legal services (see Figure 5). Even smaller companies are increasingly turning to service providers where they do not possess the necessary expertise in-

***Figure 5.* Projected employment change in service industries, 1994-2005 (From Bureau of Labor Statistics, 1996, p. 1.)**

house.

7. While production workers in manufacturing will continue to be replaced by technology, there will be an increase in the number of professional positions in manufacturing by 2005. Hiring requirements in many managerial and administrative jobs are becoming more stringent; work experience, specialized training, or graduate study as well as computer literacy will be increasingly necessary (Bureau of Labor Statistics, 1996).

8. Construction is expected to increase by 26%, but it will be primarily in infrastructure building (i.e., bridges, roads, and tunnels). Housing and office building construction will be slower (Bureau of Labor Statistics, 1996).

9. The economy will continue to shift from an industrial economy to an information economy (The Global Network, 1997; "Key Technologies," 1995). At the core of the information economy is the computer and the information highway, but it is much more: all-optical networks, wireless networks, intelligent software, virtual reality, satellite technology, "smart" credit cards, and more.

10. Many of the available jobs in the near future will require the least education and training, but these tend to be low-pay, dead-end jobs. However, the occupations requiring the most education and training will be the fastest growing and highest paying (Bureau of Labor Statistics, 1996). According to the 1998-99 edition of the *Occupational Outlook Handbook* (Bureau of Labor Statistics, 1998), "of the 25 occupations with fast growth, high pay, and low unemployment that have the largest numerical growth, 18 require at least a bachelor's degree" (p. 4). This list includes five in computer science, four in health care, and five in education.

11. Drucker (1994) stated that we are entering the knowledge society in which the acquisition and distribution of formal knowledge may come to occupy the place in the politics of the knowledge society that the acquisition and distribution of property and income have occupied in our politics over the two or three centuries that we have come to call the Age of Capitalism. Knowledge workers, he suggested, will own the "tools of production" (p. 66) in their knowledge.

12. In the 1970s and 1980s, women took two thirds of the millions of new jobs created in the information sector (Naisbitt & Aburdene, 1990). Currently 46% of the workforce, women are projected to comprise 48% by 2005 (Bureau of Labor Statistics, 1996).

Women's pay still lags males'. However, gains have been bolstered with a 22.7% rise (inflation adjusted) for college graduates since 1979, while wages for female high school dropouts fell by nearly 9% in the same period (Kacapyr, 1998). Will (1999) noted that "among people 27 to 33, women who have never had a child earn about 98 cents for every dollar men earn." The point that is made by researchers Furchtgott-Roth and Stolba (1996) is that children tend to disrupt the career paths of many women and most women do not have the requiste MBA or law degree usually nessecary to support a position as a senior member at Fortune 1000 industrial and Fortune 500 service companies.

13. A major problem facing many businesses immediately is the year 2000 compliance (Y2K) issue. To save memory, older computers and software were coded with only a two-digit date (i.e., the last two numbers of the year). Hence, the year 2000 will be 00, not 2000. To correct this problem, General Motors alone expects to spend between $400 million and $550 million (Bylinsky, 1998). Counting the costs of replacement of hardware and software, legal fees (which may exceed equipment costs), and labor in correcting the problem, the total costs may exceed a trillion dollars worldwide.

The problem exists in every aspect of society dependent on computers. Manufacturers, however, are more vulnerable than most other businesses because of the variety of equipment that has date sensitivity embedded in silicon chips and/or in the software. If inscribed on silicon chips, whole pieces of factory equipment will have to be scrapped, from time clocks to CNC robots and machine tools. Unfortunately, not enough programmers are available worldwide to solve all of the problems. Although most large companies are addressing the problem, they are also at the mercy of their suppliers. Small companies that cannot guarantee year 2000 compliance will be replaced with other vendors by the larger companies (Bylinsky, 1998).

IMPORTANT TECHNOLOGIES IN THE NEXT 20 YEARS

To provide a more complete picture of the future for education decision makers, I also sought to identify the technologies that will be the most important as the new millennium begins. Several lists of technologies for the 21st century have appeared in books and journals. Burris (1993) listed 20 core technologies, and the *Scientific American* committed an issue to "Key Technologies for the 21st Century" (1995), with articles describing more than 20 technologies. Thurow (1992) listed seven categories of technology in which there will be major competition. A final article reviewed was the list of 10 technologies "for the next ten years" by the president of Battelle, Douglas E. Olesen (1996). These lists have been compiled in Table 1. To provide some semblance of order, they are organized by major technology headings.

Of the 35 technologies identified in these four sources, only eight technologies appeared in at least three of the lists (marked with an asterisk in Table 1). Five of these were in the information field with one in gene mapping/biotechnology, one in microscopic (nano) machines, and one in super materials. Of equal interest are the two major categories that were identified as important by fewer than three list makers: transportation technologies and energy/environmental technologies.

IMPLICATIONS OF THE TRENDS

The roots of the future are firmly established in today's trends: a service economy in which all sectors—goods producing and services alike—will rely heavily on information systems technology and the knowledge worker. Business will be increasingly globalized. This means that the customer base for products and services will expand dramatically, especially as the former socialistic countries and China become more market driven, but it also means that competition for the same markets will become increasingly fierce, especially among the European group, the Pacific Rim countries, and the United States. This competition will require industry in the United States to explore new ways of doing business, to be more agile. Many companies that thought they were isolated and insulated may suddenly find themselves competing with companies from other parts of the world. Alliances and other forms of cooperative arrangements between suppliers and industries that use the materials and services will become a necessary ingredient of survival (Preiss, Golman, & Nagel, 1996). These shifts and trends have significant implications for both industry and education.

For Education

The implications for education of the information gathered for this paper depend on the level and purpose of the education program being considered. If technology education at the secondary and undergraduate levels is being addressed, knowledge about or awareness of most of the technologies listed in the table as well as the societal interaction with those technologies should be considered part of technological literacy.

If the program is engineering technology, industrial technology, or industrial engineering at the undergraduate or graduate level, career preparation is the goal. Then decisions must be made regarding which of the technologies belong in each type of program. This is obviously a difficult task, especially because the technologies are becoming increasingly more sophisticated across the board. Most, if not all, of these programs have steered away from biotechnology. The focus has been primarily on manufacturing materials and processes, certain aspects of telecommunications and information technology, and selected topics in the energy area. Are current programs too narrowly conceived? What are the practical considerations regarding expansion? What can institutions afford to include? Obviously, there is no point in duplicating what is done better at other technical levels. Yet, changes are taking place. Are programs adapting to those changes or lagging behind them?

- Students need to know much more about the aspects of being involved in international business; they need to be aware of and honor cultural differences and understand how these differences influence doing business in these countries. Employees who are bilingual and understand other cultures have an edge in international

Table 1

companies. Classes in both international business and foreign language would be beneficial in providing tools for students in industrial and technical education.

- While we have touted the value of industrial internships in career preparation, we must now consider opportunities for international business internships. Professional practice internships and/or coop programs are important components of many current programs. Now we need to identify companies that do business internationally and develop internship programs that will introduce students to that dimension of the job market. Perhaps a state's liaison office in Japan could help with such connections. (As of 1990, 40 American states already had liaison offices in Japan [Naisbitt & Aburdene, 1990].)
- The technical needs of industry need to be addressed. Besides specific attention to the selected cutting-edge technologies listed in the "Important Technologies of the Next 20 Years," subject matter in concurrent engineering, designed-in quality, flexible manufacturing, statistical quality and process control tools, robots/automation, computer numerical control, other control systems, and rapid prototyping are subjects that need to be addressed at all levels of technology and technical education and also addressed in depth if we are to supply the competitive technologists and managers for the expanding, competitive marketplace.
- Figure 2 illustrated the movement of the post-WWII baby boomers in the labor force. By 2006, the largest group in the workforce will be from age 35 to 54. This shift toward an older workforce, most of whose formal education occurred prior to the advent of the personal computer, should alert the education community to the need to provide continuing education for these adults. This will require assessment of technical needs as well as delivery techniques. On-site delivery techniques using closed-circuit interactive video classrooms, Internet delivery, and other types of electronic instructional modalities are growing in popularity.
- With the first post-war baby boomers reaching retirement age in the next 10 years, contractors can look forward to building retirement homes for the largest and most affluent retirement crowd yet. Construction technology programs would be well advised to begin addressing the design features and the technical systems that provide safety, convenience, and comfort in residential housing.
- As technology sophistication accelerates, and the level of the technical sophistication of our graduates rises, their ability to work in teams, to communicate their expertise in problem solving, and to incorporate the knowledge of others becomes more essential.
- The service economy will offer many low-wage, low-experience, low-hope jobs for the least educated. But the service sector will also offer many opportunities for employment that require personnel who are well prepared in technical subjects. Are we emphasizing the competencies in our programs to prepare our graduates to troubleshoot in technical areas and to work with clients/customers who are likely to be increasingly demanding in a highly competitive future?
- The customer focus must also become a central theme in our curriculum just as it is becoming a central focus for companies that wish to remain in business. Collaboration with a marketing department may be useful to achieve this. Today, the concept of *customer* has been broadened immensely beyond the buyer of products and services. It includes the next person on the assembly line as well as service department personnel and industrial consultants.
- Currently, women are increasing as a percentage of the labor force and are being attracted disproportionately to information jobs. Whether more can be attracted to enter industrial fields may depend on the ability of these programs to market the applications of information systems in industry. Women are also disproportionately absent in high-level managerial positions, yet are quite capable as shown by their success rates in entrepreneurial efforts. Industrial management programs should seek and encourage women to consider their potential in such a field.
- Just as businesses will increasingly benefit from alliances with other businesses, industrial and technology education would serve its customers (students) better through alliances with the business colleges/departments as well as with commercial businesses and industries. This will not be easy in most cases since turf ownership pervades higher education. Such alliances can only be developed successfully in a win-win atmosphere.
- The building blocks of the information economy focus on microprocessors, digital electronics, optical and wireless net-

works, artificial intelligence, and related technology. Are students prepared in these areas?
- As a result of the demographic shifts that are already identifiable, U.S. society in 2010 will be more ethnically diverse with a greater split between haves and have-nots. This split is not only monetary (i.e., increasing number of children in poverty) but also in technical savvy and computer skills. Higher education may not be significantly impacted by these demographic changes since most of the poorly equipped young people may not attempt college. But they will likely be part of technology and vocational education programs in the public schools and, to some degree, community colleges. Remedial programs may be necessary to bring these students up to speed so they can compete for jobs with a future.

For Industry

- The first order of business for industries is to resolve the Y2K problem. An inventory must be made of all date-sensitive equipment and action taken to repair (if possible), replace, or discard.
- Success will come to those companies that identify emerging markets first and get the product or service concept developed and marketed to the customers ahead of the competition. Concurrent engineering and rapid prototyping will become necessities.
- The focus will be on the customer as never before; this translates into customization and flexibility so that varieties of products or services can be initiated quickly and responsively. In the new century, Drucker (1994) noted that the service industries need to follow the pattern of agriculture and manufacturing in raising productivity without sacrificing the customer focus. Value-added will become the criteria for all processes and divisions within organizations. These changes have direct implications for industry and education. As competition on the same product line or service line increases, customer service may well be the determining factor for which company gets the contract. The concept of customer has been broadened immensely in recent years and needs to be addressed in employment policies and the training of workers.
- Concurrent engineering, designed-in quality, flexible manufacturing, statistical quality and process control tools, robots/automation, and rapid prototyping are practices that are helping companies gain a competitive edge. With the advent of computerization of the manufacturing processes, production will continue to move from mass production to mass customization. Customization will rely greatly on flexible manufacturing systems (FMS) and computer integrated manufacturing (CIM).

The list above addresses implications for industry and for educational content. In most cases, these trends have been visible for a decade or more. Updating a program requires updating faculty to the industrial environment of the future. This is a challenge for administrators at all levels and requires in-service education, participation in commercial exhibits and conventions, and other opportunities such as industrial internships not that different from what students are offered.

In addition to content, however, new technologies offer new ways of teaching and learning: distance learning with closed circuit or compressed video networks, distance learning via the Internet, virtual reality, interactive CDs, and other modes in process. Degrees as well as term papers are already offered via the Internet, and competition in the global economy is coming to higher education by way of the Internet and digitized technologies very soon. Is it not likely that Microsoft and Disney will collaborate to offer courses and degrees. Why not? Microsoft already owns a large collection of important artistic and historic works that is often used in teaching. Personnel from Microsoft have also paid several visits to higher education institutions to gather information about pedagogy as well as content of exemplary programs (Blumenstyk, 1998). Is higher education ready for the next century?

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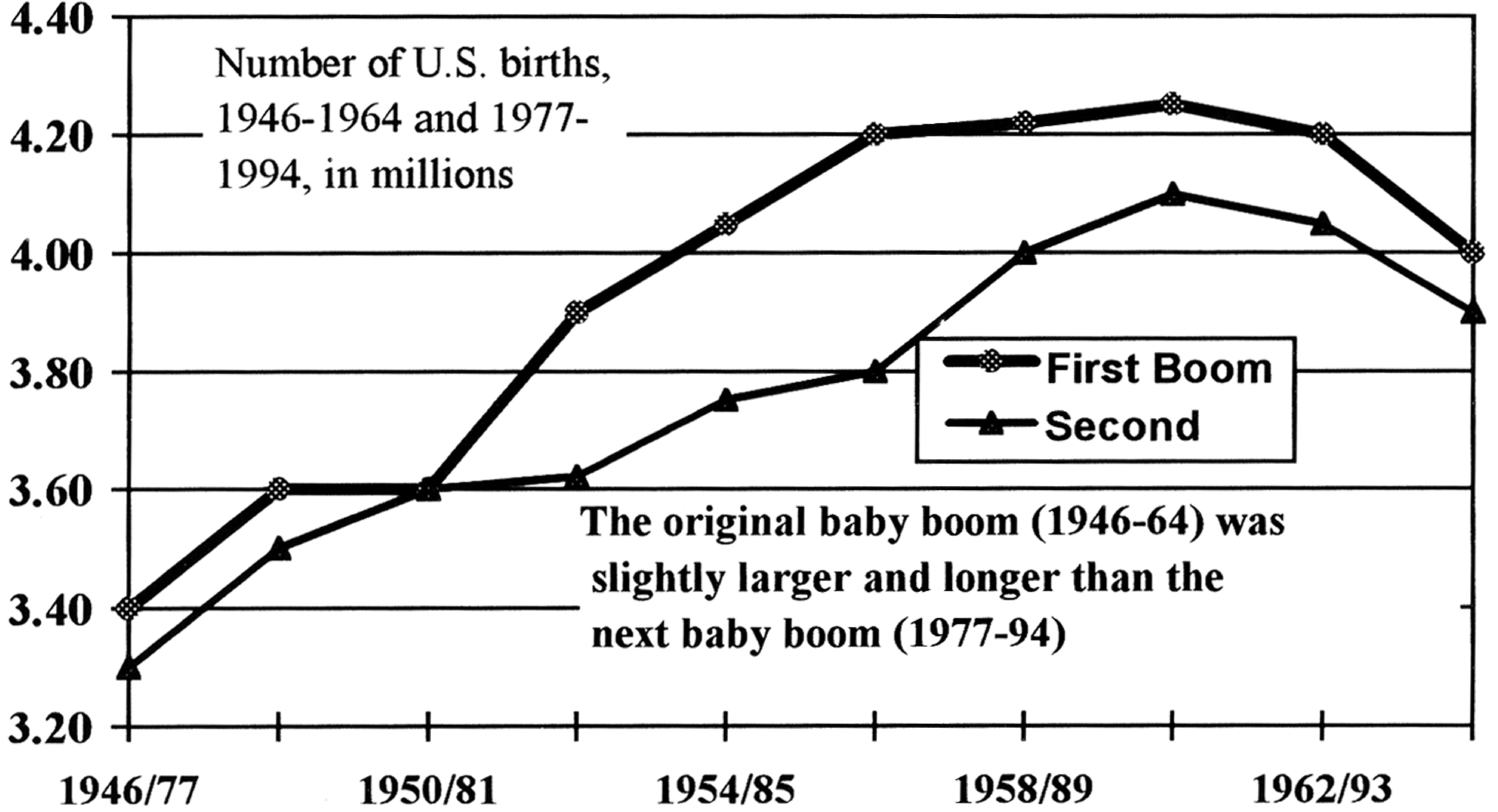
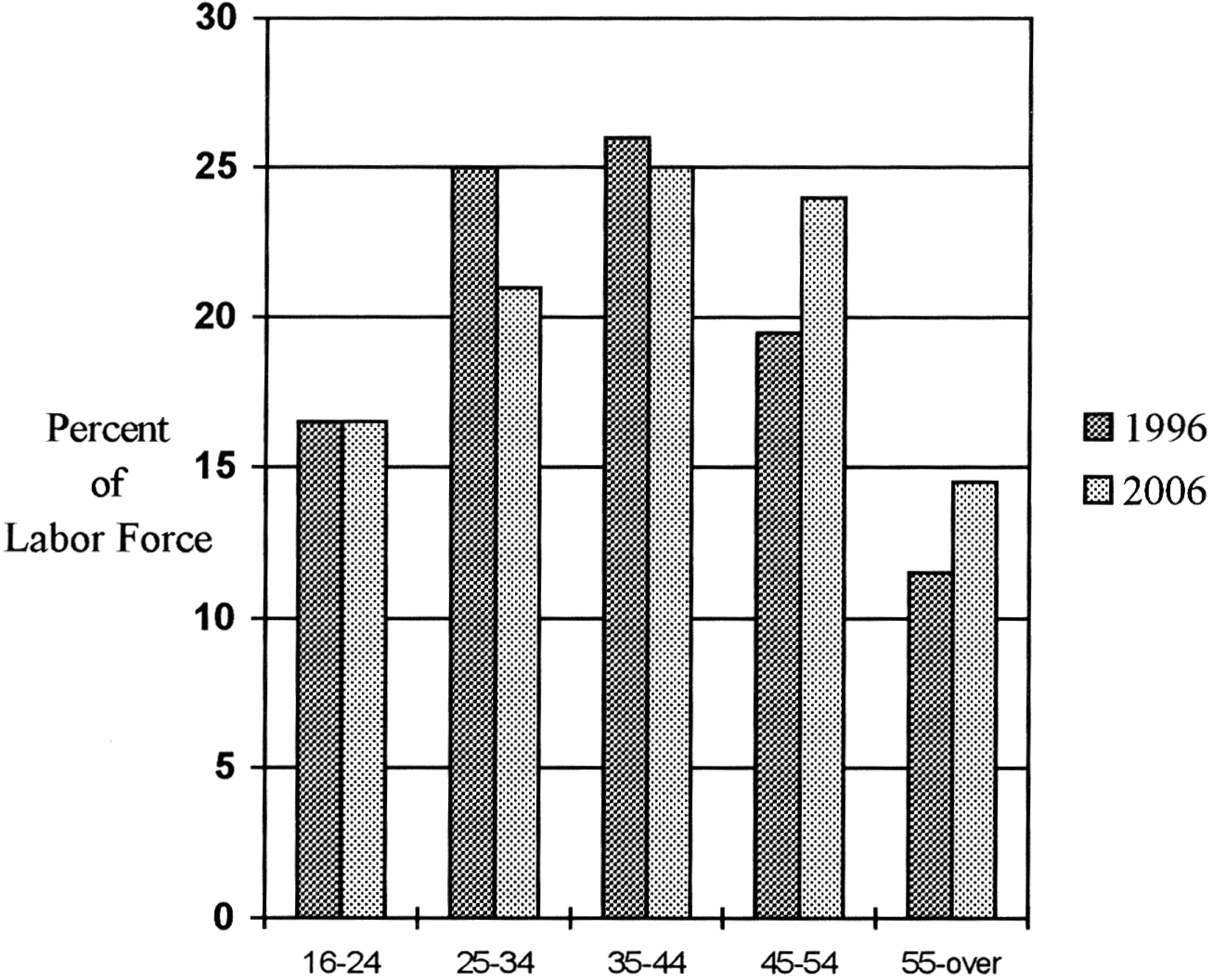
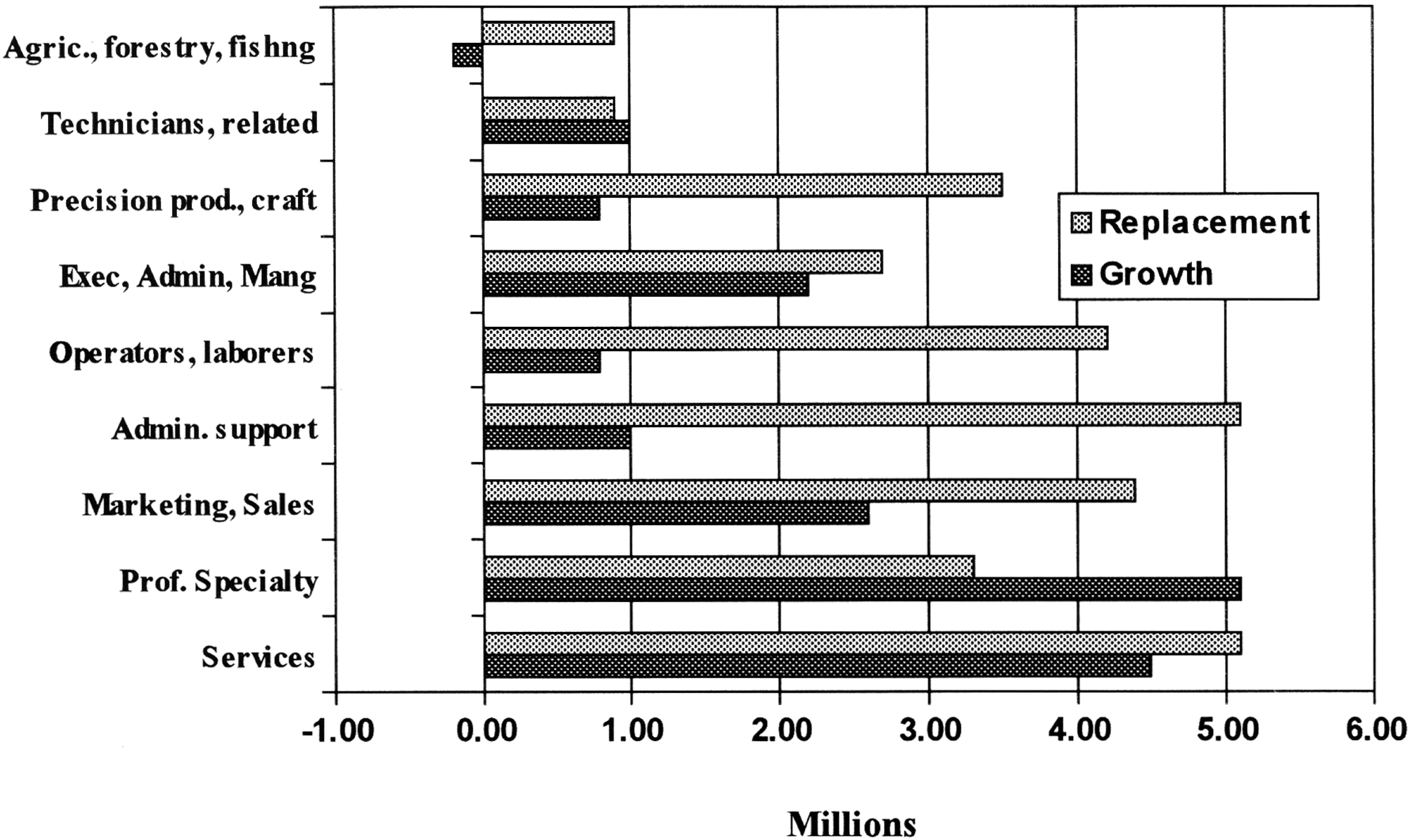
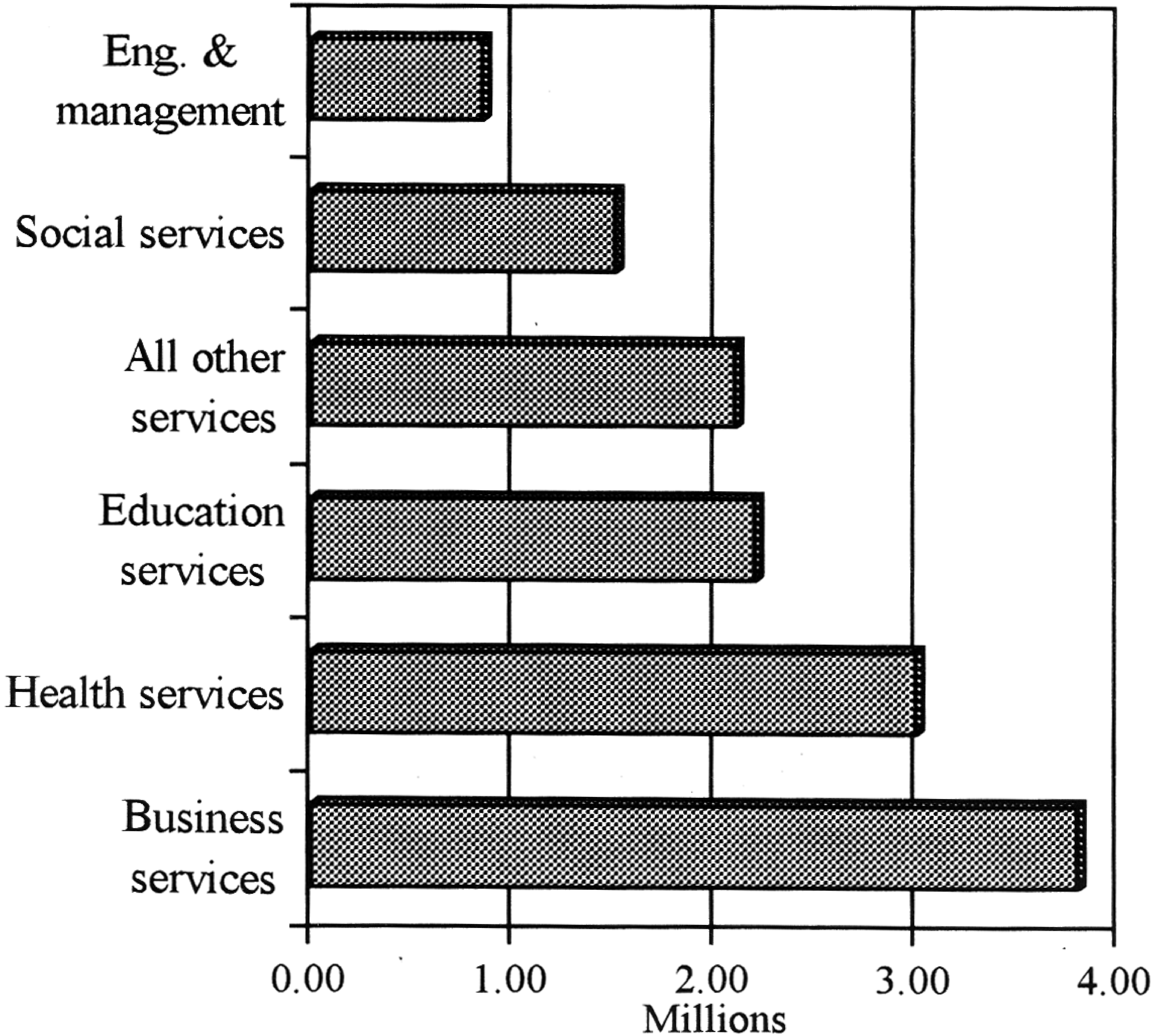

4.40
4.20
4.00
3.80
3.60
3.40
3.20
Number of U.S. births, 1946-1964 and 1977-1994, in millions
First Boom
Second
The original baby boom (1946-64) was slightly larger and longer than the next baby boom (1977-94)
1946/77
1950/81
1954/85
1958/89
1962/93


30
25
20
15
10
5
0
Percent
of
Labor Force
1996
2006
16-24
25-34
35-44
45-54
55-over

	Imports		Exports	
Country	**1985**	**1995**	**1985**	**1995**
United States	24.1	19.5	15.0	15.4
Japan	8.7	8.5	12.4	11.7
European Union[a]	22.2	18.9	22.7	19.4
Rest of OECD[b]	14.6	13.6	16.0	14.2
Total OECD[b]	69.6	60.4	66.1	60.7
China	2.8	3.3	1.9	3.9
Chinese Taipei	1.3	2.6	2.1	3.0
Hong Kong, China	2.0	4.9	2.1	4.6
Indonesia	0.7	1.0	1.3	1.1
Korea	2.1	3.4	2.1	3.3
Malaysia	0.8	2.0	1.1	2.0
Philippines	0.4	0.7	0.3	0.5
Singapore	1.7	3.1	1.6	3.1
Thailand	0.6	1.9	0.5	1.5
Total of above countries	12.4	22.9	13.1	23.0
Total of non-OECD countries[c]	30.4	39.6	33.9	39.6

[a] Excluding intra-EU trade. [b] Excluding Korea. [c] Including Korea.
(Note: Adapted from OECD, 1998, p. 207.)


Agric., forestry, fishng
Technicians, related
Precision prod., craft
Exec, Admin, Mang
Operators, laborers
Admin. support
Marketing, Sales
Prof. Specialty
Services
Replacement
Growth
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Millions


Eng. & management
Social services
All other services
Education services
Health services
Business services
0.00
1.00
2.00
3.00
4.00
Millions

Technology	Burris	Olesen	Scientific American	Thurow
Information technology				
*Adv. computers, microprocessors	X		X	X
*Wireless network, microwave	X		X	X
*All-optical network	X		X	X
Artificial intelligence	X		X	
*Intelligent software		X	X	X
Virtual reality		X	X	
Satellites	X		X	
*HDTV, digital television, interactive, advanced video displays	X	X		X
Digital imaging	X			
Optical data storage	X			
Distributed computing	X			
Transportation				
High-speed rail			X	
Autos: clean, hybrid fuel cars		X	X	
Commercial, civilian aviation			X	X
21st century spacecraft			X	
Medicine				
*Gene mapping, engineering, biotechnology	X	X	X	X
Disease detection, cell specific tech.	X	X		
Anti-aging technology & services		X		
Artificial organs			X	
Contraceptive improvements			X	
Advanced biochemistry	X			
Materials, machines, manufacturing				
Self-assembly materials			X	
*Microscopic machines	X	X	X	X
*Super materials, polymers, ceramics	X	X	X	X
High temp. superconductors	X		X	
Robotics, automation			X	X
Consumer to factory customization		X		
Thin film deposition	X			
Energy and environment				
Solar cells, solar thermal	X		X	
Wind power			X	
More laser applications	X			
High density energy, heat engine		X	X	
Fusion			X	
Cleaner fuels and/or combustion			X	
Sustainable agriculture			X	